ABSTRACT

DOWNS, BRIAN WESLEY. What is the Future of Technical Engineering Graphics Education? A Survey of Graphic Professionals Focused on the Emerging Themes of Technical/Engineering Graphics Education in the United States. (Under the direction of Dr. Aaron Clark, Dr. Alice Scales, and Dr. Terri Varnado).

This research explored emergent trends in technical/engineering graphics education as prior research suggested that changes had occurred in the instructional topics and practices of the field. Prior research also showed that instructors wondered if the same topics were taught by graphics professionals as a part of their curriculum at other institutions. The areas researched in this study were: course offerings, student populations, professional development, technical/engineering graphics education, and future research. The study sample of fifty-six (*N*=56) graphics education instructors was selected from Engineering Design Graphics Division (EDGD) members that were listed in the 2007-2008 membership directory, provided a valid email address to American Society for Engineering Educators (ASEE), had achieved at least a Bachelor's degree, and taught at least one graphics course a year. The EDGD members were contacted via email and responses were collected by an online survey instrument. Overall, the results were checked for invalid responses, compiled, and then compared to the results of previous research from 1998 and 2004. The results of this study showed a decline in the instruction of: GD&T, manual instruments, 2-D CAD, 3-D modeling, and CAM. The results indicated no change in 3-D constraint-based modeling instruction, but an increase in the instruction of animation. A decline in female students enrolled in technical/engineering graphics courses was also reported; however, an increase was reported in ethic minority students enrolled in the same courses. The results indicated a decline in the number of educational institutions that offered technical/engineering graphics

as a major degree, but an increase in institutions that offered a minor in the same field. Furthermore, the results indicated that as time progressed and technology advanced, the topics taught within technical/engineering graphics courses shifted from traditional topics and to new emergent topics. Common concerns of respondents were difficulties remaining up-to-date with changes within the field and the preparedness of incoming students to the field. Possible future trends identified in this study were all software related and included: an increased emphasis on 3-D CAD, the increased instruction of animation, and a migration to online and distance education from traditional classroom instruction. The field of technical/engineering graphics education appeared to be strong and had adapted to industrial advancements and curriculum changes.

What is the Future of Technical Engineering Graphics Education? A Survey of Graphic Professionals Focused on the Emerging Themes of Technical/Engineering Graphics Education in the United States

by
Brian Wesley Downs

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APPROVED BY:

Aaron Clark, Ed.D
Committee Chair

Alice Scales, Ed.D

Terri Varnado, Ph.D

DEDICATION

This paper is dedicated to everyone who aided, supported, and encouraged me throughout my graduate studies and along the path that led me to pursue these studies. I would like to start by thanking Dr. John Riddle. What began as an impromptu speech to his class in exchange for enrollment in his already full history course, turned into an invaluable learning experience. During Dr. Riddle's course I learned that the acquisition of knowledge could emerge from the intelligent discussion of topics and was not merely the memorization of facts. I would also like to thank my professors for their time and assistance. These individuals directed me through the graduate process and will undoubtedly aid in my future success. My greatest appreciation goes to Allison who provided me with more support, sacrificed more time, and gave up more opportunities for the completion of this degree than any other individual. Lastly I would like to thank my employers, who provided me with the needed flexibility in my work schedule, so that I could attend meetings, take courses, and study for exams.

BIOGRAPHY

Brian Downs was born in 1981 and spent most of his youth in Hickory, North Carolina, with short periods of residency in New Jersey and Arkansas. He has always loved the outdoors and was active in Boy Scouts, during which he earned the rank of Eagle Scout. Brian moved to Raleigh, NC in August 1999 to attend North Carolina State University. He completed his undergraduate studies in May 2003 and earned a degree in Technology Education, with a minor in Graphics Communications. After graduation, he remained in Raleigh and began working at a small Civil Engineering firm as a CAD Drafter. In 2005, he enrolled in graduate school at NCSU and continued working to gain professional experience. In 2006, Brian began work at a different Civil Engineering firm. In 2008, he was inducted into the Epsilon Pi Tau Honor Society. His current hobbies include attending NCSU athletics events, hiking at National and State Parks, traveling, attending concerts, and photography. Brian would like to do something each and every day that he will remember for the rest of my life.

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I would like to thank everyone who helped, encouraged, and sacrificed for me throughout my graduate studies. I could not have done it without all of you. I would specifically like to thank Allison for all of her support and sacrifices. We have missed more trips than we took, skipped more events than we attended, and let more opportunities pass us by than we took advantage of, but that is over now. I would also like to thank all of my friends who have put up with me being physically absent and mentally preoccupied. For Comp, we will take many trips but not a single one that involves pictures with the opposing team's mascot. For Trevor, we have some late night Waffle House meals coming our way. Trevor, you know you were not invited, and you could not honestly believe that you were. For everyone else, you have the unfortunate news of knowing that you are going to be seeing a lot more of me. Hope you are ready for it.

"I can do everything through him who gives me strength." – Philippians 4:13

"To me, there are three things we all should do every day. We should do this every day of our lives. Number one is laugh. You should laugh every day. Number two is think. You should spend some time in thought. Number three is, you should have your emotions moved to tears, could be happiness or joy. But think about it. If you laugh, you think, and you cry, that's a full day. That's a heck of a day. You do that seven days a week, you're going to have something special." – Jim Valvano on March 4, 1993

"**Don't give up, don't ever give up!"** – Jim Valvano on March 4, 1993

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CHAPTER ONE

INTRODUCTION TO THE STUDY

The world constantly changes, and what is recognized as the limits of technology and knowledge today is not guaranteed to be the limits in the near future. Zuga and Bjorquist (1989) wrote: "There will be newer and smarter machines tomorrow, making the knowledge acquired about today's model very perishable. By contrast, the learned ability to develop ideas and create solutions will always serve the learner" (p. 1). Changes in the types of work within the field of technical/engineering graphics education have led to changes in the curriculum. With constant change in the curriculum, efforts must be taken to ensure course content is updated with regards to technology (Whittington, Nankivell, Colwell, & Higley, 2006).

Overturn in the subject matter has created barriers for technical/engineering graphics educators, as instructors deal with learning emergent technology and must consider if fellow instructors have found new technologies relevant (Clark & Scales, 1999). This idea supported the search of better training methods and new research areas, such as distance education and professional development. Stevenson (2002) wrote "Although no one can predict the future, we have an obligation to identify evolving attitudes and practices and try our best to understand how they might affect the physical setting we use for learning" (p. 2).

This research focused on professional technical/engineering graphics educators, who were located in the United States. Collected were data, thoughts, and opinions in relation to emergent themes in graphics education. The study was based on two previous research studies conducted by Clark and Scales from North Carolina State University (NCSU). The initial study was conducted in 1998 and published in 1999, and the second study was conducted in 2004 (Clark & Scales, 2006a). The survey instrument from 2004 was modified for this study to include additional questions about distance education and professional development.

RESEARCH QUESTIONS

The primary research question was "What are the current trends and future issues for technical/engineering graphics education in post-secondary education?" Expansion of the primary question led to the study of secondary areas, such as the technological turnover within the profession, an increase in the influence of distance education and an emergent need of professional development. Questions to help expand upon the secondary areas were:

1. What role might distance education play in the future of technical/engineering graphics education?
2. The role of professional development must ensure that instructors obtain proper instruction related to changes in the field of technical/engineering graphics education?

PURPOSE OF THE STUDY

The purpose of this research was to identify possible new trends in the profession and to see how identified trends have changed since the last survey. Clark and Scales (2006b) stated that change will always be present and should be embraced "as we grow towards a greater and better future for the students we teach" (p. 7). Coyle, Jamieson and Oakes (2006) echoed the same sentiments in that more will be expected out of technical/engineering graphic students in the future and considered this embracement of change a grand challenge. Lohmann (2005) stated "The power of change, however, can be limited unless the subsequent opportunities and challenges are anticipated, embraced, and well managed" (p. 281).

Many industrial partners depend on university based engineering education to provide updated technical advancements to future employees. This process has been a delicate balance between industrial needs and academic ideals, as modern technologies became involved. Students will one day need to meet the expectations of future employers, so this situation has remained in a constant balance. This responsibility makes the successful retention of the balance critical (Cech, Boettcher, & Sherick, 2007).

Jischke (1994) wrote on the topic of concern and the difficulties one would face when change occurs in a large institution:

> Change and adaptation is absolutely essential. Change – especially in large institutions such as universities – usually occurs slowly. However, with the advent of modern transportation and communication technology, we all have seen the pace of change increase dramatically. It took 50 years for the full development of the land-grant concept. Higher education today does not have the luxury of 50 years to respond to societies changing needs. We must move more quickly. (p. 20)

Updated technology expedites the need for the next generation of courses to be developed as the current courses remain in place. This is why value came from research into current trends and issues in search of future topics that one day might impact the field of technical/engineering graphics education. Branoff, Harman and Wiebe (2002) found that over the last 10 years educators have dropped old standards, conventional practices, and instructional methods that did not remain applicable to new technologies and did not meet the needs of students and future employers. This is why a compiled knowledge base helps educators look to the future with a sense of preparation rather than a sense of despair. Branoff, Hartman and Wiebe (2003) warned that if technical/engineering graphics students were to be successful outside of the classroom, then future topics must be examined. According to Sadowski (2002), the leadership of the field is responsible for acting upon suggestions and must keep the field healthy.

Clark and Scales (1999) found that engineering graphics educators have changed what and how technology topics were taught. They also found that instructors wondered if the same course content was taught by other graphics professionals. Instructors also expressed that the act of overcoming challenges and dealing with new technology was part of the job and wondered if other instructors had a similar experience.

If uncertainty existed amongst instructors, then important questions needed to be asked during new course development, in hopes of creating the most up-to-date course(s) as possible. Some of the questions addressed in this study included: What role might distance education play in the future of technical/engineering graphics education? Will professional development soon be required to ensure instructors obtain training related to changes in the field of technical/engineering graphics education?

The five main categories researched in this study were: course offerings, student populations, professional development, technical/engineering graphics education, and future research plans (Clark & Scales, 2006a). Some categories looked at the present status of technical/engineering graphics education, to see what parts of the previous generation of topics were still taught and to what magnitude. Some survey questions offered graphic professionals the opportunity to look forward and make predictions of what is to come for the field.

JUSTIFICATION

Wicklein (1993) wrote: “The need to plan for the future is critical to the overall health of any organization” (p. 54). That statement is especially true in the field of technical/engineering graphics education which has challenging topic categorization. The increased pace of changes makes categorizing the field and its topics a challenging essential step in the development of meaningful understanding in relation to the long term needs of engineering education (Steering Committee of the National Engineering Education Research Colloquies [SCNEERC], 2006). The changes might be best associated with an era of computer models and databases that became the center of instruction (Barr, Krueger, & Aanstoos, 2002). Changes impact all instructors in the field by presenting topics that have not previously been covered in the curriculum. Barr (1999) wrote that the need for a national curriculum development project that identifies content and methodologies for 21st century technical/engineering design graphics education would emerge as the curriculum modernizes and pedagogical questions arise.

Within technical/engineering graphics education there is no consensus among instructors on how technological change impacts the field; however there is agreement that changes are inevitable and they will have a great impact. Here are three theories about the impact of changes. First, Minty (2003) wrote that as curriculum changes, the results will take us farther away from the roots of industrial arts which includes drafting. Second, Jenison (1997) wrote about the rapid development of computer graphics in the United States and how to improve engineering education through dramatic changes to the curricular and traditional pedagogical models. Lastly, Zuga (1989) warned that as a field of study evolves, the changes must be examined by instructors with respect to curriculum and instruction to determine if the emergent goals remained compatible and if implementation processes need to be developed.

Clark and Wiebe (2000) stated “Our responsibility as vocational, technical, and technology educators at the post-secondary level in graphic communications is to educate our students in the skills and knowledge needed for the 21st century” (p. 31). Clark (2008) wrote “As technology education moves into the twenty-first century, change needs to take place to keep our curricula relevant and up to date” (p. 22) and “technology education with computational science [i.e. modeling] meets and exceeds that mission and provides a technologically literate person who can function in the twenty-first century” (p. 22).

A result of this research was an expanded body of knowledge for technical/engineering graphics education that focused on current trends and emergent issues. Benson and Benson (1993) encouraged this type of study and wrote about current trends and the establishment of engineering profession standards to bring the curriculum up-to-date. Emergent issues need to be addressed because the system that prepares the next generation of instructors will play a significant role in both the choice of topics and how those topics will be implemented in the classroom (Warner and Morford, 2004).

CATEGORIES

The first category of the research covered course offerings and topics currently taught at intuitions. The expanded survey instrument included additional questions focused on distance education. O'Neill, Singh and O'Donoghue (2004) believed research should be done on distance education to "ensure the success of eLearning into the future, providing institutions with a much needed competitive edge" (p. 318). Clark and Scales (2006a) identified distance education and online instruction as the fastest growing future trend in the profession. Manning, Cohen and Demichiell (2003) wrote "[the] lack of distance education program today creates the impression the institution is not competitive" (p. 117). This instructional demand will require quality distance education based instruction to be created and presented to a diverse population.

The distance education section of the 2004 survey instrument was expanded to cover instructor preparation, perceptions, and institutional implementations. The change was driven by research that found students viewed the computer as a "natural medium" for the presentation of information in technical/engineering graphics. These findings meant that more students have become comfortable with courses in desktop publishing, website development and distance education (Wahby, 2002). While students have begun to embrace distance education the adaptation of distance education into the field of technical/engineering graphics education, has been slow (Jones, 2004), even after it was predicted that 50% of all education will take place online by 2015 (Draves & Coates, 2003). As a result of this dramatic shift towards distance education, the ability to teach and work online will be an essential skill in the 21st century. The need for instructors to stay current with students' needs exists, so that instructors can properly prepare students with the necessary skills for the modern workplace (Jones).

The second category researched was student populations, with special interest on gender, ethnicity, and the major of students who take technical/engineering graphics courses. This research could aid researchers who investigate if the population of gender minority and ethnic minority students had increased, decreased, or remained the same. Questions in this category remained unmodified from the 2004 survey instrument.

The third category looked at the instructors of technical/engineering graphics education. The questions delved into their employment statuses and pay scales. Pay scale has been linked with job satisfaction (Clark & Scales, 2002). The third category also had questions that covered major concerns, ideas on future trends, and professional activities related to the profession. This portion of the survey collected data on the forward thinking ideas of respondents in regards to where the profession may be headed. The collected data could help educators instruct engineering students on innovations as educators develop and inspire transformational change (SCNEERC, 2006). The third section was expanded from the 2004 survey instrument with additional questions focused on professional development. The new questions examined the level of involvement and the opinions of continued education from respondents.

The fourth category examined the major and minor offerings of institutions, along with information on the job fields in which recent graduates found work. Questions were also asked that covered the title of degree, annual number of departmental graduates, and if participants felt that a national honor organization should be established. This research could aid institutions as educators adapt curricula and advise students as course content changes. Fahmy (2004) stated "Students today not only need to learn how to do technology, they also need to learn how to live in today's world, which has become one that is buzzing with information and misinformation" (p.53). Questions from the fourth category remained unmodified from the 2004 survey instrument.

The final category focused on current research, grants, collaborations, and future research plans. These areas were important because Flowers (2001) identified continuing education as "the greatest job-related educational need" (p. 27). Continuing education could bring in employed educators as well as industrial workers that need to only take a few courses but not enough for a traditional degree. Questions from this category remained unmodified from the 2004 survey instrument.

METHODOLOGY

The survey instrument used was originally developed in 1998 by Clark and Scales and revised for the 2004 follow-up study (2006a). This survey instrument was selected because it was specifically designed to collect information on current trends within technical/engineering graphics and to also collect thoughts and ideas that concerned the future of the profession. The instrument was expanded to collect more information related to the topics of distance education and professional development. These areas had previously been identified as expanding areas that required additional research. The revised instrument was reviewed by technical/engineering graphics educators at NCSU and modified in accordance to the provided suggestions.

