Trends and Issues for Engineering/Technical Graphics Education: A Follow-up Survey

Aaron C. Clark, Alice Y. Scales and Julie H. Petlick

Department of Mathematics, Science and Technology Education
North Carolina State University, Raleigh, North Carolina 27695-7801

ABSTRACT –
During the 1998-1999 academic year, a survey was conducted to look at current trends and issues in the profession of graphics education (Clark & Scales, 1999). The survey solicited information from the membership of the Engineering Design Graphics Division of American Society for Engineering Education related to the field. This survey examined their view of future growth areas, existing problems, and the direction the profession of engineering graphics education is headed in the future. This survey, conducted in the spring of 2004, is a five-year follow-up using the same instrument, but with the addition of new categories to examine current trends in post-secondary education. New areas added to the survey related to certifications, distance education, salaries, and research interests.

This paper will provide a cross comparison between the 1998 survey and 2004 survey as well as findings obtained from the analysis of the new categories. It will also discuss the influence these areas are having on graphics education through the United States. Major conclusions will relate to software, pedagogical methods, professional development concerns, and current research being conducted. Post-hoc analysis will be provided to show how trends and issues have changed, or remained the same, over the last five years in graphics education.

I. Introduction

Over the last few years, engineering graphics educators at the post-secondary level have faced many challenges related to the content taught and the technology used (Barr & Juricic, 1992, Leach & Matthews, 1992, Teske, 1992). To examine these issues, future trends in the profession as well as how members of the profession are handling challenges, surveys of the profession were conducted first in the 1998 and repeated in 2004. This paper provides the results from the survey conducted in 2004 and a comparison of the results from this survey to the survey conducted in 1998 (Clark & Scales, 1999). The survey conducted in the spring of 2004 was sent to the membership in the Engineering Design Graphics Division (EDGD) of the American Society for Engineering Education (ASEE). It was the belief of the researchers of this study, as with the previous study, that the members in this division are active in the profession of graphics education and could provide needed information about the status of graphics education in the United States. Only members of the EDGD that residing in the United States of America (USA) were sent survey instruments.

The current survey consisted of five major categories, four of which were included on the original instrument developed in 1998. The categories on the survey were course offerings, student populations, professional development, technical/engineering graphics education, and future research plans (Clark & Scales, 2000). The research category was added to the current survey at the request of members in the profession. The course offerings category asked questions about the type of courses offered at participant's institutions. It also examined whether certain topics were taught as separate courses or were integrated with other types of course materials. The instrument also inquired if institutions offer the topics of manual drawing, three-dimensional modeling, geometric dimensioning and tolerancing (GD&T), sketching, animation, descriptive geometry, desktop publishing, website development, ethics, and computer-aided manufacturing (CAM). Questions related to ethics and on-line and distance education courses were added to the current survey at the suggestion of the membership of EDGD.

The second major category examined student populations, especially in regards to gender and the majors of students taking courses related to engineering/technical graphics. This category was unmodified from the previous study.

The third category concerned the backgrounds of faculty teaching engineering/technical graphics, professional activities and development as well as major concerns in the profession and future trends. New areas added to this category were faculty salary structures, responsibilities and duties, and strategies for dealing with teaching problems.

The fourth major category looked at graphics education, in particular, the number of minors and majors in fields related to technical and engineering graphics. One new question asked in the category was whether or not a national student organization is needed for majors in the field.

The last category asked questions related to future research plans. This new category examined the areas of research participants are currently working on, including major funding sources for research, collaboration, future interests, and future research topics that should be examined for our field.

II. Methodology

The data collecting procedures used by the survey instruments were established by Lybery, et al. (1997). Questions for the survey were originally selected by asking professionals in the disciplines of engineering, technical and technology education for input and comments. Once the instrument was developed, faculty at NC State University in the College of Education with expertise in statistics, graphic communications, technology education, and survey development, gave feedback with four rounds of edits (Clark & Scales, 1999, Braverman & Slater, 1996). The instrument used for this study was this original survey instrument, with modifications to add new categories and questions gleamed from informal discussion with members of the EDGD community over the last five years.

