A Study of Current Trends and Issues Related to Technical/Engineering Design Graphics

Aaron C. Clark & Alice Scales
North Carolina State University

Abstract

This paper provides results from a survey of engineering design graphics educators who responded to questions related to current trends and issues in the profession of graphics education. The study, conducted in the Fall of 1998, solicited information from the membership of the Engineering Design Graphics Division of the American Society for Engineering Education. Results discussed in this study only include data from individuals who are members of the Engineering Design Graphics Division of the American Society for Engineering Education. The study conclusions include a clear trend in institutions towards the teaching of constraint-based modeling and computer-aided manufacturing; institutions are concerned about the emphasis of software instruction over problem solving skills; and a need exists for degrees and/or training to be offered at either the undergraduate or graduate level to produce teachers of technical/engineering graphics for both secondary and post-secondary education.

Introduction

Over the past five years, engineering graphics educators have faced new challenges. Changes have taken place in the content we teach as well as in the technology we use in the classroom and laboratory (Barr & Juricic 1997; Leach & Matthews 1992; Teske, 1992). Although engineering design graphics educators manage to deal with these innovations, many in the profession wonder if the content of their engineering graphics courses is comparable to other institutions and if the barriers they have faced when dealing with new technology are the same as their colleagues. This paper attempts to answer these questions and others so the profession can address the ever-changing technology that affects our instructional content.

Engineering graphics instruction is an evolving process that has undergone significant changes in the last few years. The introduction of new drawing techniques and engineering practices require educators in the field to examine what they teach and modify their teaching to accommodate new trends in the field. As the profession makes these changes, it would be beneficial to have information on the status of similar programs and how they are coping with the same changes. This study, carried out in the Fall Semester of 1998, attempted to collect data to provide insight into the present configuration and practices of the profession.

This study involved surveying university and college engineering graphics educators in the United States. It's purpose was to identify current trends and issues related to the engineering graphics profession and to see if any conclusions could be drawn to assist graphics educators in making decisions for establishing the direction of growth for institutions. However, the study's results are not an accurate portrayal of the practices used in the field because the sampling technique could not ensure that every institution was represented equally. The researchers were primarily interested in obtaining qualitative information that would allow them to make

informed decisions about course offerings and new undergraduate and graduate degrees.

The survey was divided into four major parts. The first part concerned courses offered by institutions, the software institutions use, and the content areas offered in the field. It also inquired if engineering graphics educators are incorporating new technologies into their courses. The second part sought information on student populations and their needs. The third part related to professional development and faculty concerns. It asked participants to list concerns about the profession and to indicate where they feel engineering graphics is headed in the future. The fourth part related to degrees offered in the engineering graphics field and the need to offer a degree for training teachers to teach engineering graphics (Clark, 1998).

Methodology

The survey instrument and data collecting procedures were developed using guidelines established by Lyberg, et al. (1997). The questions in the four parts were established by asking professionals in the field of engineering graphics what information was needed from professional graphics educators. Engineering graphics professionals in engineering, technology, technical and technology education provided input. Once the survey instrument was completed, professional engineering graphics educators, statistics programmers, and survey research professionals reviewed it.

Survey participants were chosen from the membership of the Engineering Design Graphics Division (EDGD) of the American Society for Engineering Education (ASEE). All members of EDGD residing in the USA (50 states only) listed in the 1997-1998 EDGD membership directory (1997) were sent the survey instrument. A total of three hundred thirty-three survey instruments were mailed to these individuals. Once the instruments were collected, descriptive statistics and qualitative analyses were performed on the data.

Survey Results

The data discussed in this paper reflects the results of the analysis of the 71 (21%) participants (of the 333 surveys sent) that responded to the survey from the Engineering Design Graphics Division of the American Society for Engineering Education. Percentages listed in the text of this article are rounded to their nearest whole number.