The two original studies contacted possible participants and collected survey results with hardcopy mailings. Email was not used in the 1998 study, and it was only used to send out a reminder in the 2004 study. For this study, email was the only means of contact between the researcher and the population. The survey instrument was delivered via an online survey hosting website (see Figure 1.01).

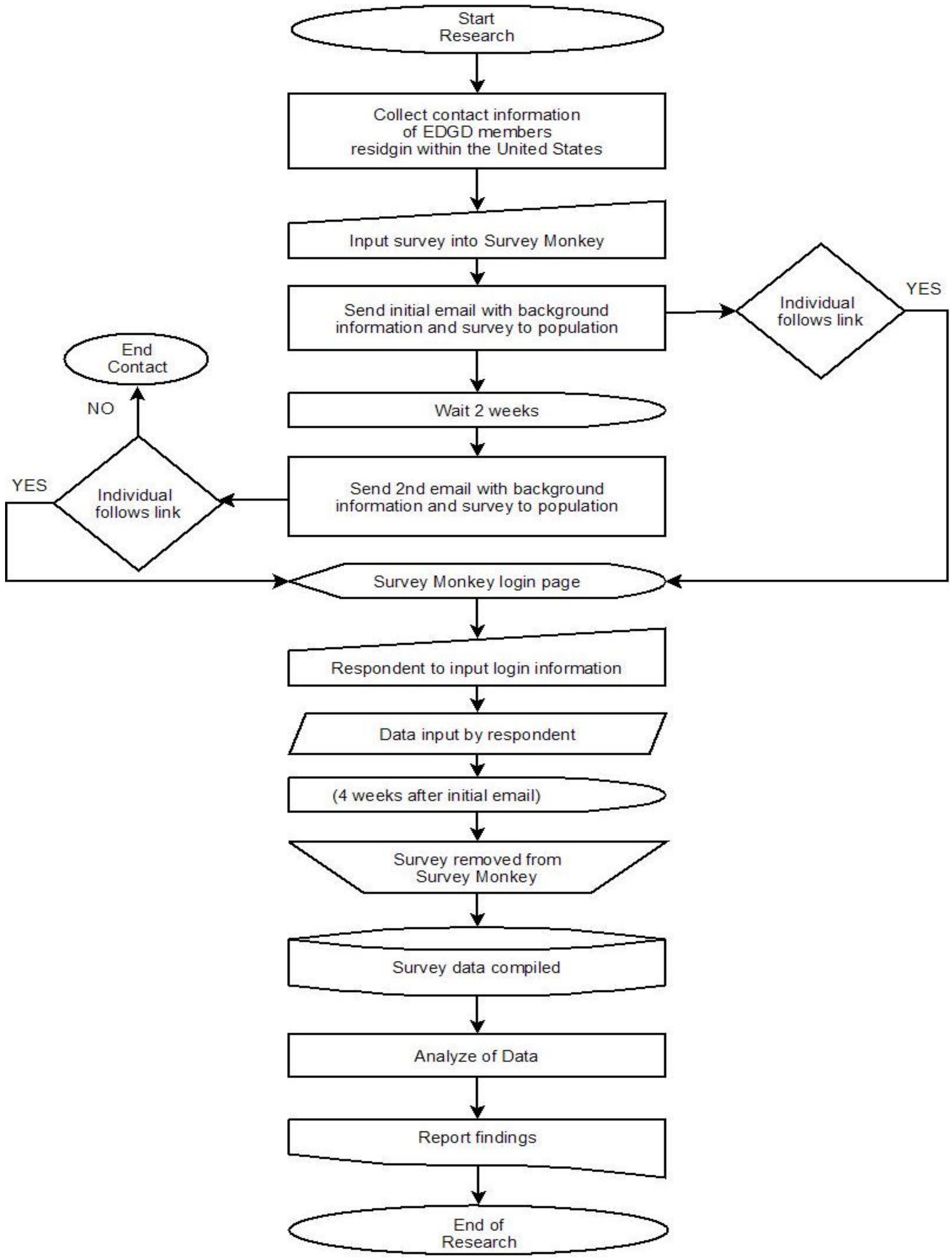

Figure 1.01 Methodology Flowchart

Contact was made with Engineering Design Graphics Division (EDGD) members listed in the 2007-2008 American Society for Engineering Educators (ASEE) Membership Directory via emails by the Chair of the executive committee for EDGD. ASEE was founded in 1893 and over the past 100 years has successfully adapted to societal changes (Harris & Meyer, 2007; Jischke, 1994). EDGD was founded in 1928 and is not only the oldest division of ASEE but also the only division specific to the field of technical/engineering graphics educators in the United States. The journal for EDGD, the Engineering Design Graphics Journal, began publication in 1936 (http://edgd.asee.org, 2008; Harris & Meyer).

A population of EDGD members, who currently had obtained at least a Bachelors degree and currently taught at least one course per year at the time of the survey, was chosen because the opinions of current instructors could influence changes to the field in order to retain those instructors. Positive changes could generate a more satisfying environment for new instructors in the future (Clark & Scales, 2002). A mass email that contained background information on the study was sent out on September 29, 2008 with a link to the online survey instrument as suggested by Downing and Clark (2007) (see Appendix A). Only instructors who currently taught technical/engineering graphics courses were asked to respond. Two weeks after the initial email was sent, a reminder email was sent to the same population. Four weeks after the reminder email, and six weeks after the initial email, a second reminder email was sent to the same population. Two weeks after the second reminder, a third and final reminder was sent. All four emails contained standardized information. The survey was presented to respondents once the emailed link to the website was followed.

In addition, the study and survey link were not advertised and the public was not made aware that the study was taking place, both of which helped maintain the security of the study. The link to the online survey was only provided to members of EDGD. This measure helped minimize the risk that undesirable individuals could have obtained the link. The link was randomly generated, unique to the study, and it contained a case specific 28-character string, which consisted of lower-case letters, upper-case letters, numbers, and underscores. This prevented the link from being easily identified. Also, the demographic information collected was used to ensure participants were qualified.

The survey was taken offline 24 hours after the final reminder email was sent and the responses were compiled though descriptive statistics and analysis. Once the information was organized, the results were compared to the two previous studies.

LIMITATIONS OF THE STUDY

1. The geographic boundary for this study was the United States of America.
2. Respondents were current members of Engineering Design Graphics Division (EDGD) of the American Society for Engineering Education (ASEE) and listed in the 2007 – 2008 membership directory.
3. Respondents supplied a valid email address to ASEE.
4. Respondents were currently employed as an instructor at a post-secondary institution.

5. Respondents were able to respond via the internet.
6. No login was required to ensure the anonymity of respondents. This meant the study could have been exposed to rogue responses through the malicious use of the survey link.
7. Respondents were able to understand English well enough to respond to open-ended questions.

ASSUMPTIONS OF THE STUDY

The following assumptions were used throughout this paper.

1. Respondents were active in the profession and were either interested in the study, or were willing to share opinions.
2. Respondents answered all questions honestly, as the respondents were under no pressure to complete the survey.
3. A knowledgeable group was the best population to consult when compiling predictions of the future.

DEFINITIONS

Distance Education - Planned learning that normally occurs in a different place from teaching and, as a result, requires special techniques of course design, special instructional techniques, and special methods of communication by electronic or other technology as well as a special organizational and administrative arrangements (Totten & Branoff, 2004).

Engineering Graphics - A system of projections and graphic symbols used to precisely convey information that otherwise would have to be represented as numbers or words (Wiebe & Clark, 1998).

Graphics Communications - Graphics produced not only as a means of communication to oneself in the course of working through design issues, but as a central medium of communication and negotiation with other members of the design team (Wiebe, Clark, Petlick, & Ferzli, 2004).

Technological Design - A distinctive process with a number of defining characteristics: it is purposeful; it is based on certain requirements; it is systematic, it is iterative; it is creative; and there are many possible solutions (Warner & Morford, 2004).

SUMMARY

This study was a replication of research done by Clark and Scales in 1998 and in 2004 that surveyed individuals teaching technical/engineering graphics that were members of the EDGD of ASEE. The five main categories studied were: course offerings, student populations, professional areas, technical/engineering graphics education, and future research plans. Additional questions, which focused on distance education and professional development, were added to the 2004 survey instrument. This research helped explore trends of technical/engineering graphics education in the form of updated course offerings, more diverse student populations, increased importance of professional development, a more unified field of technical/engineering graphics education, and future research development.

CHAPTER TWO

REVIEW OF LITERATURE

As the world changes, so do the challenges that the field of technical/engineering graphics must face. The field must adapt and change, if it is to remain relevant; therefore, it is appropriate to reflect on the new challenges and what challenges might lay ahead (Coyle et al., 2006). Changes in technology can redefine roles in society and the workplace, as specialty skills become required skills. Examples of new required skills of engineers in the field include typing and drafting, due to the recent widespread availability of personal computers (Castro-Cedeno, 2004).

Constant change in technology made research into emergent trends in education and the reading of speculative literature beneficial to the field. Though it is impossible for all aspects of emergent trends to be covered; a foundation of knowledge can be generated and an awareness of trends garnered. This awareness originated from survey research, such as the studies by Clark and Scales (1999; 2006a), or from articles about the changing role of engineers, such as the article from Castro-Cedeno (2004). The methods and categories compiled in this literature review were supported by a comprehensive combination of articles.

Barr and Juricic (1994) stated "Engineers have always needed a technique to create and communicate their design ideas" (p. 263). For the last 200 years, an era existed where engineering drawings were the primary reference through a production cycle. In that time technical/engineering graphics evolved from field based on orthographic projection theory and drafting standards that required T-squares and triangles, to a field where Computer Aided Design (CAD) systems dominated. Modern design methodology is presently based upon numerical methods that utilize computers to create, record, and analyze designs.

Multimedia is a tool that has aided the instruction of graphics students in the 21st century as most graphics students that have tested prove to be visual learners. Multimedia is not only useful for visual learners, but it can also be valuable to students of all disciplines and all types of learners. This versatility and the effectiveness of multimedia within instructional design enabled students to retain and transfer information more easily (Wittenborn, 2004). Multimedia is just one area of the graphics field that has expanded recently. As the field of technical/engineering graphics grew, it became difficult to control the content and also ensure that quality was maintained (Clark & Scales, 2006b).

COURSE OFFERINGS

General

Schools must equip students with a good foundation of skills to provide students the best opportunity to achieve personal career goals and succeed in life. Employers progressively have demanded higher skill levels from new workers in already highly technical jobs. As employer demands increase, the educational system must develop courses that cover the higher level skills required (Terry, 2006). The technical/engineering graphics education community has expressed concern over the retention of some traditional topics through publications and presentations (Branoff, 2004). Retention of some traditional topics might actually have held the education field back as the industry changed, and many university programs have been slow to update curricula. This puts instructors at a critical juncture in regards to curriculum development as areas and topics develop around instructors (Branoff et al., 2003). Traditional topics have varied application to future topics, and it is time to decide which topics are still relevant enough to remain part of the curriculum.

One such traditional topic is basic drawing competency and it empowers students to generate, interpret, and implement drafting and designing techniques. The need for traditional skills still exists and new competencies and principles must be integrated into the curriculum (Clark, Wiebe, & Shown, 1996). Cajas (2000) outlined the continuous struggle in the statement "the problem of technology literacy is not as much about what people are doing today, as it is about what kind of technological knowledge and skills students should have and will need in the future" (p. 62). This responsibility falls to the technical/engineering graphics field as practitioners help to increase the technological literacy of people in our society (Newberry, 2007).

The survey instrument addresses a number of categories that will be discussed in the following parts of this chapter:

CAD/CAM

Dr. Patrick J. Hanratty developed PRONTO in 1957 as the first commercially available CAM software. Ivan Sutherland developed Sketchpad in 1963 as the first CAD program, and Pro/E version 15 was the first parametric CAD/CAM program, when it was released in 1995 (Harris & Meyer, 2007). Software programs have developed from basic drafting packages into sophisticated design tools capable of parametric and dynamic feature-based solid geometric modeling (Ault, 1999).

Originally, software programs were merely regarded as a means of automation for the drawing of lines and were considered a tool for designers to replace hand drafting. With the inclusion of more advanced tools, such as conceptualization and analysis tools, modeling software was embraced by engineers. New abilities have allowed software to be used throughout the design process. Software can now handle early concept generation through final analysis and the detail design phase. Similar software is currently used in areas of manufacturing, assembly, and maintenance (Castro-Cedeno, 2004).

The expanded capabilities of software has revolutionized the way CAD systems facilitated data exchange and the time required to get a product to market. As capabilities advanced, students received more training, and students developed an understanding of the CAD systems, the role that CAD systems held in a products' lifecycle diminished (Kelley & Miller, 2003). The CAD systems remain important for the creation of documentation drawings but are not the preferred method of sketching initial concepts (Branoff et al., 2002; Barr et al., 2002; Harris & Meyer, 2007). This holdback means that CAD software will remain only a tool in the process no matter how sophisticated CAD software becomes. This reasoning fuels debate in regards to the importance of sketching and its inclusion in the curriculum. Freehand sketching has been removed from some technical/engineering graphics programs, but remains an extremely useful and necessary skill (Newcomer, McKell, & Raudenbaugh, 2001; Harris & Meyer; Miller, 1999).

Manual instruments

One major problem when curricula covers rapidly changing technology is the need for faculty to spend time on lower level information and concepts. Lower skills need to be covered in order for more advanced topics to be built upon them. It is the responsibility of the faculty to include new technological changes in curricula along with traditional topics (Whittington et al., 2006).

Technical/engineering graphics education underwent a drastic change from 2D hand drawings to digital 3D models and animation courses. This change revolutionized how mechanical design was done and created the need for research to be conducted in this area (Whittington et al., 2006). Changes occur and, university, students still need hands-on experience with traditional tools that the students will encounter in a professional environment (Clark et al., 1996). However, emergent topics need to be analyzed to ensure the usability of traditional skills and instruments.

Devens (2000) emphasized exercises that helped students understand how to use the instrument, but the overall purpose of the exercises was to illustrate the drawbacks of traditional instruments, as compared to more advanced systems in regards to instrument accuracy. Projects of this type help ensure that students can properly use instruments. However, students do not have to rely upon the instruments and students should understand the greater benefit of the more advanced tools. The challenge instructors' face in regards to determining appropriate projects becomes more complicated with the increased amount of technological content that has to be taught to students as classroom time remains the same (Devens).

3D Modeling

3D modeling began in the mid-1960's when 2D simple algorithms first began to display patterns, be formed from lines, and appear in 3D. Uni-Solid, which was released in the 1980's, evolved from these solid modeling systems (Harris & Meyer, 2007). Since that time, the acceptance of three-dimensional modeling, especially constraint-based modeling, has impacted the format of engineering graphics. Orthographic projection, auxiliary views, and sectional drawings have remained in many programs, but the topics taught for each has shifted away from independent topics, to topics taught within the context of 3D database centered engineering design process. Constraint-based solid modeling has impacted: the topics of instruction, the type of activities used, and how activities were evaluated (Branoff, 2004). This curricula update has benefited employers because future employees have already been exposed to a successful engineering design environment. Future employees also have gained experience in automated processes, model construction, the resolution of geometry issues, and the generation of solutions that were not immediately evident (Branoff et al., 2003).

The development of engineering abilities in students can be hindered by instructors who do not use up-to-date graphical techniques, such as 3D modeling, to solve problems. A student can develop graphical thinking skills through engineering problems, which advance the conceptual understanding of problems and enable students to rely less on the memorization of formulas. Students are also provided an opportunity to be technologically up-to-date through the use of modern software in engineering problems, and students could provide future employers with technological insight into the skills needed to remain competitive.