The 2004 survey participants were chosen from the EDGD Membership Directory for 2003-04 (Kearns, 2003). Of this membership, only the 350 members residing in the United States

and were sent surveys. These individuals represented most of the 50 states. Other restrictions on the selection of survey recipients were they had to be employed by a post-secondary institution, be a current member of EDGD, and be listed in the 2003-2004 membership directory. After two weeks, the EDGD members that participated in the EDGD listserv were sent reminders to return the surveys. The data analyzed for this paper were from instruments returned by mid-June of 2004.

Once the 2004 survey instruments were collected, those received from faculty who had retired before 1998 were excluded. The data from the remaining instruments were then analyzed using descriptive statistics and qualitative analyses. It must be noted that the original survey conducted in 1998 included participants in the professional organizations of National Association for Industrial Technology Teacher Education (NAITTE) and the Council for Technology Teacher Education (CTTE); however, the current survey was only conducted with the membership in the EDGD division of ASEE.

Survey Results

A total of 350 surveys were mailed to members of EDGD in May of 2004, with a return rate of 51 or 14.5%. A total of 480 instruments were mailed during the 1998 survey, with a return rate of 23%.The descriptive findings from the 2004 survey respondents are presented below, along with a comparison of the findings for the 2004 and 1998 surveys for categories included on both instruments. All percentages presented in this paper were rounded to the nearest whole number for simplicity of reading.

Course Offerings

In this first category of the survey, participants were asked to indicate the subject areas taught by their instructional programs, the number of courses that teach a particular subject area, and whether that subject is taught as a separate course or with other topics.

Analysis of the data found that participants' institutions offer an average of 6.29 courses in engineering and technical graphics in a regular academic year. The combined total of courses listed by the 48 participants who responded to this part of the survey was 302.

When asked if they taught GD&T in their program, 68 % (or 35 participants out of the 51 respondents) stated they did. Of these 35, 32% offered a separate course in GD&T and 65% integrated it into other courses. Three percent both integrated it into other courses as well as taught it as a separate course. The data revealed that these respondents offered an average of 1.96 courses that included GD&T, with a range from one to five. The survey in 1998 survey, by comparison, found that 79% of the survey participants offered GD&T.

Analysis of questions relating to teaching with manual instruments revealed that 55%, or 28 respondents, still taught with manual instruments in some form. Of those that responded to this question, 29% offered a separate class that used manual instruments, while 72% integrated the use of manual instruments into other courses. On average, 1.53 courses were offered at participants' institutions that involve the use of manual instruments, with a range between one and four courses. Surprisingly, there has been little change in the level of

manual drafting taught when the data from the two surveys were compared. In 1998, the data indicated that 57% of the participants still taught this subject.

In the area of two-dimensional (2D) computer aided design (CAD), 82% (45 participants) taught this subject area. Of the 45 who offered 2D CAD, 31% offered it as a separate course, 67% integrated it into other courses, and 2% offered it both as a separate course and integrated with other subject matter. Two-dimensional CAD was taught, on average, in 3.02 courses, ranging from 1-17 courses per year. AutoCAD was the most often cited software used to teach this subject in both the 1998 and 2004 surveys.

Participants were asked about sketching and the integration of sketching into their course offerings. Examination of the data revealed that only 18 out of the 51 participants, 35%, offered sketching in some of their courses. Sixty-six percent combine sketching and computer graphics or only taught computer graphics.

Questions about non-constraint based 3D modeling were also asked on the 2004 survey. Twenty-seven participants (or 53%), out of the 51 respondents, indicated that they taught non-constraint based modeling. Thirty-two percent offered it as a separate course and 68% integrated it in their other courses. On average, respondents offered 2.64 courses that included instruction in this area, with a range of one to 12. Again, AutoCAD was the most listed software used to teach this, with Solidworks and IDEAS mentioned by some participants. In 1998, AutoCAD was the most often listed software to teach non-constraint based 3D modeling.

Thirty-eight participants (75%) indicated that they taught 3D constraint based modeling. Twenty-four percent of these offered separate courses in 3D modeling and 68% taught it as part of other courses. Eight percent indicated that they taught both separate and integrated courses that included 3D constraint based modeling. The average number of courses including this topic was 2.57. The range of courses was from one to seven. Solidworks was the most common software used, with Inventor and ProEngineer also mentioned by the survey participants. In the 1998 survey, ProEngineer and Mechanical Desktop were the most often cited software packages used to teach 3D constraint based modeling.

