A Survey of Current Trends and Issues for Engineering/Technical Graphics Education: Results from a Five-Year Follow-up

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Abstract – During the 1998-1999 academic year, a survey was conducted to examine the current trends and issues in the profession of graphics education [1]. This survey solicited information from the membership of the Engineering Design Graphics Division of American Society for Engineering Education and was designed to obtain their views concerning future areas of growth, existing problems, and the direction the profession of engineering graphics education was headed. The current survey, conducted in the spring of 2004, was a five-year follow-up study that used a modified version of the same instrument. The updated survey form included additional categories and questions to address current issues in post-secondary education. Some of the areas added to the survey related to certifications, distance education, salaries, and research interests. This paper will present the findings from this five-year follow-up study.

Keywords: Technical Graphics, Engineering Graphics Education, Tends in Technical Graphics Education

INTRODUCTION

This paper provides the results from a survey of the engineering design graphics profession on current trends and issues related to teaching engineering/technical graphics in post-secondary education. Although a follow-up to a survey conducted in the Fall of 1998 that looked at most of the same issues, the current survey instrument is a modification of the original to include questions relevant to the issues presently facing the profession [1]. This study, conducted in the Spring of 2004, surveyed the membership in the Engineering Design Graphics Division (EDGD) of the American Society for Engineering Education (ASEE). It was the belief of the researchers that members in this division are active in the profession of graphics education and could provide information related to the status of graphics education in the United States (US). Only the members of the EDGD residing in the US were sent survey instruments.

The survey consisted of five major categories, four of which were included on the original instrument developed in 1998. The categories on the survey included questions related to course offerings, student populations, professional activities, technical/engineering graphics education, and future research plans [2]. The research category was added to this survey at the request of members in the profession.

The first major category, which examined course offerings, asked about the type and number of courses offered. The instrument specifically inquired if institutions offer the course topics of manual drawing, three-dimensional modeling, geometric dimensioning and tolerancing (GD&T), sketching, animation, descriptive geometry, desktop

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publishing, website development, ethics, and computer-aided manufacturing (CAM). It also asked if these topics were taught in separate courses or were integrated with other course subjects. Questions related to ethics as well as on-line and distance education courses were added to this category 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 in engineering/technical graphics. This category was unmodified from the previous study.

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

The fourth major category looked at graphics education, in particular, the number of minors and degrees that institutions offered in fields related to technical and engineering graphics. A new question included in this category was whether a national student organization should be created for majors in the field.

The last category looked at research. This additional category examined the areas of research participants are currently involved in, major research funding sources, research collaboration, future interests, and future research topics that should be examined by our field.

METHODOLOGY

The data collecting procedures used by the survey instrument were established by Lybery, et al. [3]. Questions included on the original survey were selected by asking professionals in the disciplines of engineering, technical education, 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 through four rounds of edits [1]. The instrument used for the current study was the original survey instrument, with modifications to add new categories and questions gleaned from informal discussion with members of the EDGD community over the last five years.

Survey participants were chosen from the EDGD Membership Directory for 2003-2004 [4]. The 350 members residing in the United States were the only individuals sent surveys, which provided representation from 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 participate 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 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. This research paper provides the preliminary results of the descriptive statistics on this data. Please note that the original survey conducted in 1998 included participants in the professional organizations of NAITTE (National Association for Industrial Technology Teacher Education) and CTTE (Council for Technology Teacher Education); 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%. Below are the descriptive findings from those that responded to the survey. 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, it asked participants 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. All of the respondents to the survey (51) responded to these questions. 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.

When asked if they taught GD&T in their program, 68 % (or 35 participants) 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.

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.

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 it into other courses. 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.

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 survey. Twenty-seven participants (or 53%), out of the 51 that responded to this question, 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.

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 ProE also mentioned by the survey participants.

A new area on the 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.

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.

Desktop publishing was another subject area that was part of the 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 used to teach desktop.

The teaching of website development and design was another topic the researchers were interested in. Eleven participants (22%) 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 being 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.

Distance education and on-line instruction questions were new to the 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.

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. Twenty-two percent reported they had noticed an increase in the female enrollment, six percent had noticed a decrease, and 71 percent reported no change in the number of females taking their graphics classes. Excluding gender, the participants of the survey reported that on average, 13% of their student population was minority. Thirty-one percent reported an increase in the number of minorities, eight percent reported a decrease in number of minorities, and 60% reported no change.

Participants were also asked to indicate the majors of students enrolled in their courses. The participants reported that 67% of their students were engineering majors, 20% were in technology majors, and six percent were design majors. Individuals in education programs comprised the next highest (1.48%).

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. 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.

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 1 shows the different ranks and the average number of faculty at institutions that hold that rank as well as their salary ranges. Table 2 provides a summary of the average percentage of time allocated to teaching, research, and service by the participants that responded to the survey.

Table 1
Average Salary Distribution by Ranks

Average Distribution of Faculty Salaries		
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

Table 2
Average Faculty Duties by Category

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 engineering/technical graphics. Eighteen participants (or 36%) out of the 50 that responded to this section on the survey indicated that their institution offers some type of major in engineering/technical graphics. Five participants (or 10%) also reported that they offer a minor in the field as well. Of those that offered a minor, the average number of credit hours needed to complete the minor was 20.

The survey delved into the appropriateness of offering a degree for students that want to teach graphic communications. Five participants (or 10%) of the 49 that responded to the question already offer some type of teaching degree in this field. Of that five, three indicated that their institution offers a B.S. or B.A. degree, one offered just a M.S. or M.Ed., and one said their institution offered both. As an interesting side note, only eight participants (23%) of the 35 who responded to this question felt that a national organization for students was needed.

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.

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 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.

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.

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. The list below shows the responses to this question:

*reverse engineering in industrial and medical applications
*curriculum development
*change in manufacturing needs
*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
*rapid manufacturing technology
*simulation and reverse engineering
*integrating tolerances into CAD
*graphic decision-making, learning styles, and visual language
*education and new tools such as animation and analysis
*curriculum modernization and ABET requirement for graphics
*bridging between academics and real world applications
*assessment of student learning
*rapid product development
*3D geometry, incorporating aesthetics

CONCLUSIONS

The information found in this paper is preliminary at best. All data 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 the 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. 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. 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. 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. Also, compared with the previous study, only a small gain has been made in increasing the number of female students in our classes, but minorities have increased over 30% in the last five years.

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 should 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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