Graphical analysis benefits students through the development of a strong link between visual learning and logical learning. This correlation enables students to create a deeper understanding of engineering fundamentals (Malmgren, 2006). The digital design approach does not need physically models be produced in order for the properties and behaviors of the models to be tested. This concept is known as Finite Element Analysis (FEA) and remains a powerful tool for analysis and design (Barr et al. 2002). Because physical models need not be produced, the method is quite valuable to students as more complex assemblies and systems are created. FEA allows tolerances and desired functionality to be tested before the part or assembly is ever manufactured. FEA not only insures the production of a more tested product, but the overall time of the manufacturing cycle is reduced (Barr et al.; Branoff et al., 2003).

Ethics

The correlation between technology and ethics becomes increasingly more complex with the advancement of technology. Ethical issues impact peoples' lives with more importance than ever before, and the need for the better understanding of ethical issues has emerged (Tougaw & McCuddy, 2007). As the evolution of technology leads to more efficient businesses and educational system, it is important that students become increasingly aware of ethical situations, and that students consider the proper course of action when confronted with ethical situations.

Marshall and Marshall (2007) stated that engineers should develop critical thinking skills in relation to moral issues and professional engineering practices by adopting a personal code of ethics. They also believed that students should be exposed to possible problems, to enhance their personal awareness and develop morally sound responses to unexpected ethical situations.

Three principle areas of ethical issues that must be dealt with address: what is best for the greatest number of people, what follows the highest sense of principle, and what would an individual want others to do to himself or herself (Marshall & Marshall, 2007). Students can prepare for ethical issues in the professional environment by developing the ability to: comprehend and exemplify what it means to be an ethical worker, realize the implications of social and ethical relationships that are garnered in a work environment, and react to ethical situations, and remain responsible enough to maintain a professional manner (Newcomer et al., 2001).

Tougaw & McCuddy (2007) believe that ethical issues can be used to teach emergent technologies to students and need to be taught in such a manner that the example ethical situations relate to the life experiences of each student. This can be achieved if instruction is based off shared experiences, such as the development from a child into adulthood. Initial discussions could be followed by discussions centered on ethical situations, where societies have developed and overcome similar challenges. Whenever possible, examples should center on contemporary issues, team experiences, real life situations, and public speaking (Lo, Lohani, & Mullin, 2006).

Emergent technology holds possible situations that may solve all types of problems, and it is the responsibility of everyone to deal with the technologies in an ethical manner. Engineers are particularly challenged by their extensive training requirement and their responsibility to help society understand technical issues. Engineers are also accountable for: knowledge development, skills and attitudes, and leadership in regards to informed decisions on emergent technologies (Tougaw & McCuddy, 2007).

Marshall and Marshall (2007) proposed a three component approach to help instructors make ethics decisions on their own that concern emerging technologies. The first component required that a moral person be properly trained, the second component concerned the influence the profession imposed upon an individual, and the final component concerned the creation of a professional society to govern ethical conduct. The three previously mentioned components could help guide professionals as the field develops and new areas emerge where ethical issues have not previously been defined.

Desktop publishing

The emergence of affordable desktop computers in the mid-1990s and an increased demand for them has since aided the universal acceptance of desktop publishing and meant that computer graphics tools were available to and demanded by the general public (Clark & Wiebe, 2000). This updated the technology within the field from traditional manual instruments to computers that could run page-layout programs, connect to laser printers, and take advantage of image scanners (Marsden, 1994).

The importance of desktop publishing has diminished over the last five years, but desktop publishing has remained part of the field. Desktop publishing in the graphics curriculum has mainly focused on training students on desktop publishing software, as students prepare to produce future business publications (Zirkle, Norris, Winegardner, & Frustaci, 2006). Cookman (1998) warned against too much emphasis on software but stressed the initial teaching of software to avoid student frustration and failure. Software package have incorporated craft knowledge into the packages (Lewis, 1997; Marsden, 1994) and there is now more need than ever to make sure students are well grounded in design principles (Marsden).

Website Development

The increased use of website development has expanded web-based materials that are placed, accessed, and designed, as paper-based instruction disappears from the classroom and more information and publications become available in electronic form (Stevenson, 2007). Zhao (2002) researched Fortune 500 IT professionals who use the Internet/Web, intranet, and wireless/mobile Web applications and asked the respondents to rate the primary telecommunication skills business professionals needed then and towards the future. This research was important to the educational community because demand for these skills emerged from the industrial sector (Taylor, England, & Gresty, 2001). Surveyed IT practitioners stated that hands-on exercises not gained from educational institutions were the main source of the practitioners' experience. It was also found that the skills, tools, and knowledge used to construct a professional website differed from skills, tools, and knowledge used in other IT systems (Taylor et al.).

These findings by Zhao indicated that the technical/engineering graphics community needed to become a reliable source of instruction of the skills necessary to succeed in the field. The skills that needed to be covered were: knowledge of the communication process; an understanding of graphics, animation, video, and sound; understanding of hardware, software, and web standards; emergent issues and capabilities of the web; and the phases and development of system life cycles (Kovacs & Rowell, 2001). New skills need to be introduced and embraced regardless of shorter development times and product life cycles (Taylor et al., 2001).

Animation

The population at large has mainly seen animation used for entertainment though movies and cartoons in the past. But individuals in the field of technical/engineering graphics have viewed animation as a means to improve communication, increase visual capabilities, and demonstrate processes (Lieu, 2004; Clark, 2005). Animation has evolved into a highly desirable presentation method as it provides a means by which objects, places, and events that do not exist in reality to be presented. Animation uses sequential presentation of individual graphic images at sufficient rates to convey the impression that objects have real motion. This technique offers the opportunity for clarity in explanation, presenting technical information to non-technical audiences, and engineers to properly depict parts, processes, and operations (Lieu).

Attributes of animation afford the need to teach students good technical presentation skills. Presentation skills benefit students as the fields grows and students are required to demonstrate good visual skills and apply them in everyday situations. As society and institutions become more dependent on visual information as a means of communication, technical/engineering graphics should strive to prepare students for the “visual age” (Clark, 2005).

The information age is here for good and that is evident in the speed with which new technologies are developed. The hastened pace of new technology creates the need for people to effectively communicate difficult concepts in a way that is clear and lacks confusion (Clark, 2005). Effective communication is especially challenging in technical/engineering graphics education because many of the topics deal with 3D objects or concepts, which can be difficult to visualize. 3D representations and animations may be beneficial to students who learn about concepts, objects, structures, mechanisms and operations in technical/engineering education (Lieu, 1999; 2004).

It is important for students to possess good presentation skills and understand the topics and concepts as they will be the ones who create future animations. Animation skills require practice because the creation of 3D animations, unlike traditional CAD, requires the work to be conducted simultaneously in three coordinate systems (Clark, 2005). This increased difficulty in the design process is critical when engineering, science, and technology disciples are simultaneously dealt with because the topic areas are not always common knowledge.

Animation has advantages that provide clarity in areas of confusion, through use of transparency, slow motion, and the illustration of invisible objects. Transparency allows solid parts to be made transparent, or partially transparent, which in turn allows difficult and intricate assemblies to be better illustrated. The use of slow motion allows rapid movements to be broken down, so the dynamic processes can be better communicated visually. Other complicated visualizations can be aided through animation, such as airflow, the movement of fluids within pipes, and thermal gradients. Airflow and fluid movement can be simulated with the addition of moving arrows, and thermal gradients can be illustrated with color distributions and color changes (Lieu, 2004).

Distance Education

Over the next decade, there will be more people who seek additional education and some schools are currently not prepared to accommodate the increase in enrollment, due to limitations of present infrastructure. Distance education may help alleviate some of the pressure created by an enlarged enrollment (Totten & Branoff, 2004). The expansion of distance education means that educational infrastructures are no longer limited by bricks and mortar. A greater emphasis on distance education must be initiated and supported by university programs though new opportunities centered on life-long learners (Goldin, 1999).

Manning et al. (2003) wrote “[the] lack of a distance education program today creates the impression the institution is not competitive” (p. 117). A significant motive for institutions to be more competitive lies in many students' opinion that the computer is a natural medium for an educator to use in technical/engineering graphics course presentations (Wahby, 2002). The new instructional demand provides the opportunity for the presentation of information to a more diverse population via distance education. O'Neill et al. (2004) believes the instructional demand will help ensure the future success of distance education and will provide institutions with a competitive edge. The greatest support for research in the area of distance education thus far was stated by Clark and Scales (2006a). They stated: "The largest growing future trend for the profession is in distance education and on-line instruction" (p. 30).

If properly implemented within distance education, multimedia can motivate students to learn more technical/engineering graphics topics without much difficulty. Pre-prepared multimedia demonstrations can free up instructors' time, and allow instructors to concentrate more on student interaction, which enables more effective instruction (Wahby, 2002). Lieu (1999) suggested that the most important benefit of multimedia happened when students interacted with visual information and were provided a positive encounter that allowed learning and the internalization of information.

STUDENT POPULATION

The study of student populations was important because current students will one day be the future educators in the field and, if some demographic areas were continuously overlooked, then negative results could be detrimental to the future success of the field. It has been known that, since the early 1990s, the engineering community had not made enough progress to bridge the gender gap. In fact, the number of female first-year engineering and female computer science students had dropped since the early 1990s (Coyle et al., 2006). The lasting difference in enrollment has fueled studies of gender differences in the field. It has not been just females who lost interest in engineering, but American youths' regard for technological innovations have also declined. This decline could be a signal that the United States is in danger of loosing prosperity and security, if action was not taken (SCNEERC, 2006).

From an alternate perspective, Strong and Smith (2002) outlined that gender bias might come from the difference in the inherent natural abilities between genders. The difference could indicate that an individual's gender overshadows the individual's age and experience when spatial abilities were examined (Strong & Smith). Cech et al. (2007) suggested the historic gender and ethics discrepancies may arise from different intrinsic altruistic motivations held by those groups. Ethnic minority students have had to be convinced that the field provided an opportunity to advance the living standards of minority groups. Gender minority students reported feeling more threatened by negative stereotypes and considered changing majors more often. Female role models and mentors could help eliminate gender diversity. What remains is evidence that suggests the innate spatial skills of women lag behind their male counterparts (Sorby, 2005).

The importance of gender diversification, within engineering graphics, is highlighted by findings that show prior experiences and attitudes of students do not have a significant correlation to scores on their spatial visualization tests. An individual's spatial skill is the most significant predictor of an individual's ability to learn CAD software and take advantage of a computer interface and database manipulations (Strong & Smith, 2002; Sorby, 2005).

PROFESSIONAL DEVELOPMENT AND CONCERNS

The quality and success of instruction originate from the productivity of instructors, as the instructors who teach technology-based courses act as a link between technological advancements and students (Clark & Scales, 2002). With the importance of instructors, it is essential for instructors to stay current with constant changes in curriculum and industrial practices. Exposure to the latest technologies is vital for students who are to become successful within the field because even the best traditional programs may not prepare students for all of the tools required in the workplace (Miller, 1999).

Faculty

A major aspect of research in the field of technical/engineering graphics education is to develop a better understanding of the students, faculty, and professionals in the field. The information necessary to accomplish the goal cannot simply be gathered though observation. Self-reporting instruments administered to instructors in the field assist in the collection of data to expand the knowledge base through honest responses and accurate reporting from participants (Olds, Moskal, & Miller, 2005). This collected data can aid leaders of the field to plan for changes to the curricula. When instructors respond to survey instruments with information on topics that require change, the field can update curricula to meet the needs of students and change, so more impact can originate from the collected data (Rutz, 2000).

Major Concerns

Faculty must continuously update courses, in order to maintain current hardware and keep pace with rapidly changing technology (Whittington et al., 2006). Support and resources must be provided to instructors who teach the updated courses, to ensure the success and continued implementation of changes. Also, recognition on some level must be given to instructors who take on the additional tasks and keep departments updated. Ndahi (1999) outlined this problem well and stated that some institutions required instructors to teach a distance education course but did not provide the necessary support, additional salary, or consideration during tenure discussion for the instruction of the distance education course.

Another problem of concern is tradition, which is likely the most common excuse for revisions not being made to the core curriculum of technical/engineering graphics. The core curriculum mainly focuses on engineering drawings which have not changed much over the last 50 years, but have come to be viewed as supplemental documentation in the design process. The influence of CAD has revolutionized the design and manufacturing process (Branoff et al., 2002). The disconnect between the topics that are taught in classrooms and the processes that are found in industry reveal that tradition may be the factor to overcome when faculty is rallied in support of changes.

An instructor's concern, regarding how a course should be taught, may change along with technology. The instructor-student relationship can be altered dramatically, from a situation where an instructor sees the same students every class period, to a situation where an instructor never meets the students in person, as is the case in distance education. The resulting lack of interaction, driven by technological developments, breaks down the qualities, dynamics, and instructor familiarity, that physical face-to-face learning fosters (O'Neill et al., 2004). As technology is updated and curriculum changes in reaction to those changes, the need for a theoretical educational framework increases (O'Neill et al.; Manning et al., 2003). This means the use of technology can, not only replace part of the learning process, but enhance and extend the learning capabilities of learners.

Future Trends

Because technology stimulates human productivity and knowledge acquisition, it should play a major role in the decision making process of educational enhancements (Buzzetto-More & Alade, 2006). Technological implications and topics that rapidly change is probably illustrated by the fact that engineering design was not a part of the field until a generation ago, and now it is a primary focus for the Accreditation Board for Engineering and Technology (ABET) (Pannabecker, 2004). The ever-changing landscape of the field of technical/engineering graphics has created the need for an extensive review of how future generations of students should be instructed. Future graduates will need experience in the use of varied approaches because the global economy is fueled by innovations and the speed at which the innovations need to be accepted (SCNEERC, 2006).

The rate of advancements can hinder traditional universities, due to the fundamental change that is constantly required to stay up-to-date. As a growing number of institutions exist only in cyberspace, the learning experience of students has changed, due to the removal of the traditional classroom and the substitution of an online program. The affect of instructional change on both traditional universities and modern students must be accounted for, as their relationship is complicated and dynamic (O'Neill et al., 2004).

Complications associated with advancements can not be completely identified through research, but Fromm (2003) suggests research be divided into two areas when making predictions about the future of instructional settings. The first area is the education of engineering students, and the second area is the broader role of instructors. The two areas are linked, in that an expanded curriculum can lead to an expanded role for instructors. Fromm believes the engineering program will likely become more global, as cross-institutional cooperation increases. The globalization of the program will, in turn, lead to the further integration of topics that complete the holistic educational experience for students.

Sadowski (2002) suggests that the field should expand its vision of who is included in the field and what topic areas are covered in the curricula, since it is impossible to know which direction the field will head in the future. Sadowski encourages a view of the field that encompasses more graphics, as the job description of engineering and the description of engineering graphics has changed over the last 50 years. Although change will be difficult in the future for some, it will be beneficial for students and instructors.

It is possible that academic programs will, not only become more focused and technically intensive, but also more intellectually varied. The advancement in programs can be accomplished through the development of new tools that enrich the human existence. Understanding how to better function in our world comes from access to and proper integration of emergent topics, and it is equally important that students mature intellectually and culturally (Fromm, 2003).

The idea of technology as a major part of change in the field was highlighted in a research study by Clark and Scales (2006a). Clark and Scales asked graphic professionals to provide ideas about future trends in the field. Although, no definitive trends were identified, the top three topics of response in the field were: online and distance education instruction, an increased emphasis in 3D CAD, and an increased use of 3D prototyping. All three areas were directly linked with technology, either in regards to the instruction of information or the implementation of course information. Other suggestions of future trends included: the integration of the designer and programmer roles as curriculum and online technology advance (Branoff et al., 2003), diversification within the field to include community colleges, and finally the expansion of the recognized content of the curriculum (Sadowski, 2002).