A new area on the 2004 survey dealt with the teaching of ethics. Twenty of the 51 respondents (39%) taught some form of ethics in graphics related courses. Ten percent of these offered a separate course in ethics and 90% included it as part of other courses. On average, 1.29 courses were taught by the participants that included some ethics instruction, with a range between one and two.

Computer-aided Manufacturing (CAM) was taught by 24 (47%) of the participants. Forty-one percent of the respondents who taught CAM offered it as separate course, while 54% included it as part of the content of other courses. On average, CAM was taught in 2.0 courses, with the number of courses including this topic ranging from one to eight. MasterCAM was the most often listed software used to teach CAM for both surveys.

Descriptive geometry was another area of instruction included in this portion of the survey. Twenty-nine participants (57%) offered some form of descriptive geometry instruction. Of those, 39% taught descriptive geometry as a separate course, and 61% integrated descriptive it into the content of other courses. Forty-five percent of the participants who teach this subject indicated that they use software as part of its instruction. An average of 1.25 descriptive geometry courses were offered at participates' institutions. The range of courses that included descriptive geometry was between one and three. AutoCAD was the most often software mentioned by individuals who use software for instruction in this area. In the 1998 survey, CADkey was the primary software for this area.

Desktop publishing was another subject area that was part of the 2004 survey. Analysis of the data from these questions revealed that 11 (22%) of the participants teach some form of desktop publishing. Of these, 55% offer it in a separate course, while 36% integrate it into existing courses. Nine percent reported having both integrated and separate desktop publishing courses. The average number of courses that included this subject was 1.78, with a range from zero to four. Adobe products were the most utilized software to teach desktop.

The teaching of website development and design was another topic the researchers were interested in. Eleven participants (22%) who responded to the 2004 survey also offered some form of website instruction. Eighty percent of those that responded they offered website development teach it as a separate course and 20% integrate the instruction into other courses. On average, 1.5 courses in website development were offered by the participants' program, with a range from zero to three courses. Dreamweaver and Frontpage were the most commonly cited software packages used to teach website development.

Animation instruction was offered by 51% (or 26 participants). Of the participants who taught animation, 24% taught it as a separate course, and 72% integrated it. The average number of courses that included animation instruction was 1.33, and the number of courses ranged from one to three. Of those respondents that offered animation, 44% focused their animation instruction on technical animation, 40% on simulation, nine percent on artistic, and seven percent on scientific explanations. Of the respondents who were not currently teaching animation, four percent indicated they would offer courses in this subject in the near future. The software package most often used to teach this animation was 3D StudioMax for both survey years.

Distance education and on-line instruction questions were new to this survey. Of those participants that responded they teach on-line courses, 10 (or 40%), out of the 25 participants that responded to this question, either teach partially or fully using on-line methods. Four (or 21%) out of the 19 participants responded that they teach using distance education methods. However, only one respondent, out of the 48 that responded to the questions related to distance education, offer some form of distance or on-line certification program related to graphic communications.

Table 1 provides a side-by-side comparison of findings for the same questions included in the 1998 and 2004 surveys.

Table 1: Course Offerings found in both Surveys

Courses Offered	1998 Survey (n=111)	2004 Survey (n=51)
GD&T	79%	68%
−Integrated	52	65
−Separate	14	32
Manual Drafting	57%	55%
−Integrated	42	72
−Separate	14	29
2-D CAD	93%	82%
−Integrated	68	67
−Separate	21	31
3-D non-constraint	61%	53%
−Integrated	47	68
−Separate	12	32
3-D constraint-based	46%	75%
−Integrated	34	68
−Separate	10	24
CAM	56%	47%
−Integrated	18	54
−Separate	35	41
Animation	34%	51%
−Integrated	22	72
−Separate	12	24

Student Population

The second major area of the survey asked questions related to the student populations enrolled in engineering/technical graphics classes. The 51 participants that responded to the survey reported an average of 17% were female, compared to 16% reported on the 1998 survey. On the 2004 survey, 22 percent indicated an increase in females taking their classes, compared to 36% on the 1998 survey. Six percent had noticed a decrease in female populations on this survey, compared to eight percent in the 1998 survey. Seventy-one percent reported no change in the number of females taking their graphics classes (50% on the 1998 survey).