Course Offerings

The first question asked how many technical/engineering graphics courses were offered by the participant's institution. Of the 71 participants that responded to this question, 10 percent offer one course, 23 percent offer two courses, 14 percent offer three courses, 11 percent offer four courses, and 10 percent offer five courses on a regular basis. This part of the survey also asked participants to list the software used in their programs. Software packages indicated by respondents included both 2-D and 3-D computer aided design (CAD), computer-aided manufacturing (CAM), design, and animation. The CAD software most frequently listed was AutoCAD followed by ProEngineer. CADKEY and SDRC-Ideas were listed third and fourth, respectively. MasterCAM was the CAM package most frequently listed by respondents and 3DStudio the most frequently listed animation software. See *Table 1* for a listing of software packages with their frequency and percentage of use.

Other software packages listed more than once, but not in the top six, were AutoCAD LT, ALIAS, Ansys, EasyCAD, Mechanical Desktop, Microstation, Rhino, Silverscreen, SmartCAM, Solidedge, Solidworks, SurfCAM, Unigraphics, and Working Model.

Software	Frequency (n=71)	Percent*
AutoCAD	56	78.9
ProEngineer	18	25.4
CADKEY	13	18.3
SDRC-Ideas	12	16.9
MasterCAM	7	9.9
3DStudio	13	18.3

**Note: Maximum possible percentage for each row (software) is 100%.*

***Table 1** - Most identified software packages used in Technical/Engineering Graphics courses.*

The survey asked if respondents teach the use of manual drafting (drawing) equipment in their courses. Thirty-eight participants (54%) responded they teach the use of manual equipment, and 33 participants (47%) indicated they no longer teach the use of manual equipment. Of the participants who stated they teach manual drafting techniques, the most frequently cited method for delivering this instruction was to integrate it with other course material (*see Table 2*). Twenty-five participants (36%) indicated that they offer manual drafting techniques in one course, and 13 participants (19%) taught it in two courses.

The survey instrument asked respondents if they offer instruction in geometric dimen-

Subject	Offered* % (n)	Not Offered* % (n)	Integrated* % (n)	Separate* % (n)	Both* % (n)
Man. Equip.	53.6 (38)	46.5 (33)	39.4 (28)	11.3 (8)	2.8 (2)
GD&T	66.2 (47)	33.8 (24)	46.5 (33)	12.7 (9)	7.0 (5)
2-D CAD	91.5 (65)	7.0 (5)	71.8 (51)	15.5 (11)	7.0 (5)
3-D non-con	70.4 (50)	25.4 (18)	60.0 (42)	11.9 (13)	1.8 (2)
3-D con	53.5 (38)	38.0 (27)	42.3 (30)	9.9 (7)	2.8 (2)
CAM	43.7 (31)	50.7 (36)	22.5 (16)	19.7 (14)	1.4 (1)
Animation	29.6 (21)	66.2 (47)	21.1 (15)	8.5 (6)	2.8 (2)

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

***Table 2** - Types of course content offered in Technical/Engineering Graphics courses that are taught separate or integrated (n=71).*

sioning and tolerancing (GD&T). Of the 71 instruments analyzed, 47 (66%) participants indicated they offer some type of instruction in this area. Forty-six percent said they integrate GD&T into existing courses, 13% offer a separate course, and 7% offer it both ways *(see Table 2)*. Participants were also asked how many courses included GD&T as a part of their content. A total of 25 percent indicated that they include it in one course, while 10 percent indicated they include it in two courses.

The same questions were asked concerning the teaching of 2-D CAD. Most participants, 65 (92%), indicated they teach 2-D CAD as a part of their course offerings and most participates (72%) integrate the teaching of 2-D CAD with other forms of instruction *(see Table 2)*. Participants were also asked for the number of courses in which they offer 2-D CAD. The most common response was one course with 21 participants (30%). Twenty participants (28%) stated they offer two courses and 10 participants (14%) indicated they offer three courses in 2-D CAD.