Professional Development

Instructors in the field of computer graphics are presented with the challenge of continually updating their skills and the skill taught to students (Whittington et al., 2006). Branoff (2004) wrote that the two biggest challenges for instructors were faculty training and the development of instructional materials. The frequency of software releases remain a concern for instructors who must find a way to understand the new capabilities of the tools before connections can be made between engineering graphics topics and course material. For course material to remain useful, it must be kept current with changes and be applicable for all instructors across the field. For those two criteria to be met, a time consuming effort must occur (Branoff). If instructors' concerns are not addressed by the leadership of the field, then it becomes the responsibility of instructors to make sure the material is properly taught.

One of the ways individuals can keep current with the field is through professional organizations. Instructors have the opportunity to meet like-minded people and cooperate cross-institutionally (Whittington et al., 2006). Expansion of knowledge in the field has created a need for faculty to broaden personal educational competency, before heading into the changing classroom environment. Therefore, better resources are needed, along with an increased understanding of how students learn, for instructors to adequately prepare for the differing abilities of students to apply new information, tools, and skills (Fromm, 2003). An instructor can overcome aspects of challenges by joining professional organizations to stay current with the literature that other instructors produce. As change builds upon change, meetings and conferences allow the member to stay up-to-date with current events and trends (Clark & Scales, 2006a).

The rapid growth of distance education has helped to break down barriers in higher education and has also helped traditional universities meet the worldwide demand for education (O'Neill et al., 2004). Instructors remain the common thread throughout the distance education process, and they must be able to instruct a distance education course effectively. Instructors must also be knowledgeable of the subject matter and familiar with proper teaching methods (Totten & Branoff, 2004).

One commonly overlooked benefit of professional development is that instructors are able to keep current with emergent technologies. The use of the new technologies in education can improve learning and make the learning experience more enjoyable for students. Students reported feeling more engaged in classroom activities through the use of technologies that were not previously available in the classroom. This study by Smith, Taylor, Green, Peterson, Garetty, Kemis, and Thompson (2005) afforded instructors the opportunity to understand the demands of emergent topics and determine possible roles for emergent topics in the ever-changing educational curriculum.

TECHNICAL/ENGINERING GRAPHICS EDUCATION

For nearly a century, the field of technical/engineering graphics education has been a cornerstone for engineering education. For the most part, the field has centered on teaching graphical techniques that vary from spatial problems to 3D solid modeling. The field is on the cusp of a digital paradigm, which is likely to include simulation, rapid prototyping, and low-cost analysis due to the decreased cost and increased viability (Barr et al., 2002; Krueger & Barr, 2007).

Wiebe (2001) saw a shift in laboratory environments from manual instruments to computer based CAD software as well as a shift in the quality of instruction as the faculty/student relationship remained. The shift could combine the job roles of engineers and drafters into one, with the field of technical/engineering graphics education poised to bridge the gap between engineers and drafters. This opportunity is a good example of why the field needs to keep up-to-date with industrial needs. Terry (2006) suggested that the leaders of the field meet regularly with industrial leaders to have discussions about curriculum improvement. The meetings could address the opinion of some critics that engineering curriculum centers on the theory-based courses and lacks problem-solving challenges. Real world changes in the industry would benefit the field and help produce future employees with applicable skills (Aschenbrand, 2008).

Increased course complexity, based on emergent concepts, should help students acquire a better understanding of graphics, science, and technology (Gradinscak, 2001). This advancement would gain more respect for technical/engineering graphics education and, therefore, the field of engineering could become more reliant upon technology. Rose (2006) wrote “The engineering community also values technological literacy, especially as it relates to the knowledge and abilities which enable them to engage in their fundamental professional act of engineering design” (p. 14). Increased industrial acceptance could push the field towards mainstream acceptance, while computers become more powerful, solve problems that were previously handled by human intuition, and enable users to build more complex networks of knowledge (Schmid-Kirsch, 1997). Cech et al. (2007) warned the profession against over-specialization, in an effort to prevent industry from viewing engineers’ opinions as too narrow and technical.

The expansion of the field into both secondary and post-secondary education could increase the depth of student training (Clark and Scales, 2006b). The sooner students become exposed to the field; the more likely students will understand the field. To aid younger students, the skills taught in secondary courses would be limited mostly to fundamentals. Fundamental skills would, not only benefit the younger students, but also the field, especially if the duties of drafters become expected of engineers (Castro-Cedeno, 2004). The extended exposure to the field could also help students acquire new skills in the industrial setting because students would have already experienced first-hand change in their coursework.

RESEARCH

Technical/engineering graphics topics are updated frequently, and this creates a substantial challenge for instructors as they attempt to keep up with the most current information. As the critical skills areas of the field become impacted by changes, the complexity of the field increases (Strong & Smith, 2002). Future innovations and changes could require the field to develop, or adapt, methodologies and instruments specific to the fields' knowledge base (SCNEERC, 2006).

One example of the fields' adoption of change was when post-secondary instructors' interconnected with members of industry through the use of liaisons in the mid-1980s. This connection meant the traditional role of instructors, who had to search for funding, shifted from academic funding to external funding. For the past 20 years, this practice has continued as business partnerships have become common place. Business partnerships are important, as higher education has taken on aspects of the global economy, and the United States competes on a more global market (Harris & Sadowski, 2005). This globalization means that the research topics and funding sources of studies remain important.

Current trends and issues researched in the past

Research into current trends and issues is a well documented practice of researchers. The methods of gathering information and the topics of research vary from study to study, but the purpose of the research is to gather information from participants in regards to the fields' status and direction in the future. Studies of current trends have been replicated often and provide a unique opportunity for researchers to compare findings from studies that used the same population, similar survey instruments, and similar circumstances. Observations can then be made on new trends and longevity patterns, based on replicated studies (Newberry, 2001).

The areas currently under investigation and areas of future interest

As many tenure-track instructors have shifted from a strictly instructor role to an instructor-scholar role, the reasons behind their research has come into question. Questions emerged such as:

1. Were instructors examining traditional topics?
2. Were instructors conducting applied research?
3. Was the research connected to coursework?

All questions were possible, due to the variety of skills offered in the technical/engineering graphics field (Harris & Sadowski, 2005).

Areas of future research remain important to the profession of technical/engineering graphics because industry skills and occupational skills may become obsolete. Skills over time become outdated, so students must be trained with skills that are currently needed in the workplace, and they must be capable of attaining easily-transferable skills (Terry, 2006). One of the major purposes of engineering education is to prepare students to impact the world of tomorrow. Researchers must, therefore, look forward and explore topics and skills that tomorrow's engineers might need to master (SCNEERC, 2006).

The major sources of funding for research in program/department areas

Since the 1980's, sources of funding have shifted from state allocations to the private sector. The academic world has been forced to look for external funding, which meant the sources have become more diverse. The variation has forced instructors and public university programs to adopt an entrepreneurial attitude to survive financially. Private sector funding has allowed instructors to sustain, and possibly advance, personal positions at universities. It has also provided instructors the freedom to essentially engage in academic capitalism. This is important because the possibility exists that an over-reliance on external funding could push the academic arena away from a liberal arts foundation and towards a business mindset (Harris & Sadowski, 2005). This reasoning is why knowledge on the field's funding sources has become important.

Collaborations outside of programs

Building a workforce that is able to thrive in diverse situations is imperative to the future of engineering. For this to happen, the field must first value diversified perspectives, help create educational initiatives, and build programs that encourage diversity (SCNEERC, 2006). Denton (1998) wrote that interdisciplinary research directions aided engineering faculty and also made major contributions to the research strength and economic health of the United States. Interdisciplinary approaches could help the field succeeded in the coming decades as universities pioneer new research directions.

Professional collaborations have become more prevalent within the field as the internet, and its related technologies, have been embraced, and companies have devoted more resources towards the issue. Collaboration is something all instructors must consider in regards to projects, papers, programs, and even grants. Collaborations should occur within the professors' university, among professors within a field, and also with professionals who work in outside industries (Branoff et al., 2003; Sadowski, 2002; Harris & Meyer, 2007). Collaborations among professors can mimic those of industry by crossing time zones and international borders.

SUMMARY

This chapter discussed the literature regarding course offerings, student populations, professional development and concerns, technical/engineering graphics education, and research. The categories covered were well supported by literature from the field of technical/engineering graphics education and by related literature from outside the field. The topics researched ranged from, existing topics that have existed longer than EDGD, to common topics that have been taught in numerous courses, and emergent topics that have yet to find their niche. All of the topics were a part of the field as it existed at the time of the research and helped describe the field to outside observers. The structure of the field is what will drive it, as it adapts to changes in the near future.

CHAPTER THREE

SURVEY

Surveys collect data that can not be acquired through observation. The use of survey research is a well-established practice in engineering education (Olds et al., 2005). Its history dates back over 100 years, with modern survey methods having been established in the 1930s (Lyberg, Biemer, Collins, DeLeeuw, Dippo, & Schwarz, 1997). Along with an established history, survey research also has a list of other advantages. Some of the advantages were: the low cost of survey instrument distribution, the ability to obtain shorter responses to open-ended question than interviews; non-response results typically remain limited to questions or sections, rather than entire studies; low response rates could be reduced by incentives and follow-ups; consistent questions could be provided to all respondents; anonymity; information could be gathered on sensitive questions; and respondents could complete the survey instrument at a time convenient to them.

Web-based surveys have increased in popularity over the last decade, as technological innovations have changed online surveys from text-based instruments to powerful feature-rich surveying tools. The advancement has made online surveys easier to use and less expensive than physical printed surveys. Researchers found that internet application to online surveys had several benefits which included: ease of data entry and analysis, low administration costs, ease of attaining large samples, and timeliness of responses. The ease of data entry and analysis was apparent, as the online survey host collected data as completed instrument were submitted and analyses was completed before the data was downloaded.

Low administration costs of online surveys fell into two categories: preparation and administration. Lower preparation costs increased the availability of advanced survey software, and administration costs were lowered by the elimination of postage and interviewers as well as integrated tabulation and analysis of data. Large samples became easily attainable due to email database availability and nonrestrictive costs required to contact samples.

One negative aspect of online survey advancement has been an abundance of requests for faculty participation in studies, where the survey instrument has not been properly prepared or tested. Also, the increased frequency of surveys has hindered response rates and led to faculty member fatigue (Umbach, 2005). To combat the degradation of survey respectability, increased scrutiny has been placed upon researchers by Institutional Review Boards (IRB). IRB approval has ensured, and continues to ensure, that potential respondents would not be harmed, coerced, or exposed to objectionable material due to participation in survey research (Porter, 2005).

All surveys rely on some level of self-reported data, and some researchers do not regard data complied in this fashion with the same respect as objective measures. There is still value in the data, even though complete agreement does not exist among researchers on its quality. Self-reported surveys have the most accuracy when they contain clearly worded questions that collect background data inherently known by the respondent. Data gathered from surveys that use self-reported methods have less accuracy but allow researchers to study a wider range of topics simultaneously. This advantage means that surveys and self-reported data may be the only practical means of collecting data on some topics.

Concerned over the use of self-reported data is needed because survey research lacks control over the formulation of responses and because the questions remain less order dependent (Krathwohl, 1997). Despite these hindrances, self-reported data can generally be trusted as long as the survey instrument and administrative processes were developed to ensure quality within the instrument and institutional framework (Gonyea, 2005).

Web surveys place another restriction on respondents, in that respondents must have access to the internet. Web surveys have increasingly been used to measure the effectiveness of various programs, but potential respondents have been found to resist responding to web surveys for numerous reasons. These reasons include but are not limited to: the difficulty of the survey, difficulty interpreting survey questions, and concerns about confidentiality (Huang, 2006). The main issues concerning web surveys were confidentiality and proving to the respondents that the survey is secure, professional, and that personal information is to be kept confidential and anonymous.

Error in survey research refers to the difference between the truth and what was measured. No survey is error free, so the researcher must be aware of imperfection but also try to reduce errors at each development and implantation stage. As surveys become easier to develop and implement, the importance of taking the time to reduce errors has become more critical (Umbach, 2005). There are two categories of errors and two issues that impact surveys. The two categories are observational and nonobservational errors. Observational errors occur when responses deviate from the true values of a measure. Nonobservational errors occur when surveys do not research part of a population (Umbach). In addition, the two issues are Social Desirability Bias (SDB) and Halo Error. SDB occurs when a respondent purposefully responds inaccurately to a question in an attempt to favorably present their position or preserve their self-esteem. Halo Error occurs when respondents provide consistent evaluations for several individual questions because they ignore provided criteria and base answers on internal perceptions of the subject matter, rather than base answers on proper evaluation of the questions (Gonyea, 2005).

This type of error is known as measurement errors, and guarding against it is essential for any researcher who desires to collect accurate data (Umbach, 2005). Lyberg et al. (1997) suggested some helpful questions a researcher should contemplate during the design phase of a study which include:

1. What do I want from this survey?
2. What makes these questions special?
3. Why am I studying this population?

Answers to these questions can help focus a study, identify background areas to review, and help format questions. The key stages of the design process of the study, as stated by Lyberg et al., include: the establishment of familiarity with the population, the implementation of guidelines to ensure that quality research is conducted, listing out the survey phases, proper analysis of each phase, adaptation of each phase for the population, and discussion of all possible aspects of the survey with informed colleagues and experts in the field of research.

Olds et al. (2005) suggested the use of both open-ended and selected response questions to help maximize information acquired from a survey.

Survey measurement has advanced with technology, and for the past decade the data collected has primarily been tabulated, compiled, and analyzed with computer-based statistical software. Software makes statistical measurements that were once impractical accessible to researchers (Krathwohl, 1997). Even though the number of statistical methods available to researchers has grown, the time needed to prepare a targeted survey remains about the same. The quality requirements that must be built into a survey instrument is due to the number of statistical methods available and the need for quality assurance (Krathwohl).

The use of a computer in the data collection process allowed the software to check answers for validity, check data ranges, and check for response consistency immediately upon survey completion. Computers can display warnings to respondents, allow for corrections to take place after the completion of the survey, and stop the progression of the survey until any errors are corrected (Lyberg et al., 1997). These precautions helped eliminate processing errors, which occur after data has been collected but before analysis. The three most common sources of processing errors are coding, entry, and outliers. No technology can completely prevent errors but web surveys make entry errors less problematic (Umbach, 2005). The amounts of time required to process and publish information decreased with more accurate data collection measures. Increased accuracy enables fellow researchers to make more timely decisions. Simply put, the longer it takes for results to be published, the less useful the results become to fellow researchers (Lyberg et al.).

Nonobservational error, as opposed to observational error, is divided into four types: coverage, sampling, non-response, and adjustment (Umbach, 2005). If respondents were representative of the population, and non-respondents were to answer like respondents, then a low response rate is acceptable (Krathwohl, 2004). Still, non-responses must be limited, and the best motivation for possible respondents to complete a survey is internal motivation. Self-motivation implies there is only so much that a researcher can do to lower the rate of non-response. So the best way to maximize survey completion is to motivate respondents some way. An initial follow-up has been found to increase the rate of response, but each consecutive follow-up after that has less impact. Also, indicating an appropriate allocation of time for responses to be turned in is helpful, as the bulk of survey instruments commonly get returned about two weeks after receipt (Umbach; Krathwohl; Olds et al., 2005).

The means of data collection and the specialization of the research studies have changed over time, but the steps required to design and implement a successful study have essentially remained the same (Lyberg et al., 1997). The benefits of new technology become apparent when the reduced timeframes and reduced operational costs of conducting an online survey are compared with traditional timeframes and costs of conventional printed surveys (Umbach, 2005).

SURVEY RESEARCH

Survey research was a common practice and was well documented in the areas of how it should be conducted and the benefits it provides. Survey research had the ability to get past screeners and could provide confidentially to the respondents who anonymously returned the survey instrument. Anonymity assurance enabled respondents to express privately held opinions without fear of criticism (Krathwohl, 2004). Surveys provide the population with the same questions in the same format and the same order, but remain limited in regards to the honesty and accuracy of responses (Olds et al., 2005).