Excluding gender, the participants of the 2004 survey reported that, on average, 13% of their student population was minority (14% in the 1998 survey). Thirty-one percent reported an increase in the number of minorities taking their classes and eight percent reported a decrease in number of minorities taking their classes. On the 1998 survey, 28 reported an increase in the number of minorities and seven percent indicated a decrease. The 2004 survey data indicated that 60 percent found no change in the numbers of minorities taking their classes, as compared to the 1998 survey, where 54% participants reported no change in numbers of minority students taking graphics courses.

Participants were asked about student majors taking their graphics courses. Of the 51 participants that responded to this question, they reported that 67% of the students taking courses in graphics were engineering majors (47% in 1998). Twenty percent were in technology (32% in 1998) and six percent from design majors (seven percent in 1998). The next highest major was education with only 1.48% of the total being this type of major in the 2004 survey only. These size differences between the survey results are largely due to the difference in the population surveyed between the two surveys.

Professional

This section of the survey asked questions related to professional areas and activities associated with technical and engineering graphics education; daily tasks of instructors, ranks and salary ranges, and professional development. The average number of full-time faculty members per institution that teach technical and/or engineering graphics as their primary responsibility was found to be 2.15. The average of full-time faculty that teach graphics, but not as their primary teaching load, was 2.94. In 1998 only 1.97 fell in this category. Fifty-five percent of the respondents indicated that faculty teaching these courses had mostly engineering and/or technical degrees. Other degree types held by faculty teaching in the field included technology, design, and education. This finding stayed consistent across both surveys.

A new area for this survey looked at salary ranges for the different ranks associated with post-secondary education. Also examined were the required faculty teaching, service, and research loads. Table 2 shows the different ranks, the average number of faculty at institutions that hold that rank, their salary ranges as well as a summary of the average percentage of time allocated to teaching, research, and service by the participants that responded to the survey.

The 2004 survey asked questions about degree offerings by participant's institutions that are directly related to engineering/technical graphics. Eighteen participants (or 36%) out of the 50 that responded to the question indicated that their institution offers a major in engineering/ technical graphics, as compared to 23% in the 1998 survey. Five participants on the 2004 survey (or 10%) reported that they offer a minor in areas related to graphics, as compared to 14% in the 1998 survey. As an interesting side note to the 2004 survey, eight participants (or 23%) of 35 responded that a national organization for students is needed.

Table 2: Salary and Distribution of Faculty Duties 2004 Survey Only

Rank	**Average # who hold this rank**	**Salary Range**
Full Professor	1.90	45k-200k
Assoc. Prof.	2.48	45k-90k
Assist. Prof.	2.14	40k-80k
Instructor	2.35	20k-85k
Lecturer	2.83	10k-90k
Adjunct	4.02	605-50k
Average Distribution of Faculty Duties		
Teaching	*Service*	*Research*
75.22%	17.13%	7.33%

Of interest to the researchers were degrees offered by participants' institutions that are directly related to preparing engineering/technical graphics educators. Five participants (or 10%) out of the 49 that responded to this section on the survey indicated that their institution offers some type of major in engineering/technical graphics teaching, compared to the 1998 survey that indicated 15 percent offered this type of degree. Of the five that responded to this question in the 2004 survey, three indicated their institution offers a B.S. or B.A. degree, one offered just a M.S. or M.E.d related to this area, and one said their institution offered both. Again, the population difference for the two surveys is reflected in the responses to these questions.

Questions relating to professional development were included in the survey to determine the type of activities participates use to stay current with the profession. Many write-in answers were given, but the most frequent response was ASEE and EDGD activities, followed by NAIT workshops and conferences. AutoDesk sponsored events through AutoDesk University and courses at training centers were second only to ASEE and EDGD sponsored activities. Other vendor sponsored workshops by Solidworks and CAD/CAM companies were mentions by many participants as well. This closely mirrored the responses given on the 1998 survey.

One new question added to the professional category asked participants about the strategies they have initiated to deal with teaching problems over the last five years. Again, many comments were made, but those mentioned most often included greater utilization of web-based instruction and tutorials, emphasis on 3D visualization using testing and help sessions, and project-based learning with students working in teams.