The survey then dealt with instruction of non-constraint based 3-D modeling software (i.e. traditional 3-D CAD). Fifty participants (70%) responded that they offer this type of 3-D CAD training, and most (60%) indicated that 3-D modeling is integrated with other types of instruction *(see Table 2)*. Twenty-eight (39%) participants indicated that they teach non-constraint based modeling in one course, 11 (16%) teach it in two courses, and seven (10%) teach it in three courses.

Participates were then asked the same questions concerning constraint-based 3-D modeling software instruction (i.e. ProEngineer, etc.). Twenty-seven participants (38%) indicated they did not offer instruction in constraint-based 3-D software and 38 participants (53.5%) said that they did. Of those that stated they offer 3-D constraint-based modeling, most indicated that it is integrated with other types of instruction *(see Table 2)*. Eighteen participants (25.4%) stated that they offer this type of instruction in one course and 5 (7.0%) offer it in two courses. Five participants (7.0%) failed to respond to the question.

Participants were asked if they offer courses in computer-aided manufacturing (CAM). Out of the 71 completed surveys, 31 participants (44%) said they offer CAM instruction. Of those who offer CAM, 14 (20%) offer it as a separate course and 16 (23%) integrate it into other courses. Fourteen participants (20%) only offer one course and 12 (17%) offer two courses *(see Table 2)*.

Twenty-one (30%) indicated they offer animation training, and, of those that offer animation, most integrate it into other courses. Table 2 summarizes the participant frequency and percentages for each subject content area mentioned.

Next, the survey dealt with the number of courses participants' offer using only sketching. Of the 71 who responded, 32 participants (45%) responded that they do not offer courses at their institutions that use only sketching. Twenty-one participants (30%) said they offer one course that use only sketching, 9 (13%) offer two courses, and 9 (13%) said they offer three or more courses that use only sketching.

Of participants who offer a manual-equipment-based course at their institution, this type of instruction is usually offered at the freshman level *(see Table 3)*.

Student Populations

The second part of the survey solicited information on student populations. For the question related to female students enrolled in technical/engineering graphics classes, the mean percentage provided by the 63 individuals who responded indicated female enrollment was approximately 16 percent. Twenty-eight participants (39%) indicated an increase in females over the last five

Level	Use Man. Equip. % (n)*	Do Not Use Man. Equip. % (n)*	No Response % (n)*
Freshman	45.1 (32)	---	46.2 (18)
Sophomore	15.7 (11)	---	81.4 (54)
Junior	7.1 (5)	2.9 (2)	90.0 (63)
Senior	2.9 (2)	2.9 (2)	94.3 (66)

Note: Total percentage for each student classification is 100.
*Note: * % is percentage of responses; (n) is total number of responses for each category and question.*

***Table 3** - Academic levels offering manual equipment instruction and use (n=70).*

years, 6 (8%) indicated a decrease in female enrollment, and 32 (45%) indicated the female enrollment had remained steady.

The participants were asked the same questions regarding minority students. Of the 62 participants that responded to these questions, the mean percentage of minority students enrolled in technical/engineering graphics classes was 13 percent. Thirty-eight participants (54%) stated that their minority enrollment has remained steady, 21 participants (30%) indicated that it has increased, and five participants (7%) indicated that it has decreased over the last five years.

The survey inquired about the majors of students enrolled in technical/engineering graphics courses, and supplied participants with a broad classification list of majors. The survey instructed participants to estimate the percentage of students in these majors enrolled in their courses and allowed a maximum of 100 percent for their combined scores. The scores from the respondents who answered the question were combined to formulate a mean percentage and standard deviation. The results indicated that engineering majors accounted for the majority of the students taking graphics courses with a percentage mean of 67%. Technology majors were second with a mean of 21 percent. The range for other majors varied from a mean of less-than-one to 2.9 percent. The "other" category specified majors not specifically listed. Please note that the percentages indicated in this part of the survey only reflect those participates that responded. *Table 4* shows the overall means (percentages) with the standard deviations for each major by rank.