Some important considerations for surveys include: what to ask, how to ask it, how to order the questions, how to format the survey, and how to improve it (Krathwohl, 2004). The initial task of all researchers is to define the target population (Umbach, 2005). After this step, the research instrument must be generated, selected, or selected and modified. The development of a new instrument requires time and effort to ensure quality (Gonyea, 2005). Developing the survey also includes preparation of descriptive instructions, determining the type of questions to be asked, and ordering the questions themselves. Two main types of questions can be used: multiple-choice and short answer questions. Multiple-choice questions allow the data to be turned into statistical percentages and short answer questions allow for free responses. The type of question is determined by the situation addressed in or the nature of the question as well as the type of information desired. Olds et al. (2005) suggested that researchers should design surveys to include both types of questions in order to optimize the data gathered. Similar studies support modifying an existing survey to collect the most complete and specific data set possible, especially when the researcher is faced with a limited amount of time for the study (Couper, Traugott, & Lamias, 2001; Dugger, 2007).

There are three main situations where a respondent may not answer honestly. The first situation exists when respondents felt the researcher would judge the respondent negatively or if respondent was embarrassed that his or her answers may vary from social norms. The second situation presented itself when respondent felt like the questions were too personal or invaded his or her privacy. The last situation was when a respondent feared his or her answers would be shared with outside individuals with his or her biographical information still attached (Huang, 2006). The format of data collected must also be considered as researchers aim to protect respondents from harmful situations. Researchers have access to numerous surveys options and must implement the proper options to obtain the best data set possible.

Some drawbacks of online surveys include lower response rates, different monitor screen displays, and the oversampling of a population. There is dispute among research on whether the response rate of online surveys is higher, the same (Evans & Mathur, 2005), or lower (Manfreda, Bosnjak, Berzelak, Haas, & Vehovar, 2008; Downing & Clark, 2007), compared to paper surveys. Because email requests for participation in online surveys often appear as spam, researchers must consequently battle the tendency of respondents to: instantaneously decide not to respond, have limited computer literacy, and use various screen display formats (Evans & Mathur). Oversampling of a population can also lower the response rate in online surveys (Manfreda et al.).

After a survey instrument is implemented there are two problems left for the researcher. The first problem is to determine if non-respondents possibly held different opinions than the respondents (Krathwohl, 2004). The second problem is to determine if the demographic data of respondents significantly differed from that of the population at-large in regards to race, gender, and education level (Umbach, 2005).

EXAMPLES OF OTHER SURVEY STUDIES

Since 2000, only a small number of published studies have used surveys within the field of technical/engineering graphics. Studies that surveyed only the EDGD population were limited to the two surveys discussed in the "Previous Studies" section, and another study by Clark and Scales in 2002. However, different parts of the research methods used in this study were utilized in other pieces of literature. Some studies researched future topics, but no study completely paralled the methods used in this study.

One of the studies that did use similar research methods was conducted by Dugger (2007) and the International Technology Education Association (ITEA) as a continuation of two original studies from 2000-01 and 2003-04. The research study examined the condition of the study of technology in all 50 states (Dugger).

The online survey was conducted by Dugger and the ITEA allowed respondents to complete and return questionnaires electronically. The questionnaire consisted of 10 questions and modeled the instruments used in the previous two studies aforementioned. A total of 3 questions were used from the original instrument and 2 others were added to the original instrument used in 2003-04. The questions inquired upon whether or not technology education was required in the state curricula, the number of technology teachers employed in the state, and whether or not the Standards for Technological Literacy (STL) were used in the state curricula (Dugger, 2007).

In situations where a state did not have a State Supervisor of Technology Education, the preferred respondent to the Dugger survey, an alternate contact was identified. Email was used to deliver not only the original round of questionnaires, but also two additional follow-ups aimed at possible participants that had not yet responded. Toward the end of the study, telephone follow-up calls were used in an attempt to gather unreported data from incomplete returned instruments and also gather questionnaires from non-respondents. Overall, the results of the study reinforced the need for continued implementation of the STL (Dugger, 2007).

In a 2006 study, Sadowski, Birchman, and Harris compared 56 faculty members who attended the 2004 EDGD Mid-Year Conference in Williamsburg, Virginia and 15 graphics faculty members from Purdue University to 90 first-semester freshmen majoring in Computer Graphics Technology at Purdue University at that time. A Gregorc Style Delineator and word matrix were used to help determine the learning style of each participant. The delineator matrix consisted of ten word sets, which were grouped in sets of four and presented to the participant. The respondents ranked each set of words according to how the words applied to their lives (Sadowski et al.).

The Sadowski et al. (2006) study was based on the idea that once the learning style was known for a person, appropriate strategies could improve the learning abilities for that individual. The findings of the study did not provide information based on individual respondents or individual improvements in relation to learning abilities, but data was provided on the learning styles of the respondents as a whole. It was found that male and female students had similar learning styles and that the learning styles of male and female instructors varied. In addition, the study reported that the specified learning style of female instructors was the same as the majority of freshman students, both male and female. The female instructors and freshman students reported a learning style which was "concrete/random" while the male instructors' reported a "concrete/sequential" learning style. This study provided a valuable assessment of respondents, identified the dominant mode of thinking of respondents, and aided learning for respondents (Sadowski et al.).

Another study researched the implementation of Virtual Reality (VR) technology into a certain classroom to find whether or not students became more engaged in classroom activities, communicated graphics concepts differently, and were able to strengthen their visualization skills due to technology. Smith et al. (2005) used an online survey based upon previously published findings and previously recorded observations throughout the course. This use of VR had not previously been used in the classroom and the students seemed to become more engaged with the instructors after the addition of VR. Observations of the instructors in the classroom also revealed that the use of new technology seemed to excite students (Smith et al.).

In addition, VR technology seemed to impact the classroom in a number of positive ways. First, there was a shorter mental feedback cycle from students. Secondly, students viewed the new technology as merely an instructional tool instead of an improved means by which instructors could critique their work. The positive reaction of the students was due to their lack of hand-on experience with the new technology and their passive interaction with

VR. Regardless of passive interaction, the students still appeared to be excited about VR in the classroom, and some normally reserved students became more willing to share their 3-D models with the class. These changes in behavior among normally reserved students could have resulted from their perception that all of the students in the class were equal in their lack of experience using the new technology. The overall findings from the Smith et al. study suggested that students have more hands-on interaction with new technology in the future (2005).

Akmal, Oats, and Baker (2002) conducted the third study in a series of national surveys that assessed the status of technology education in the United States and Canada. The first two studies were previously conducted to determine the progress of industrial arts in technology education and establishing a national Canadian census on technology education. Of the original eleven topic areas in the first two studies, five areas of major focus were reused as a part of the third study (Akmal et al.).

The survey instrument for the third study was specifically designed for state-level Technology Education supervisors and was based on the two prior previous instruments. After the researchers completed the design of the study survey instrument, it was reviewed and analyzed by a representative group of K-12 technology educators. After improvements to the instrument were implemented, state supervisors also examined and then approved the survey instrument before it was mailed out to technology education supervisors or designees from all 50 states for data collection. Completed survey instruments were returned to the researchers though self-addressed pre-paid envelopes. Telephone follow-up reminders came three weeks after the initial mailing in an attempt to increase the response rate. Final contacts were then made six weeks after the initial contact by means of telephone calls and emails (Akmal et al., 2002).

The questions of the Akmal et al. survey instrument addressed the recognition and status of technology education within each state. The purpose of the research was to establish an understanding of how technology education was currently perceived at the state level. The study contained separate questions pertaining to women and racial minorities in an attempt to target the status of these groups within technology education (Akmal et al., 2002).

In another study, Strong (2002) used paper-based spatial visualization tests to test students enrolled an engineering graphics course in 1999. The tests utilized three different versions of the Mental Rotation Test (MRT) and the Purdue Spatial Visualization Test. The tests were conducted on 107 students enrolled at post-secondary institutions and arranged according to class rank, from freshman to seniors. The primary purpose of the study was to establish a computerized version of the MRT that was equal to the paper version used to test spatial visualization. A paired sample t-test, with a .05 level of significance, was used to analyze the results. The study results showed that the proposed computer MRT could be used to monitor and improve curriculum (Strong).

Newberry (2001) conducted a different study to determine the status of technology education within the United States. The study examined how technology education has increased in importance within public schools. This survey instrument was sent to all State Supervisors of Technology Education in the United States as well as territorial supervisors outside of the continental US. The instrument consisted of three questions which inquired about the state framework, the requirement of technology education, and the number of teachers in the state. The data was analyzed in an attempt to better understand how technology education was affected as academic requirements increased over time (Newberry).

Newcomer et al. (2001) conducted a qualitative exit survey of 79 students in the Fall semester of 1998, 109 students in the Fall semester of 1999, and 51 students in the Winter semester of 2000. The survey originally only included students enrolled in Engineering Design Graphics (EDG) I. However, through the 1999-2000 academic year, the survey was modified and administered to students enrolled in EDG II. Additional questions addressed the student satisfaction with EDG course sequencing. Students were asked to rate their learning improvements in eight educational areas using Likert scales. Qualitative assessment of the survey results showed the revised curricula met classroom goals and prepared students for future courses (Newcomer et al.).

Shaw and Giacqunita (2000) researched graduate students in a large-scale survey in order to gather information regarding: attitudes on and uses of computers in graduate school, the computer skills that graduate students possessed at the time and also desired in the future, the means of acquiring those computer skills, and the students' educational backgrounds. Over a two year period, a survey instrument was developed that consisted of five sections. The survey instrument also contained Likert-type scales, and it was sent to 412 students (Shaw & Giacqunita).

Students' anonymity in the survey was assured through the use of identification numbers and separate return measures for the questionnaire and a postcard. Four weeks after the initial mailing of the questionnaire, a follow-up reminder was sent to the potential participants who had not yet responded. In the conclusion, the study highlighted differences in opinions held by graduate students from different age groups, genders, degree statuses, and program affiliations (Shaw & Giacqunita, 2000).

Alexander, Allen, Nelson, and Sisk (1998) conducted a similar study to the one in this paper and researched the nationwide shortage of certified instructors in the U.S. The study was designed to prepare future American workers for multi-tasked jobs due to the ever-changing nature of industrial infrastructure, career expectations of American workers, and career paths for education students. The authors stressed the need for creative thinking, problem solving skills, and the ability to make correct decisions on important issues in the workplace (Alexander et al.).

The researchers developed a survey instrument and mailed it to the 50 State Departments of Education in the United States. The survey instrument questions covered: the availability of technology education instructors, primary and alternative certification requirements, delivery systems for information, the strengths and weaknesses of the technology education profession, and general conclusions (Alexander et al., 1998).

PREVIOUS STUDIES

The purpose of the original studies was to take a "barometric reading" of the engineering graphics profession and to aid graphics educators who wanted to make informed decisions (Clark & Scales, 1999). The studies gathered information that would benefit decisions on future course offerings and new undergraduate and graduate degrees. The original survey of 1998 contained four major categories related to technical/engineering graphics education. A fifth category was added to the 2004 study that covered future research plans. Additional specific questions were also added to the 2004 study in the first, third, and fourth categories, based off suggestions made by EDGD members (Clark & Scales, 2006a).

Both previous studies concerned members of EDGD who resided in the United States as a part of the population, but the 1998 study also included members of the National Association for Industrial Technology Teacher Education (NAITTE) and the Council for Technology Teacher Education (CTTE). The population of the study was narrowed to EDGD in 2004, based on the active membership of EDGD (Clark & Scales, 2006a).

The two original studies contacted possible participants and collected survey results through hardcopy mailings and envelopes with pre-paid postage. Both studies ran for one month and used a reminder two weeks after the original information was sent to respondents. Email was only used in the 2004 study to send out the reminder. The data were reported by means of descriptive language and tables and the 2004 study also included a comparison of results to the 1998 data (Clark & Scales, 2006a).

METHODOLOGY

The data collection procedures utilized in this study were established by Lyberg et al. (1997) and put into practice by Clark and Scales in a 1998 study (1999) and in a 2004 study (2006a). The original studies were conducted five years apart. This study was conducted four and a half years after the 2004 study. It differed from the previous research by the use of a narrowed population and a modified version of the 2004 survey instrument. Other variations from the 2004 survey included the utilization of email in all stages of contact with respondents, an internet survey to present and collect results, and restricting respondents to those with at least a Bachelors degree and who, at the time of the survey, taught at least one graphics course a year.

Questions in the first section of the survey instrument covered technical/engineering graphics courses at the institutions where respondents were employed. Other questions aimed at courses offered at least once every two years, asked about manual drawing, three-dimensional modeling, Geometric Dimensioning and Tolerancing (GD&T), sketching, animation, descriptive geometry, CAM, distance education, etc. Additionally, questions covered operating systems, the number of courses in which each topic was covered, whether the topic was the main topic of a course or integrated in another course, and the various software packages used to teach individual topics. An additional 25 questions that included distance education were added to the 2008 survey instrument that were not covered in the previous studies. The additional questions asked about instructor retention, if the respondent had taught an online course, differences between the amount of credit given for teaching online courses versus traditional courses, and other topics.

The second section of the survey instrument asked questions that covered the student population taking technical/engineering graphics courses, gender discrepancies, and the majors of students enrolled in technical/engineering graphics courses. Other questions inquired about the percentage of female and minority enrollment within instructors' respective program, if the percentages had increased or decreased over the years, and the majors' of students. Questions in the second section were not changed from the 2004 survey instrument.

The third section of the survey instrument examined the background of respondents. Some questions covered professional activities, professional development, major concerns regarding the field, ideas on future trends, salary, responsibilities, and strategies used when dealing with teaching problems. Other questions addressed the number of faculty in university programs, faculty classifications, and faculty duties. An additional 17 questions were added to this section of the 2008 survey instrument, as compared to the 2004 study, which focused on professional development. The additional questions asked about tenure positions, how respondents kept up-to-date with changes in the field, and professional activities.

The fourth section of the survey instrument covered topics that were currently under investigation by EDGD members, the different titles of graphics majors and minors at institutions, and whether or not a need existed in technical/engineering graphics education for a national student organization. The fourth section of the 2004 survey instrument was used in the 2008 study with no additional questions.

The final section of the survey instrument focused on future research plans, current research, funding for research studies, collaborations of professors, future interests of respondents, and ideas for future research topics. One question was added to the fifth section of the 2008 survey instrument when compared to the 2004 survey instrument. This question covered the future role of graphics in game art and design.

After the data from the study was collected and analyzed, the results were compared to the findings of the two previous studies. Variations and consistencies among the three studies were then reported.

SURVEY INSTRUMENT

The survey instrument used in this study was originally developed by Clark and Scales (1999) in 1998 to conduct research on current trends and emergent issues in technical/engineering graphics education. The survey questions were collected from professionals in engineering and technical and technology education. After the survey instrument was formatted, it was reviewed by technical/engineering graphics instructors at NCSU. The instrument was finalized after four cycles of feedback and revisions (Clark & Scales, 1999). The original 1998 survey instrument was expanded for a 2004 study. The updates included the addition of a fifth category and questions added to the first, third, and fourth categories based off suggestions made by EDGD members between the two studies (Clark & Scales, 2006a). The complete 2008 survey instrument can be found in Appendix B.

The five categories researched in this study were: course offerings, student populations, professional, technical/engineering graphics education, and future research plans (Clark & Scales, 2006a). These are the same five categories that were researched in the 2004 study, but with questions added to collect data on distance education and professional development. The new questions originated from: conversations held with members of the

NCSU advisory committee, topic research, thinking in regards to future topics, and self-reflection upon existing topics. The proposed instrument was reviewed by technical/engineering graphics educators at NCSU and then modified, based on feedback (Clark & Scales, 1999; 2006a; Flowers, 2001).