The 2004 survey requested that participants list their major concerns related to the teaching of engineering/technical graphic communications at the post-secondary level. Overall, the most cited concerns were the quality of students entering programs; staying current with changes in technology (the cost of software/hardware, faculty development, and the

complexity of new software); issues regarding graphics as an area of study (curriculum changes, fitting into engineering programs, and the increased emphasis on research); and the need to maintain practices, such as sketching, rather than focusing on teaching software. Other concerns mentioned more than once were teaching content verses software and the complexity of software increasing faculty workloads. In the 1998 survey, the four most frequently mentioned concerns in order of importance was adequate funding, software emphasis over basic skills, difficulty in staying up-to-date in hardware and software, and obtaining training to stay current with the rapid change in technology.

A final question in this category asked participants what they felt were the future trends for the next five years as it relates to the teaching of engineering/technical graphic communications. Numerous responses were given and few trends could be detected, but the three areas that seem to standout most were on-line and distance education instruction, increased emphasis in 3D CAD, and increased use of 3D prototyping. In the 1998 survey, the top three future trends were increase in 3D modeling, increased sophistication of software, and decrease reliance on technical drawing.

Research

At the request of the membership in EDGD, a fifth category was created for this survey that looked at the status of research being conducted by professionals in engineering/technical graphics communication. One of these questions sought information on the degree that participants perform collaborative research outside of their program area as well as outside their institution. Twenty-six participants (or 67%) out of the 39 that responded to this question indicated that they collaborate outside of their program for research. Fourteen participants (or 37%) out of 38 who responded to this question reported that they also collaborate outside of their institution as well.

The survey asked participants to list the areas of research in which they are currently involved. Of those that responded to this question, rapid prototyping was mentioned more that any other area. Areas mentioned more than once included assessment, working with secondary schools, and on-line instruction. The survey also asked participants to identify current or previous sources of funding for their research. The responses to this question indicated that the National Science Foundation (NSF) was the most mentioned source, followed by grants from private industry. When asked what grants participants are currently involved with, no one grant or funding title was mentioned more than once.

The survey asked participants about the types and topics of research they were most interested in for the future. The most frequently mentioned area was outreach to high school students, and the second most frequently listed was research in 3D printing and prototyping. Teaching and visualization were also mentioned in some of the responses. Finally, the survey asked participants what they felt were the main research topics that should be examined by our field. Again, many different responses were given. Table 3 below shows the frequent responses to this question in the 2004 survey:

Table 3: Most Frequent Responses to Topics of Research Needed for the Field in 2004 Survey

Curriculum development
The best ways to teach constraint-based modeling
Using parametric modeling as a means to teach visualization
Virtual reality and simulation
Improving visualization in 3D modeling
Visualization- pedagogy, solid modeling methodologies for practical application
Trends in industry as related to CAD and modeling
Simulation and reverse engineering
Graphic decision-making, learning styles, and visual language
Education and new tools such as animation and analysis
Curriculum modernization and ABET requirement for graphics
Assessment of student learning
Rapid product development

IV. Conclusions

All data presented in this paper are descriptive and only reference the respondents that completed the survey; however, some observations can be made from the data that has been analyzed. From questions asked in the course offerings category, the following conclusions were reached by the authors. First, the profession has long discussed the elimination of manual instruments from its instructional practices, but a sizable number of programs are still using them, 57% in 2004 and 55% in 1998. Since the survey did not ask how these are being used, no conclusions can be drawn to the appropriateness of their inclusion in participants' curricula. Next, 3D constraint-base modeling accounts for 75% of the software used in courses related to our field, as compared to 46% who taught this in 1998. This trend seems to be growing and most likely will eventually replace traditional 2D CAD packages. Third, animation seems to be the next largest growth area for courses we offer. Over 51% of those that responded to the 2004 survey (34% in the 1998 survey) indicating that they teach animation or simulation is some form. This subject will probably take the form of simulation and technical animation, since over 85% of the courses currently offered relate to these types of animation. New areas for the profession are the teaching of ethics, on-line instruction, and distance education. The authors see distance education methods as a major growth area for the field and that ethics will eventually be a part of the general content we all teach.

In the category of student population, one can see that the types of students we attract to our subject are typically individuals majoring in engineering, design, and technology. The authors feel that more attention should be placed on recruiting a variety of majors to take technical graphics classes. The content we teach and the skills we develop in students are appropriate for a variety of majors not currently enrolling in them.