Professional Development and Concerns

This part of the survey solicited information about teaching faculty at different institutions, their backgrounds, and the current trends and issues engineering graphic educa-

Major	M (overall %)	SD
Engineering	66.82	36.78
Technology	21.28	32.35
Design	5.16	14.98
Computer Science	.98	3.14
Other	2.94	12.95

***Table 4** - Percentage of student majors taking Technical/Engineering Graphics courses (n=71).*

No. Faculty per Institution	Full-time n=70 % (n)*	Full-time not major load n=67 % (n)*	Part-time n=68 % (n)*
1	23.9 (17)	15.5 (11)	28.0 (20)
2	11.3 (8)	18.3 (13)	11.3 (8)
3	11.3 (8)	7.0 (5)	11.3 (8)
4	1.4 (1)	7.0 (5)	1.4 (1)
5	5.6 (4)	2.8 (2)	4.2 (3)
6	1.4 (1)	7.0 (5)	2.8 (2)
7	---	1.4 (1)	---
8	2.8 (2)	---	1.4 (1)
10	---	1.4 (1)	---
12	2.8 (2)	---	---
13	---	---	1.4 (1)
19	1.4 (1)	---	---
20	1.4 (1)	---	---

**Note: Maximum percentage for each cell is 100.*

Table 5 *- Number of faculty at institutions responding to the survey that teach Technical/Engineering Graphics courses.*

tors are facing. The survey asked questions about the number of full and part-time faculty members that teach technical/engineering graphics and their educational backgrounds. From the participants that responded, the mean number of full-time faculty that exclusively teach technical/engineering graphics is 2.37. The mean number of full-time faculty that teach graphics classes, but not as their major load, is 1.92. The mean number of part-time faculty that teach graphics classes is 1.64. *Table 5* indicates the number of faculty for each of the teacher categories.

The survey then inquired about the educational backgrounds of individuals that teach technical/engineering graphics. *Table 6* summarizes the frequencies and percentages for each background category respondents could chose.

The survey asked participants to list the major concerns they had that related to the teaching of technical/engineering graphics and their opinions about future trends in the graphics profession for the next five years. Although a variety of concerns were given, the six most often listed by participants are shown in *Table 7*. Of the 28 trends listed by the participants, the four that were stated most often are shown in *Table 7*.

The researchers were also interested in professional development. Three categories of activities related to technical/engineering graphics were examined: conferences, work-

No. Faculty per Institution	Education % (n)*	Engineering % (n)*	Technology % (n)*	Design % (n)*	Other % (n)*
1	9.9 (7)	23.9 (17)	18.3 (13)	5.6 (4)	2.8 (2)
2	2.8 (2)	15.5 (11)	12.7 (9)	2.8 (2)	---
3	1.4 (1)	2.8 (2)	4.2 (3)	---	---
4	7.0 (5)	5.6 (4)	4.2 (3)	1.4 (1)	---
5	---	7.0 (5)	1.4 (1)	---	---
6	---	5.6 (4)	1.4 (1)	---	---
7	---	2.8 (2)	---	---	---
8	---	1.4 (1)	---	---	---
9	---	1.4 (1)	---	---	---
10	---	---	1.4 (1)	---	---
11	---	---	1.4 (1)	---	---
12	---	1.4 (1)	---	---	---
17	---	---	1.4 (1)	---	---
19	---	---	1.4 (1)	---	---
50	---	---	---	1.4 (1)	---

Note: --- no response was given
**Note: Maximum percentage for each cell is 100.*

***Table 6** - Backgrounds of faculty that teach Technical/Engineering Graphics courses (n=71).*

	n	%*
Major Concerns:		
1. Software emphasized over basics/problem solving/skills	13	18.3
2. Quality of faculty/technical graphics instruction	9	12.7
3. High or increasing costs of adequate funding	7	9.9
4. Rapid rate of change in technology; getting needed training	7	9.9
5. Credit hours decreasing	7	9.9
6. Low level of experience of incoming students	6	8.5
Future Trends:		
1. Increase in 3-D parametric/solid modeling	25	35.2
2. More sophisticated/integrated software systems	8	11.3
3. Decreased reliance on technical drawing	4	5.6
4. Increased prototyping/rapid prototyping	4	5.6