The approved survey was hosted online at http://www.surveymonkey.com and data were collected through the site. Surveymonkey™ collected data from several respondents simultaneously and also filtered data into downloadable files.

Population

According to Krathwohl (2004) the first step in sample population selection is to precisely determine the population of interest. The population for this study was post-secondary graphics educators who resided in the United States, were members of EDGD listed in the 2007-2008 membership directory, provided a valid email address to ASEE, achieved at least a Bachelor's degree, and taught at least one graphics course a year. The population for the 1998 study included members from the NAITTE and CTTE. Both the 1998 and the 2004 study were conducted through mail, so the valid email address restriction for EDGD participants was new for this study. Also new for this study was the requirement that respondents held at least a Bachelors degree and taught at least one graphics course a year at that time.

The EDGD division was chosen for this study because it contained a diverse group of instructors from many engineering disciplines and several technology programs. EDGD aimed to revise both national and university curriculum, and, therefore, its broad approach to improvement insured revisions to both levels of curriculum (Branoff et al., 2002). EDGD members are known for their cooperative work (Barr, 1999), and the organization promotes itself on teaching, researching, discussing, and communicating engineering design graphics by means of conferences, short courses, and the Engineering Design Graphics Journal. EDGD exists to coordinate and promote activities that pertain to engineering graphics, design, and education (http://edgd.asee.org, 2008). EDGD achieves improvements in technical/engineering design graphics through "investigating the evolution and impact of computer graphic on engineering design graphics and informing its membership of current and future trends" as well as "promoting and developing ideas and providing opportunities for professional dialogue among its membership" (http://edgd.asee.org, ¶ 2).

Once data was collected on instructors' opinions, suggestions were then made on how to apply the instructors' opinions in order to retain them in the field. The purpose of the generated suggestions was to create a more satisfying environment for new instructors in the future (Clark & Scales, 2002). Clark and Scales stated: "As the profession of engineering/technical graphics grows into the 21st century, let us not forget who got us there. It is the instructor, researcher, and service agents that will carry the profession into the "visual age" (p. 10).

PROCEDURE

With more than a billion internet users around the globe, and that number increasing every year, internet surveys have become more relevant than ever. Situations applicable to internet surveys include: when the accessibility of a satisfactory sample list, when longitudinal comparisons remain the goal, and when interviewer interaction is not required with respondents (Evans & Mathur, 2005). This study fit all three categories. A satisfactory sample list was provided by the EDGD, so that only professionals who were well versed in the subject area of technical/engineering graphics were contacted. The survey compared results from two previous studies, so the results included longitudinal comparisons. Also, interviewer interaction with respondents was not required for the self-administered survey to be completed.

This study used a convenience sample of EDGD members who were first contacted regarding this study through email. With the assistance of the EDGD executive committee Chair, the members who had provided their email address to EDGD received a brief email that explained the purpose and topic of the research. Included in the email was a written statement approved by the EDGD committee that justified the validity of the research. The statement also contained a description of the study and the steps taken to ensure respondent privacy and security (Evans & Mathur, 2005; Huang, 2006).

Before the initial email was sent, the survey was checked for potential display problems on Internet Explorer and Firefox on a computer that ran Windows XP. This precaution served to account for technological variations as the online survey instrument would be displayed on many types of computers used by respondents (Evans & Mathur, 2005).

Along with the brief description of the research study, the email also contained a link to the online survey instrument. The most significant challenge was to simply get possible participants to open the email, read the contents, and sustain interest long enough to click through the study (Downing & Clark, 2007). This challenge was a potential hindrance because unsolicited emails could appear as junk mail. Manfreda et al. (2008) found that respondents preferred to complete a survey in the same mode as the initial contact.

The survey was hosted on http://www.surveymonkey.com, and neither the survey link or study were advertised to the public. Thus, the public was not made aware that the study was in fact taking place, which helped maintain the security of the study. The link to the online survey was only provided to members of EDGD, which minimized the risk of undesirable individuals obtaining the link. The link was also randomly generated and unique to the study. Furthermore, it also contained a case specific 28-character string, which consisted of lower-case letters, upper-case letters, numbers, and underscores. The complicated nature of the link prevented it from being easily guessed. Although the backgrounds of EDGD members were not checked, the demographic information collected from the survey verified that each respondent was qualified to complete the survey.

Throughout the course of the study, the results were downloaded every three days to ensure data would not have been completely lost if the servers crashed. The ability to download files with tabulated data lessened the administrative burden and eliminated the data input process of data analysis (Evans & Mathur, 2005).

Follow-up reminders were sent out to the population in an effort to increase the response rate (Evans & Mathur, 2005). The first reminder email was sent two weeks after the initial email and contained the same information as the initial email. Four weeks after the first reminder email and six weeks after the initial email, a second reminder email was sent. Finally, the survey was taken offline one week after the second reminder email.

When participants accessed the survey, they were presented with an informed consent page that showed the study had passed the IRB at NCSU. The survey was designed to appear like a printed survey, in order to alleviate possible problems encountered by respondents. For their convenience, respondents were able to start the survey and respond to the questions at any time, and they also had an unlimited amount of time to respond (Evans & Mathur, 2005). Furthermore, the anonymity of respondents was protected because no login was required to respond and only identifying demographic information was tied to respondents' answers.

There were several limiting criteria of the population of interest that provided security for this study. ASEE membership, which requires a financial commitment, must have been renewed annually by the population. EDGD membership also required an additional financial commitment, and was restricted to ASEE members. Even though no background checks were performed on individuals who joined EDGD, there was security in that current EDGD members had to seek out the organization and make a financial commitment in order to be added to the membership roster. Additional steps that eliminated unqualified individuals from corrupting the survey were: demographic questions, a link to the survey was only provided to current EDGD members, and other privacy measures prevented anyone from randomly stumbling upon the survey instrument.

The survey was controlled through an online email account that used a unique login and password only known to the main researcher. The email account linked to the

Surveymonkey™ account was accessed only by the main researcher through a unique login and password. These security measures eliminated the possibility that unapproved modifications were made to the survey, the account, or the collected data.

The collected data were saved on external servers hosted by Surveymonkey™ as the responses were completed. During the seven week span of the online survey, the collected responses were downloaded every three days, in order to prevent data loss if the servers crashed. The data sets were also downloaded after work hours, to ensure the most complete data set was backed up on each download. The electronic data were downloaded through a secured hardwired internet connection and stored on a private laptop. The laptop was protected by a biometric password directly linked to the main researchers' fingerprints. At all times, the laptop was stored in a secure environment. Upon completion of the study, the data sets were downloaded one final time and the survey removed from the website.

ANALYSIS

The database features of Surveymonkey™ provided an appropriate format of the results from which they could easily be analyzed. Prior to analysis of the data, it was checked for responses from unqualified individuals, outliers, and other incompatible responses. The results were then compared to the results of the two previous research studies. Lastly, frequency distributions were conducted on the data.

Frequency distribution reports were generated by listing out the possible intervals for each relative question, and then creating a table to summarize the number of observations for each interval. This procedure of data reporting is common and helped to summarize data. The intervals were of equal width and each possible value was mutually exclusive, which meant it could only fit into one interval (Agresti & Finlay, 1997).

Relative frequencies provided comparisons of intervals as the results were progressively reported. Relative frequencies showed how responses for each interval broke down the overall number of observations. This analysis occurred as the number of observations per interval was divided by the total number of observations. The numbers were reported in two different fashions, either proportionally or as a percentage. The numerical findings are sometimes reported through the use of tables, known as relative frequency distributions, which contained the total number of responses listed as a part of each table (Agresti & Finlay, 1997).

Because the data collected from this study was descriptive, it was best reported and displayed in tables. At the conclusion of the study, all respondents who had requested a copy of the data set were emailed an electronic copy.

SUMMARY

Survey research not only had a long history in educational research but had also adapted to changes over time to remain one of the most common methods of conducting research. Examples of similar studies and methodologies were summarized to provide background for this study. The original survey instrument used in this study was created by Clark and Scales (2004). It was updated by adding questions and covered essential topics in the field. The updated topics had increased in importance since the 2004 study and were justifiably included to keep the survey relevant to the current educational environment. The change in the presentation format of this survey to an online survey instrument, as opposed to the hardcopy version of the 2004 instrument, also reflected current educational trends.

This research was based on two previous professional surveys, thus the methodologies used, topics covered, population surveyed, procedures used, and methods of statistical analyses were all properly vetted. The research topics of the previous surveys had remained relevant to this survey, and an appropriate amount of time had passed to justify a current updated analysis. The most appropriate population of interest remained a collection of active professionals, and the procedures utilized were well documented. Finally, the statistical analyses used to analyze the data, in this study and the two previous studies, were established statistical measurements.

CHAPTER FOUR

RESULTS

The initial and reminder emails were sent out to 239 members of EDGD who had provided a valid email address. A total of 57 responses were returned, but one respondent stated that her or he was retired and, therefore, did not meet the teaching requirement. After this individual's responses were removed from the data set, the final number of responses totaled 56, thereby yielding a total response rate 23.4%. All descriptive data reported proportionally was rounded to the nearest hundredth, and data reported via percentages was rounded to the nearest tenth.

Course Offerings

The first category of questions asked participants to provide information in regards to the courses offered at their educational institutions.

The first question of the survey asked how many different technical/engineering graphics courses their educational institution offered at least once every two years. The question was answered by 54 respondents or 96.4% of the total respondents. A total of 7 respondents or 13.0% reported one course, 7 respondents or 13.0% reported two courses, 8 respondents or 14.8% reported three courses, 7 respondents or 13.0% reported four courses, and 25 respondents or 46.3% reported five or more courses.

Respondents were then asked to list the top three CAD/modeling/CAM/animation software packages used at their educational institutions in question two. This question was answered by 49 respondents or 87.5% of the total respondents. The variety of responses given by respondents covered programs dedicated to various disciplines within the field of technical/engineering graphics education (see Table 4.01).

Table 4.01

Top Seven CAD/Modeling/CAM/Animation Software Packages used in Technical/Engineering Graphics Courses

Software	Frequency (n = 49)	Mean %*
AutoCAD	36	73.5
Solidworks	23	46.9
Pro/E	13	26.5
Inventor	12	24.5
CATIA	5	10.2
Maya	5	10.2
NX	5	10.2

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

Respondents were asked in question three if their program offered instruction in GD&T, and 53 respondents or 94.6% of the total respondents answered. A breakdown of the responses is provided in Table 4.02. Question four addressed respondents who answered “Yes” to question three and asked if GD&T was taught in a separate course or if GD&T was integrated into the content of other graphics courses. This question was answered by 38 respondents or 67.9% of the total respondents and details were provided in Table 4.02.

Table 4.02

Topics Offered in Technical/Engineering Graphics Courses that were taught Separate or Integrated – Part 1

Subject	Offered* % (n)	Not Offered % (n)	Separate % (n)	Integrated % (n)
GD&T	66.0 (35)	34.0 (18)	21.1 (8)	78.9 (30)
Manual Instruments	49.1 (26)	50.9 (27)	24.0 (6)	76.0 (19)
2-D CAD	86.8 (46)	13.2 (7)	40.4 (19)	59.6 (28)
3-D Modeling	50.0 (25)	50.0 (25)	16.0 (4)	84.0 (21)
3-D Constraint	74.5 (38)	25.5 (13)	31.6 (12)	68.4 (26)

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

In question five, the survey asked respondents to indicate in how many different courses GD&T was presented. The question was answered by 42 respondents or 75.0% of the total respondents. Analysis of the data found that 22 respondents or 52.4% reported one course, 13 respondents or 31.0% reported two courses, 4 respondents or 9.5% reported three courses, 3 respondents or 7.1% reported four courses, and 0 respondents or 0.0% reported five or more courses.

Respondents were asked in question six if they or their faculty peers taught the use of manual instruments in courses. The question was answered by 53 respondents or 94.6% of the total respondents and response details are provided in Table 4.02. A follow-up question, question seven, was directed at respondents who answered “Yes” to question six. The question asked if the use of manual instruments was taught in a separate course or if the use of manual instruments was integrated into the content of other graphics courses. The question gathered 25 responses or 44.6% of the total respondents.

Respondents were then asked in question eight how many different courses taught manual instruments. A total of 27 respondents or 48.2% of the total respondents answered. The data showed that 18 respondents or 66.7% reported one course, 6 respondents or 22.2% reported two courses, 2 respondents or 7.4% reported three courses, 0 respondents or 0.0% reported four courses, and 1 respondent or 3.7% reported five or more courses. A breakdown of responses is provided in Table 4.02.

Forty-nine respondents or 87.5% of the total respondents responded to question nine. They were asked which operating systems their institution used for: 2-D CAD, 3-D modeling, CAM, desktop publishing, website development, and animation. For each subject Windows was the most predominant operating system. For details see Table 4.03.

Table 4.03

Top Operating Systems used for instruction in Technical/Engineering Graphics Courses

Subject	Windows* % (n)	Mac-based OS % (n)	Linux % (n)	Unix % (n)
2-D CAD	97.8 (46)	0.0 (0)	2.2 (1)	0.0 (0)
3-D Modeling	100.0 (47)	0.0 (0)	0.0 (0)	0.0 (0)
CAM	100.0 (32)	0.0 (0)	0.0 (0)	0.0 (0)
Desktop Pub.	86.7 (26)	13.3 (4)	0.0 (0)	0.0 (0)
Website Dev.	78.6 (22)	14.2 (4)	7.1 (2)	0.0 (0)
Animation	88.9 (32)	5.5 (2)	2.8 (1)	2.8 (1)

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

Respondents were asked in question 10 if they or their faculty peers taught 2-D CAD in their courses. A total of 53 respondents or 94.6% of the total respondents answered the question and the results are in Table 4.02. Question 11 was a follow-up question for those respondents who answered “Yes” to question 10 and asked if 2-D CAD was taught in a separate course or was integrated into the content of other graphics courses at their institutions. The question was answered by 47 respondents or 83.9% of the total respondents, and the details of the responses are provided in Table 4.02.

In question 12, respondents were asked in how many different courses at their educational institution was 2-D CAD taught. The question was answered by 48 respondents or 85.7% of the total respondents. Analysis showed that 24 respondents, or 50.0% of those who answered the question, reported one course, 10 respondents or 20.8% reported two courses, 5 respondents or 10.4% reported three courses, 4 respondents or 8.3% reported four courses, and 5 respondents or 10.4% reported five or more courses.

Question 13 asked respondents what software packages were used in the instruction of 2-D CAD courses. A total of 46 respondents or 82.1% of the total respondents answered the question, and the top two responses were AutoCAD and Solidworks respectively (see Table 4.04).

Table 4.04

Top Five Software Packages used in the Instruction of 2-D CAD

Software	Frequency (n = 46)	Mean %*
AutoCAD	46	100.0
Solidworks	3	6.5
Solid Edge	2	4.3
Civil 3D	1	2.1
Illustrator	1	2.1

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

Question 14 inquired if respondents, or their faculty peers, taught courses or parts of courses devoted to hand sketching in their program's curriculum. A total of 52 respondents or 92.9% of the total number of respondents answered this question, 22 respondents or 42.3% of the 52 responses answered "Yes," but 30 respondents or 57.7% answered "No."

Question 15 collected data regarding the overall percentage of respondents, or their faculty peers, who taught technical/engineering graphics courses that only used sketching and computer graphics or just computer graphics in their courses. A total of 50 respondents or

89.3% of the total respondents answered, who indicted that, on average, 52.3% of their courses only utilized sketching and computer graphics or simply computer graphics.