As compared with the previous study in 1998, only a small gain has been made in increasing the number of female students in our classes, but minorities taking our classes have increased

over 30% in the last five years. Although the percentage of minorities and females match the national average, more can be done to attract a diverse population to our classrooms.

New areas for the profession are the teaching of ethics, on-line instruction, and distance education. The authors' feel that distance education methods are major growth areas and will only continue to grow, given comments from 2004 survey participants in the category of research and research trends. Ethics will become a part of the general content we all teach in our courses if we are not doing so already. Of those that responded to the 2004 survey, 39% are already teaching ethics in the classroom; however, the survey did not ask what was being taught and how it is being conveyed to the students. Therefore, the authors of this study would like to suggest that the EDGD division look at offering either workshops or paper sessions on this topic to help the membership integrate this important area into classes.

Professional develop is still a major concern for members of the EDGD community. The ASEE and EDGD meetings are major conferences that allow the membership to stay up-to-date with current events and trends in our field. Also, vendors play a major role in updating the skills needed to teach our courses. Stronger alliances should be developed between the membership and vendors so that better and more productive professional development can continue from this source.

Salaries for the EDGD members vary from institution to institution with the average starting salary for an assistant professor occurring in the $40k-50k range, associate professor in the 50k-60k range, and professor at 70k and higher. The major responsibilities for the faculty that answered this survey is teaching, then service, with research last; however, given the comments made throughout the survey, research is beginning to play a larger role in what we do as graphics faculty.

The biggest innovation for improving teaching and course offerings to our students is the use of on-line instruction and tutorials. Our major concerns are the quality of students taking our classes and keeping up-to-date with current technologies. Although these concerns exist, one can also see that the profession's investment in K-12 outreach means it is committed to the improvement of student quality, and the amount of time devoted to professional development indicates that the individuals in the profession are also dedicated to staying abreast with technological developments. Further evidence for this is the fact that the fastest growing future trend for the profession is distance education and on-line instruction.

Finally, in the research category, few conclusions can be drawn, since this area is fairly new to the membership; however, based on the data and comments of the respondents, the authors have the following observations and suggestions. First, most collaborative efforts are still within researchers' existing program and institution. In order to facilitate better research, the authors suggest collabatories be established by the EDGD membership to help facilitate the research needs of the profession and individuals across different institutions. The authors further suggest that the leadership of the EDGD develop a structure for establishing such collabatories and that meetings be held at the mid-year and annual ASEE conferences for those members interested in collaborative research. From the comments given in the survey, these collabatories should focus on areas related to teaching and pedagogical practices,

visualization, and k-12 outreach. Another suggestion would be that the EDGD division should also consider offering workshops that assist in developing grants and seeking research funding sources. A final suggestion would be that two new director positions be established for the executive committee of the EDGD division, one that deals directly with research topics and one responsible for k-12 outreach.

In conclusion, the profession is doing well and progress is being made on every front in post-secondary graphic communications education. The membership is active and has the ability to adapt to changes in our profession. Overall, one can easily see that the future of our discipline looks bright and that we are stronger than ever as we move forward in a century that can be termed as the "visual age."

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Aaron C. Clark is an Associate Professor of Graphic Communications at North Carolina State University in Raleigh. He received his B.S. and M.S. in Technology and Technology Education from East Tennessee State University. He earned his doctoral degree from NC State University. His teaching specialty is in introductory engineering drawing, with emphasis in 3-D modeling and animation. Research areas include graphics education and scientific/technical visualization. He presents and publishes in both vocational/technology education and engineering education.

Alice Y. Scales is an Assistant Professor at North Carolina State University, where she has taught since 1988. At NCSU, she serves as the Assistant Department Head of the Department of Mathematics, Science, and Technology Education and Coordinator of the Graphic Communications Program. She received her B.S. in Science Education in 1965, her M.Ed. in Industrial Arts Education in 1983, and her Ed.D. in Occupational Education in 2000.

Julie H. Petlick is a Visiting Assistant Professor in the Graphic Communications Program. She earned her doctorate at NC State University in Psychology. Her teaching and research interests are in technical data presentation, visualization, and learning. She is a member of the Engineering Design Graphics Division of the ASEE.