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

***Table 7** - Major concerns and trends in Technical/Engineering Graphics stated most often by participants (n=71).*

Category/Activities	%*	Attended (n)
Conferences:		
American Society for Engineering Education (ASEE)	52.1	37
Engineering Design Graphics Division of the ASEE	26.8	19
International Society of Geometry and Graphics	9.8	7
Workshops:		
Computer-aided design/Computer-aided Manufacturing	11.3	8
National Science Foundation	5.6	4
American Society for Engineering Education	5.6	4
Training/Seminars:		
AutoCAD	5.6	4
ProEngineer	2.8	2
Industry Sponsored	2.8	2

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

***Table 8** - Most cited professional development activities by survey participants for conferences, workshops, and training/seminars (n=71).*

shops, and training/seminars. Of the 11 conferences listed by participants, the most regularly attended were the American Society for Engineering Education Annual Conferences and Engineering Design Graphics Division Mid-Year Meetings. Of the 16 types of workshops listed by participants, CAD/CAM workshops were most frequently attended. AutoCAD and industry-sponsored training appeared most often of the 18 different training/seminars participants listed under this category. See *Table 8* for a list of the three most frequently provided responses in each category.

Emphasis	%*	n**
Design and/or Drafting	9.9	7
Computer-Aided Design	5.6	4
Animation/Illustration	4.2	3
Manufacturing Processes	2.8	2
Architecture/Construction	2.8	2
Engineering	2.8	2
Multimedia	2.8	2
3D	2.8	2

**Note: Total percentage for each program emphasis is 100%.*
***Note: Maximum number for each emphasis is 13.*

***Table 9** - Highest number of responses for Technical/ Engineering Graphics degree program areas of emphasis (n=13).*

Technical/Engineering Graphics Education

This part of the survey requested information on degrees offered in technical/engineering graphics education and the program emphasis of each degree. It also inquired about minor programs and sought participant's opinions on the need for a degree in teaching graphics education at both the undergraduate and graduate levels. Of the 70 participants that responded, 13 participants (18% said their institutions offer a graphics

degree. The emphasis of the major most often given was design and drafting with 7 participants (10%). *Table 9* lists the five areas of emphasis that had the highest number of participant responses. The survey also asked participants if their institution provides a minor in technical/engineering graphics communications. Sixteen participants (22%) of the 70 that responded said they offer a minor. Part of this question asked participants to indicate the number of hours required for their minor. Of those participants who indicated their institution offers a minor, 2 participants (3%) require 30 academic hours for a minor program, and 5 participants (7%) indicated their institution requires between 15-25 academic hours for a minor.

Next, the survey looked for institutions offering visual or graphic communications degrees for students who wish to teach technical/engineering graphic communications. Of the 68 participants that responded to this part of the survey, 4 (6%) offer this type of degree. Three who indicated they offer a degree in this area said they offer a BS/BA degree, two participants (3%) offer a graduate level MS/MEd degree and none indicated his or her institution offers a doctorate. The title/name for degrees varied with names such as Technology Education, Industrial Technology, Technical Graphics, Printing Management, and Industrial Education. There was no clear trend towards a specific name for these programs.

The study asked participants if a need existed for an undergraduate degree specializing in teaching technical/engineering graphics education. Of the 71 participants that responded to the survey, 35 participants (49%) said that this need exists, and seven respondents (10%) did not answer the question. The same question asked about a graduate degree specializing in teaching technical/engineering graphics education. Thirty-four participants (48%) said that this need exists. Forty-three participants (61%) indicated a Master of Science degree would be the best graduate degree for this area of education. *Table 10* shows the type of degrees, in descending order, participants suggested for a technical/engineering graphics education graduate degree.