Course Offerings – 3-D

Question 16 asked if respondents, or their faculty peers, taught any non-constraint based 3-D modeling in their courses. Analysis showed that 50 respondents or 89.3% of the total respondents answered. For details, see Table 4.02. Question 17 targeted respondents who answered "Yes" to question 16 and asked if non-constraint based 3-D modeling was taught in a separate course at their institutions, or if 3-D modeling was integrated into the content of other graphics courses. A total of 25 respondents or 44.6% of the total respondents answered this question, and details of the responses were shown in Table 4.02.

In question 18, respondents were asked in how many different courses was non-constraint based 3-D modeling offered at their educational institution. A total of 41 respondents, or 73.2% of the total respondents, answered the question. A total of 14 respondents or 34.1% reported one course, 6 respondents or 14.6% reported two courses, 15 respondents or 36.6% reported three courses, 5 respondents or 12.2% reported four courses, and 1 respondent or 2.4% reported five or more courses.

Question 19 asked respondents what software packages were used for 3-D modeling in the technical/engineering graphics courses at their institution. A total of 37 respondents, or 66.1% of the total respondents, answered the question and the top two responses were Solidworks and AutoCAD respectively (see Table 4.05)

Table 4.05

Top Five Software Packages used in the Instruction of 3-D Modeling

Software	Frequency (n = 37)	Mean %*
Solidworks	15	40.5
AutoCAD	13	35.1
Inventor	8	21.6
Pro/E	8	21.6
3D Studio Max	4	10.8

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

Question 20 asked if respondents, or their faculty peers, taught 3-D constraint-based modeling (i.e. parametric, variational) in the course offerings of their institutions. The question was answered by 51 respondents or 91.1% of the total respondents, and details of the responses were provided in Table 4.02. Question 21 was a follow-up question for respondents who answered “Yes” to question 20, and asked if 3-D constraint-based modeling was taught in a separate course at the respondents’ institutions, or if 3-D constraint-based modeling was integrated into the content of other graphics courses. A total of 38 out of 56 respondents answered, or 67.9%, and the breakdown of responses were detailed in Table 4.02.

In question 22, respondents were asked in how many different courses was 3-D constraint-based modeling instruction offered at their educational institution. The question was answered by 38 respondents or 67.9% of the total respondents. A total of 1 respondent or 2.6% reported that one course was offered, 18 respondents or 47.4% reported two courses, 15 respondents or 39.5% reported three courses, 2 respondents or 5.3% reported four courses, and 2 respondents or 5.3% reported five or more courses.

Question 23 asked respondents what software packages were used for parametric modeling in technical/engineering graphics courses offered at their educational institutions. A total of 37 respondents, or 66.1% of the total respondents, answered, and the top two responses were Solidworks and Inventor respectively (see Table 4.06).

Table 4.06

Top Five Software Packages used in the Instruction of Parametric Modeling

Software	Frequency (n = 37)	Mean %*
Solidworks	21	56.8
Inventor	10	27.0
Pro/E	8	21.6
NX	6	16.2
CATIA	4	10.8

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

Course Offerings – Ethics & Descriptive Geometry

Question 24 asked if respondents, or their faculty peers, taught ethics in relation to graphics (i.e. copyright, patents, etc.) in the courses offered at their educational institutions. The question was answered by 49 out of the 56 respondents, or 87.5%, and the details of the responses are displayed in Table 4.07. Question 25 was a follow-up question for respondents who answered “Yes” to question 24, and asked if ethics in relation to graphics were taught in a separate course or was integrated into the content of other graphics courses. A total of 23 respondents, or 41.1% of the total respondents, answered this question, and details are provided in Table 4.07.

Table 4.07

Topics Offered in Technical/Engineering Graphics Courses that were taught Separate or Integrated – Part 2

Subject	Offered* % (n)	Not Offered % (n)	Separate % (n)	Integrated % (n)
Ethics	49.0 (24)	51.0 (25)	12.5 (3)	87.5 (21)
CAM	46.9 (23)	53.1 (26)	42.9 (9)	57.1 (12)
Descrip. Geo.	54.2 (26)	45.8 (22)	30.8 (8)	69.2 (18)
Desktop Pub.	28.6 (14)	71.4 (35)	71.4 (10)	28.6 (4)
Website Dev.	31.9 (15)	68.1 (32)	68.8 (11)	31.3 (5)
Animation	58.3 (28)	41.7 (20)	28.6 (8)	71.4 (20)

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

In question 26, respondents were asked in how many different courses was ethics related to graphics taught at their educational institution. The question was answered by 24 respondents or 42.9% of the total respondents. A total of 13 respondents or 54.2% reported it was taught in one course, 8 respondents or 33.3% reported two courses, 0 respondents or 0.0% reported three courses, 0 respondents or 0.0% reported four courses, and 3 respondents or 12.5% reported five or more courses.

Question 27 asked if respondents, or their faculty peers, taught CAM as a part of the course offerings of their educational institution. A total of 49 respondents, or 87.5% of the total respondents answered, and the responses are recorded in Table 4.07. Question 28 was for respondents who answered “Yes” to question 27, and it asked respondents if CAM was taught in a separate course or if CAM was integrated into the content of other graphics courses. The question was answered by 21 out of the 56 respondents, or 37.5%, and Table 4.07 summarized the results.

Question 29 asked respondents in how many different courses was CAM taught at their educational institution. A total of 24 respondents, or 42.9% of the total respondents answered. A total of 15 respondents or 62.5% reported one course, 7 respondents or 29.2% reported two courses, 1 respondent or 4.2% reported three courses, 0 respondents or 0.0% reported four courses, and 1 respondent or 4.2% reported five or more courses.

Question 30 asked respondents what software packages were used for CAM instruction at their educational institution. The question was answered by 17 respondents, or 30.4% of the total respondents, and the top two responses were MasterCAM and Solidworks respectively (see Table 4.08).

Table 4.08

Top Five Software Packages used in the Instruction of CAM

Software	Frequency (n = 17)	Mean %*
MasterCAM	7	41.2
Solidworks	4	23.5
Camworks	2	11.8
NX	2	11.8
GIBBS	2	11.8

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

Question 31 asked if respondents, or their faculty peers, taught descriptive geometry in the course offerings of their institution. A total of 48 respondents, or 85.7% of the total respondents answered, and results are shown in Table 4.07. Question 32 addressed respondents who answered “Yes” to question 31 and asked if descriptive geometry was taught in a separate course or if descriptive geometry was integrated into the content of other graphics courses. The question was answered by 26 out of the 56 respondents, or 46.4%, and response details are shown in Table 4.07.

In question 33, respondents were asked in how many different courses was descriptive geometry taught at their educational institution. A total of 26 out of 56 respondents, or 46.4%, answered. A total of 19 respondents or 73.1% reported one course, 5 respondents or 19.2% reported two courses, 2 respondents or 7.7% reported three courses, 0 respondents or 0.0% reported four courses, and 0 respondents or 0.0% reported five or more courses.

Question 34 asked respondents if software packages were used to teach descriptive geometry in technical/engineering graphics courses at their educational institution. The question was answered by 27 respondents, or 48.2% of the total respondents. Overall, 12 respondents or 44.4% answered “Yes,” while 15 respondents or 55.6% answered “No.” Question 35 was a follow-up question for respondents who answered “Yes” to question 34 and asked respondents what software packages were used in the instruction of descriptive geometry. A total of 13 out of the 56 respondents, or 23.2%, answered this question, and the top two responses were AutoCAD and CATIA respectively (see Table 4.09).

Table 4.09

Top Seven Software Packages used in the Instruction of Descriptive Geometry

Software	Frequency (n = 13)	Mean %*
AutoCAD	7	53.8
CATIA	3	23.1
PowerPoint	2	15.4
Solidworks	1	7.7
NX	1	7.7
Pro/E	1	7.7
Illustrator	1	7.7

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

Course Offerings – Desktop Publishing & Web Site Development

Question 36 asked if respondents, or their faculty peers, taught desktop publishing as part of the course offerings of their educational institution. The question was answered by 49 respondents, or 87.5% of the total respondents (see Table 4.07). Question 37 targeted respondents who answered “Yes” to question 36, and asked if desktop publishing was taught in a separate course, or if desktop publishing was integrated into the content of other graphics courses. A total of 14 respondents, or 25.0% of the total respondents answered, and details are summarized in Table 4.07.

In question 38, respondents were asked in how many different courses was desktop publishing taught at their educational institution. The question was answered by 12 respondents, or 21.4% of the total respondents. Overall, 8 respondents or 66.7% reported one course, 1 respondent or 8.3% reported two courses, 2 respondents or 16.7% reported three courses, 1 respondent or 8.3% reported four courses, and 0 respondents or 0.0% reported five or more courses.

Question 39 asked respondents what software packages were used for instruction in desktop publishing at their educational instruction. A total of 11 respondents, or 19.6% of the total respondents, answered. The top responses are summarized in Table 4.10.

Table 4.10

Top Five Software Packages used in the Instruction of Desktop Publishing

Software	Frequency (n = 11)	Mean %*
Adobe InDesign	4	36.4
Adobe Photoshop	2	18.2
Adobe Illustrator	2	18.2
Adobe Tools	2	18.2
Publisher	2	18.2

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

Question 40 asked if respondents, or their faculty peers, taught website development within the course offerings of their educational institution. The question was answered by 47 respondents, or 83.9% of the total respondents. The results are displayed in Table 4.07. Question 41 addressed respondents who answered “Yes” to question 40, and asked them if website development was taught in a separate course, or if website development was integrated into the content of other graphics courses. A total of 16 out of the 56 respondents, or 28.6%, answered this question (see Table 4.07).

In question 42, respondents were asked in how many different courses was website development taught at their educational institution. The question was answered by 16 respondents, or 28.6% of the total respondents. Overall, 9 respondents or 56.3% reported one course, 3 respondents or 18.8% reported two courses, 3 respondents or 18.8% reported three courses, 1 respondent or 6.3% reported four courses, and 0 respondents or 0.0% reported five or more courses.

Question 43 asked respondents what software packages were used for website development instruction in the technical/engineering graphics courses at their institution. A total of 11 respondents, or 19.6% of the total respondents, answered this question and the top two responses were Dreamweaver and HTML editors respectively (see Table 4.11).

Table 4.11

Top Five Software Packages used in the Instruction of Website Development

Software	Frequency (n = 11)	Mean %*
Dreamweaver	6	54.5
HTML editor	5	45.5
ASP.net	2	18.2
Sharepoint Designer	2	18.2
Frontpage	2	18.2

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

Question 44 asked if respondents, or their faculty peers, taught animation within the course offerings of their educational institution. The question was answered by 48 respondents, or 85.7% of the total respondents (see Table 4.07). Question 45 targeted respondents who answered “Yes” to question 44, and asked the respondents if animation was taught in a separate course or if animation was integrated into the content of other graphics courses. A total of 28 out of the 56 respondents, or 50.0%, answered this question, and the results are presented in Table 4.07.

Furthermore, in question 46, respondents were asked in how many different courses was animation taught at their educational institution. A total of 27 respondents, or 48.2%, of the total respondents answered. A total of 15 respondents or 55.6% reported one course, 7 respondents or 25.9% reported two courses, 3 respondents or 11.1% reported three courses, 1 respondent or 3.7% reported four courses, and 1 respondent or 3.7% reported five or more courses.

Question 47 asked respondents what software packages were used for animation instruction at their educational institution. The question was answered by 26 out of the 56 respondents, or 46.4%, and the top two software packages were 3D Studio Max and Solidworks respectively (see Table 4.12).

Table 4.12

Top Five Software Packages used in the Instruction of Animation

Software	Frequency (n = 26)	Mean %*
3D Studio Max	10	38.5
Solidworks	8	30.1
Pro/E	4	15.4
Maya	4	15.4
Inventor	4	15.4

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

Question 48 asked the respondents what the main focus of animation instruction was at their educational institution. Respondents were asked to select all options that applied. A total of 30 out of the 56 respondents, or 53.6%, answered (see Table 4.13).

Table 4.13

The Main Focus of Animation Instruction in Technical/Engineering Graphics Courses

Focus	Frequency (n = 30)	Mean %*
Technical	26	86.7
Simulation	24	80.0
Scientific	10	33.3
Artistic	7	26.5
Gaming	7	23.3
Web	6	20.0

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

Question 49 asked respondents if they planned to teach an animation course in the future, and 18 respondents, or 32.1% of the total respondents, answered. A total 5 respondents or 27.8% answered “Yes,” while 13 respondents or 72.2% answered “No.”

Course Offerings – Distance Education

Question 50 asked if respondents, or their faculty peers, taught any part of their courses online or through distance education. The question was answered by 46 respondents, or 82.1% of the total respondents. Overall, 15 respondents or 32.6% answered “Yes,” while 31 respondents or 67.4% answered “No.” Question 51 was a follow-up question for respondents who answered “Yes” to question 50 and asked if courses were taught online. A total of 13 out of the 56 respondents, or 23.2%, answered with an average of 4.4 courses per institution that utilized online distance education. Question 52 also addressed respondents who answered “Yes” to question 50, and asked if courses were taught through other distance education formats. A total of 9 respondents, or 16.1% of the total respondents, answered, and an average of 1.3 courses per institution utilized other distance education formats was calculated. For complete results, see Appendix C.

Question 53 asked if the respondents' program offered any online/distance education degree programs or online/distance education certifications related to graphics. The question was answered by 38 out of 56 respondents, or 67.9%. Overall, 3 respondents or 7.9% answered "Yes," while 35 respondents or 92.1% answered "No." Question 54 served as a follow-up question for those respondents who answered "Yes" to question 53 and asked them what subjects were taught through online/distance education formats. A total of 4 respondents, or 7.1% of the total respondents, answered. Here were selected responses: 'Intro' classes and "MS in Technology-Graphic Information Technology concentration." For the complete list of responses see Appendix D.

Question 55 asked respondents if the faculty within their program had received any training focused on distance education in the last 5 years. The question was answered by 45 respondents, or 80.4% of the overall respondents, and 21 respondents, or 46.7%, answered "Yes," and 24 respondents, or 53.3%, answered "No." Question 56 asked respondents if they were scheduled to have any training in the next year focused on distance education. A total of 44 respondents, or 78.6% of the total respondents, answered and 13 respondents, or 29.5%, answered "Yes," and 31 respondents, or 70.5%, answered "No."

Question 57 asked respondents if they had taught a course that utilized online/distance education to instruct any course. Overall, 46 respondents, or 82.1% of the total respondents, answered. Analysis showed that 18 respondents, or 39.1%, answered

“Yes,” and 28 respondents, or 60.9%, answered “No.” Question 58 focused on respondents who answered “Yes” to question 57, and asked if the respondents had used distance education to instruct a technical/engineering graphics courses. The question was answered by 26 respondents, or 46.4% of the total respondents, and 9 respondents, or 34.6%, answered “Yes,” and 17 respondents, or 65.4%, answered “No.”

Question 59 asked if the respondents’ program offered any online/distance education degree programs or online/distance education certifications related to graphics. A total of 44 respondents, or 78.8% of the total respondents, answered and 19 respondents, or 43.2%, answered “Yes,” and 25 respondents, or 56.8%, answered “No.”

Question 60 asked respondents if they considered themselves prepared to teach a technical/engineering graphics education course through online/distance education. The question was answered by 45 respondents, or 80.4% of the total respondents, and 20 respondents, or 44.4%, answered “Yes,” and 25 respondents, or 55.6%, answered “No.” Question 61 followed up question 60 and asked respondents if they considered themselves prepared to single-handedly retool a traditional course to be an online/distance education course. A total of 43 out of the 56 respondents, or 76.8%, addressed this question and 19 respondents, or 44.2%, answered “Yes,” and 24 respondents, or 55.8%, answered “No.”

Question 62 asked respondents what hurdles they thought existed for the instruction of technical/engineering graphics education content through online/distance education courses. Overall, 33 respondents, or 58.9% of the total respondents, answered. For example, one specific individual’s open-ended response reported:

> The validity of testing and also could be difficult to answer software specific problems/questions without seeing what the students are actually doing at the time because often what the students say the problem is, and what the problem actually is, are two different things.