Degree Type	%*	n**
MS	60.6	43
MEd	21.1	15
PhD	18.3	13
EdD	8.5	6
MAT	5.6	4
Other	5.6	4

**Note: Total percentage for each degree type is 100%.*
***Note: Participants could respond to more than one-degree type.*

Table 10 *- Technical/Engineering Graphics education graduate degree preference as indicated by survey participants (n=64).*

Conclusions

This study was a qualitative examination of engineering/technical graphics education practices currently being employed by members of the Engineering Design Graphics Division of the American Society for Engineering Education. The survey is not a precise picture of the practices because of the limits involved in conducting a survey; however, the information was sufficient to provide an overview of the profession. From the data gathered through the survey, several conclusions could be drawn.

In the area of computer instruction, there is a clear trend towards teaching constraint-based modeling and computer-aided manu-

facturing. Instruction in these areas needs to be fully implemented in programs and the relationship of CAM and CAD needs to be incorporated into instruction.

Instructors in this field are primarily concerned with issues related to software and technological changes. They are concerned that software and technology will become the core of courses to the detriment of graphical and visual science concepts; however, they are also concerned about staying technologically current as well as obtaining the training needed to teach the changing technology in their classes. These concerns about technology are further evident in the predominance of software workshops attended by respondents.

The participants indicate that the percentages of minorities and females in graphics programs have remained essentially the same over the last five years. Also, the greatest concerns voiced by the participants related to the emphasis of software instruction over problem solving skills and the quality of teaching in engineering/technical graphics programs. Other major concerns related to adequate funding, the rapid change of technology, the need for adequate training in new or updated software, and the limited number of training opportunities available.

Finally, the majority of engineering graphics professionals responding to the survey indicated that a strong need exists for degrees and/or training to be offered at either the undergraduate or graduate level to produce teachers of technical/engineering graphics for both secondary and post-secondary education. This conclusion is reinforced by the fact that the majority of training activities that respondents participated in were software related, rather than pedagogical, and two of the top concerns of respondents were directly related to the need for a degree in graphics teacher education. One of the concerns related to the quality of students entering their institutions. By providing certified teachers trained in our field at the secondary level, we can promote our subject in the public schools which provides greater opportunities for students to take classes in technical graphics and obtain the appropriate background for understanding visual science.

The second concern related to the quality of higher education instruction of graphics. Content knowledge does not imply that faculty have the appropriate pedagogical understanding or training to convey this information to students. Together, these concerns support a need for pedagogical training related to teaching visual science and the establishment of a degree in this field.

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

References

Barr, R. E. & Juricic, D. (1992). Classroom experiences in an engineering design graphics course with a CAD/CAM extension. *Engineering Design Graphics Journal, 62 (1)*, 9-21.

Bell, P. B. (Ed.) (1997). Industrial teacher education directory 1997-1998. (36 ed.). Sponsors: Council on Technology Teacher Education & National Association of Industrial and Technical Teacher Education.

Boyer, E. T. (Ed.) (1997). Engineering Design Graphics Directory 197-1998. (6 ed.). Sponsor: Engineering Design

Graphics Division of the American Society for Engineering Education.

Braverman, M. T., & Slater, J. K. (Eds.). (1996). *Advances in survey research.* San Francisco: Jossey-Bass.

Clark, A. C. (1997). Quality characteristics for technology education, *Journal of North Carolina Technology Teacher Education.*

Leach, J. A. & Matthews, R. A. (1992). Utilization of solid modeling in engineering graphics courses. *Engineering Design Graphics Journal, 56 (2)*, 5-10.

Lyberg, L., Biemer, P., Collins, M., De Leeuw, E., Dippo., Schwarz, N., & Trewin, D. (Eds.). (1997). *Survey measurement and process quality.* New York: John Wiley & Sons.

Teske, C. E. (1992). Freshman engineering graphics and the computer. *Engineering Design Graphics Journal, 56 (3)*, 5-10.