Another respondents listed some hurdles and explanations in the open-ended format which included:

> Licensing of CAD for remote students. This can be handled through cooperation of CAD companies, using 'student versions.' SolidWorks and SolidEdge are very cooperative in this fashion. 2) Lack of administrative/staff support in handling the additional workload typically associated with distance courses. 3) Increased computing requirements, associated with a) bandwidth and b) storage. CAD files are typically much larger and more complicated that what the Distance Education staff are accustomed to. 4) IT policies on servers and faculty access. Due to item 3 above, it is simpler for me to set up and run my own download/upload site separate from the university WebCT/Blackboard system. However, the university frowns on 'independent' faculty distance resources (mostly organizational turf protection issues, which I frequently ignore).

The complete list of open-ended responses is posted in Appendix E.

Question 63 asked respondents if their program valued the instruction of an online/distance education course any differently than the instruction of a traditional course during tenure considerations. A total of 33 respondents, or 58.9% of the total respondents, answered. Furthermore, 4 respondents or 12.1% answered “Yes,” while 29 respondents or 87.9% answered “No.” Question 64 addressed respondents who answered “Yes” to question 63 and asked respondents to please detail the differences. A total of 5 respondents, or 8.9% of the total respondents, answered this question. Most stated that institutions did not provide additional benefits to the instructors of online courses. One respondent supported this notion by stating in open-ended format:

> And this is the problem. There is a tremendous start-up overhead for online instruction that is not considered in tenure and promotion decisions. At my institution, no release or extra resources are given to develop a new course or roll an existing course over online. It's just part of your job.

Another respondent confirmed the sentiment in his or her statements: “Yes, but only a little recognition for the extra work. There is on-going discussion about that issue and proposed changes to the workload document under consideration.” A complete list of responses is documented in Appendix F.

Question 65 asked respondents whether their programs compensated instructors of online/distance education courses any differently than instructors of traditional courses. A total of 32 respondents, or 57.1% of the total responses, answered. Moreover, 4 respondents or 12.5% answered “Yes,” but 28 respondents or 87.5% answered “No.” Question 66 targeted respondents who answered “Yes” to question 65, and asked them to detail the differences in compensation. A total of 6 respondents, or 10.7% of the total respondents, answered the question. Some of the open-ended responses were: “less in contact hours” and:

> There is an additional charge per credit hour per student (above straight tuition), of which a fraction (40% or so) is returned to the faculty for expenses. The Engineering course sizes (particularly for those with highly technical content) are never large, so funds are not much. $100's per offering, typically, back to the faculty.

For complete results to question 65, see Appendix G.

Question 67 asked respondents if they would go out of their way to teach a course they were interested in, even if it required the course to be taught through online/distance education. The question was answered by 38 respondents, or 67.8% of the total respondents. Overall, 24 respondents or 63.2% answered “Yes,” but 14 respondents or 36.8% answered “No.”

Question 68 asked respondents if they believed an instructor who used online/distance education should be required to be available 24/7 to students. Overall, 42 respondents, or 75.0% of the total respondents, answered the question. A total of 3 respondents or 7.1% answered “Yes,” while 39 respondents or 92.9% answered “No.”

Question 69 asked respondents if they felt the instructor role, within the classroom of a major university, could be outsourced within the next five years. The question was answered by 44 respondents, or 78.6% of the total population. Furthermore, 13 respondents or 29.5% answered “Yes,” but 31 respondents or 70.5% answered “No.”

Question 70 asked respondents if they would consider the outsourcing of an instructor radically different from a teaching assistant becoming the lead of a course, given a sufficient level of communication. A total of 40 respondents, or 71.4% of the total respondents, answered the question. Overall, 15 respondents or 37.5% answered "Yes," while 25 respondents or 62.5% answered "No." Question 71 addressed respondents who answered "Yes" to question 70, and asked respondents to detail the differences of an instructor being outsourced and a teaching assistant becoming the lead of a course. The question was answered by 15, or 26.8%, of the total respondents. One respondent explained the distinction in his or her open-ended statement: "Availability, ability to help the student connect with institution, peers, and profession, decreased mentorship role, role in department, communication between dept and instructor regarding student and course needs." Another respondents detailed the difference in the claim that: "TAs have a measure of built-in quality control; some things cannot be replicated digitally (non-specific)." Finally, one respondent affirmed: "It would be like the University of Phoenix--you have very little quality control." See Appendix H for a complete list of responses.

Question 72 asked respondents if their program offered any courses in a hybrid format, meaning the course contained traditional and online/distance education portions. The question was answered by 44, or 78.6%, of the total respondents. Seventeen respondents or 38.6% answered "Yes," but 27 respondents or 61.4% answered "No." Question 73 targeted respondents who answered "Yes" to question 72, and asked them to provide percentages of courses offered in traditional/hybrid/online format, in a manner such that the total percentage came out to 100%. A total of 17 respondents, or 30.4% of the total respondents answered. Overall, an average of 64.5% of courses utilized a traditional format, an average of 35.6% of courses utilized a hybrid format, and an average of 7.4% of courses utilized a totally online format.

The final question in this category, question 74, asked respondents if they believed the amount of hybrid courses offered at their educational institutions would increase over the next five years. A total of 41 respondents, or 73.2% of the total respondents, answered the question. Moreover, 36 respondents or 87.8% answered “Yes,” but 5 respondents or 12.2% answered “No.”

Student Population

In the second category of this study, asked participants to provide information regarding the student population at their educational institutions.

The first question in the Student Population category, question 75, asked respondents what percentage (0-100%) of their student population enrolled in graphics courses were women. A total of 45 respondents, or 80.4% of the total respondents, answered the question. The responses had an average of 16.3% of the students enrolled in technical/engineering graphics courses were women. Question 76 asked respondents how this percentage had qualitatively changed over the last 5 years. A total of 46 respondents, or 82.1% of the total respondents, provided an answer and the results are documented in Table 4.14.

Table 4.14

Changes in the Percentage of Women Enrolled in Technical/Engineering Graphics Courses over the Last Five Years

Change	Frequency (n = 46)	Mean %*
Increased	18	39.1
Decreased	2	4.3
Stayed steady	26	56.5

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

When question 77 asked respondents what percentage (0-100%) of their student population enrolled in graphics courses were of a minority (excluding gender), a total of 41 respondents, or 73.2% of the total population, replied. The responses had an average minority population of 21.1% of the entire student population enrolled in technical/engineering graphics courses. Question 78 asked respondents how this percentage had changed over the last 5 years. The question was answered by 43 respondents, or 76.8% of the total respondents. See Table 4.15 for frequency and percentage data.

Table 4.15

Changes in the Percentage of Minorities Enrolled in Technical/Engineering Graphics Courses over the Last Five Years

Change	Frequency (n = 43)	Mean %*
Increased	14	32.6
Decreased	1	2.3
Stayed steady	28	65.1

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

The final question in the Student Population category, question 79, had several parts and asked respondents to provide the percentage of their student population (0-100%) that were enrolled in technical/engineering graphics communications courses but were enrolled in a major other than their program. The question was answered by 41 respondents, or 73.2% of the total respondents. For the response rate to each major and the average percentage of each major see Table 4.16. No specific data was collected as to what "other" majors entailed.

Table 4.16

Majors of Students Enrolled in Technical/Engineering Graphics Courses

Major	Average % (n = 41)	Average # of Students
Engineering	64.3% (36 or 87.8%)	67.5
Technical/Technology	33.9% (19 or 46.3%)	62.1
Design	25.0% (14 or 34.1%)	24.0
Liberal Arts	19.6% (11 or 26.8%)	3.5
Business	16.1% (9 or 22.0%)	1.1
Other	14.3% (8 or 19.5%)	8.9
Computer Science	12.5% (7 or 17.1%)	2.0
Education	20.7% (6 or 14.6%)	4.8
Sciences	10.7% (6 or 14.6%)	2.0
Humanities	8.9% (5 or 12.2%)	3.4
Mathematics	8.9% (5 or 12.2%)	1.2
Agriculture	7.1% (4 or 9.8%)	1.3
Psychology	7.1% (4 or 9.8%)	0.0

Note: Maximum percentage for each subject was 100%.
Note: % is percentage of responses, (n) is the total of responses for each category and question.

Professional

In the third category of this study, questions asked participants to provide information in regards to professional development and instructor concerns about the profession.

The first question in this category, question 80, asked respondents how many full-time faculty members at their educational institutions taught technical/engineering graphics as their primary responsibility. A total of 40 respondents, or 71.4% of the total respondents, answered the question and an institutional average of 3.2 faculty members was calculated.

Question 81 asked respondents what percentage of the faculty at their educational institution had an engineering/technical degree. The question was answered by 33 respondents, or 58.9% of the total respondents. The overall responses had an average of 34.7% of faculty members had attained an engineering/technical graphics degree. Question 82 asked respondents how many full-time faculty members at their educational institution taught technical/engineering graphics, but not as their major course load. A total of 38 respondents, or 67.9% of the total respondents, answered this question and the responses had an average of 2.1 faculty members per institution. Question 83 asked respondents how many part-time instructors taught technical/engineering graphics courses at their educational institutions. A total of 39, or 69.6%, of the total respondents, answered the question and the response data had an average of 1.8 faculty members per institution.

Question 84 asked respondents how many faculty members from various fields taught technical/engineering graphics at their institution. The question was answered by 34, or 60.7%, of the total respondents (see Table 4.17).

Table 4.17

Background Fields of Faculty Members who Teach Technical/Engineering Graphics

Major	Response Rate % (n = 34)	Average # of Faculty Members
Engineering	73.5 (25)	3.0
Education	41.2 (14)	1.6
Design	29.4 (10)	0.6
Other	23.5 (8)	8.8
Technology	5.9 (2)	4.4

Note: Maximum percentage for each subject was 100%.
Note: % is percentage of responses, (n) is the total of responses for each category and question.

Question 85 asked respondents about the basis for merit pay in regards to increases/tenure/promotions at their institutions. The question asked respondents to provide a percentage (0-100%) breakdown for how much teaching, research, and service was taken into account for merit pay. The question was answered by 28, or 50.0%, of the total respondents. For Teaching, 28 respondents, or 100.0% of those who answered question 85, stated that 54.9% of their teaching on average was the basis of their merit pay. For Research, 23, or 82.1%, of those who answered question 85 stated that their merit pay was based on research an average of 26.8%. For Service, 26 respondents, 92.9% of those who answered question 85, stated that service on average was 24.8% of the basis for their merit pay.

Question 86 asked respondents if they had witnessed an increase or decline in tenured positions at their educational institutions. A total of 39, or 69.6%, of the total respondents answered. Twelve of the 39 respondents, or 30.8%, stated that they had seen an increase in the number of tenured positions at their educational institutions, while 12 respondents, or

30.8% of those who answered question 86, stated that they had seen a decrease in the number of tenured positions at their educational institutions. Finally, 15 of the 39 respondents, or 38.5%, stated they did not know.

Question 87 asked respondents how many faculty members in their program/department were classified in various ranks and to indicate the range of salaries for each position in their program/department. The question was answered in some part by 24, or 42.9%, of the total respondents. For the average number of employees that hold specific ranks and salary ranges see Table 4.18.

Table 4.18

Faculty Positions and Salary Ranges

Position	Average # of employees that hold this rank	Standard Deviation for avg. #	Salary Range	Median Salary
Full Professor	3.4	6.2	45K – 150K	85K
Associate Prof.	4.0	3.9	40K – 95K	70K
Assistant Prof.	4.0	3.1	35K – 90K	60K
Instructor	2.2	2.6	32K – 68K	45K
Lecturer	1.7	2.4	45K – 68K	55K
Adjunct	3.0	1.6	3K – 35K	3K

Question 88 asked respondents, in an open-ended format, what some of their current major concerns were related to the instruction of technical/engineering graphics communication at the post-secondary level. A total of 24, or 42.9%, of the total respondents answered. For example, one respondent in particular stated:

> Graphics instruction is being pushed out of a very full undergraduate engineering curriculum. Graphics skill is seen as a tool that can be picked up once the engineer is in the workforce, not as a crucial part of their education.

Another respondent echoed the same sentient in his or her statement:

> Engineering Graphics is being belittled as a legitimate area of instruction at most Engineering programs with doctoral degrees, and even with masters as the terminal degree. The reason is that the tenured and tenure-track professors have never actually worked in industry and thus have never used CAD as a communication tool. Related to that issue is the fact that in Engineering programs CAD instruction is not seen as being supported by funded research. That is: Whereas faculty and administrators see fundamental courses such as Statics [*sic*] and thermo to support higher-level courses which can educate students to, in turn, be research assistants, and thus bring in research, they do not view engineering graphics in that manner.

See Appendix I for a complete list of responses.

Question 89 asked respondents, again in open-ended format, what they considered to be future trends within the next 5 years related to the teaching of technical/engineering graphics communications. Overall, 23 respondents, or 41.1% of the total respondents, answered the question. One respondent, for example, stated these thoughts on future trends: "The most significant would be efficiency (vs effective[ness]) of delivery and the continued migration to online and distance delivery of instruction." Another response suggested:

"Integration with the math and sciences to provide applied learning opportunities in the traditional math and science classes." See Appendix J for a complete list of responses.

Question 90 asked what type of professional activities respondents, or their faculty peers, have participated in on a regular basis that relate to graphics communications. The question was answered by 28 respondents, or 50.0% of the total respondents. In their responses, 27 of the 28 respondent, or 96.4%, stated that their professional activities included attending conferences, 17, or 60.7%, of those who answered question 90, participated in workshops and 18 of the 28 respondents, or 64.3%, stated that they participated in training/seminars. See Appendix K for a complete list of responses.

Question 91 asked respondents how they kept up with changes in the curriculum. A total of 25 respondents, or 44.6% of the total respondents, answered this question. One particular participant in the survey stated that his or her approach to staying current with curriculum changes was to: "Read, attend conferences, talk with our advisory committee, serve on accreditation visiting committees." Another respondent kept up with the changes by: "Review technical and industrial articles. Attend occasional presentations at more general Engineering Education conferences (such as ASEE or FIE)." A complete list of responses was documented in Appendix L. Question 92 asked respondents how they kept up with changes in software. A total of 29 respondents, or 51.8% of the total respondents, answered this question. One individual, for example, indicted that his or her approach to staying up-to-date with software changes was to: "Take an occasional local workshop which is sponsored by the CAD commercial provider." Another respondent stated that he or she participated in: "User groups." See Appendix M for a complete list of responses.

Question 93 asked respondents if they had undergone retraining associated with professional development in the last five years. Overall, 34 respondents, or 60.7% of the total respondents, answered this question. Furthermore, 17 respondents, or 50.0% of those who answered question 93, replied "Yes," while 17 of the 34 respondents, or 50.0%, replied "No." Question 94, a follow-up to question 93, asked respondents if they were currently scheduled to attend any professional development related courses/seminars/workshops in the next year. The question was answered by 36 respondents, or 64.3% of the total respondents. Similarly, a total of 18 respondents, or 50.0% of those who answered question 94, replied "Yes," but 18 of the 36 respondents, or 50.0%, answered "No." Question 95 asked respondents if they believed they should attend a professional development course in the next five years to keep up with the changes within the field of technical/engineering graphics education. A total of 36 respondents, or 64.3% of the total respondents, answered this question. Moreover, 31 of the 36 respondents, or 86.1%, replied "Yes," while 5 respondents, or 13.9% of those who answered question 95, answered "No."

Question 96 asked respondents what conferences they planned to attend in the next five years, and 28, or 50.0%, of the total respondents, answered this question. The most common conferences listed were ASEE and EDGD. See Appendix N for a complete list of responses. Question 97 asked respondents which workshops they planned to attend in the next five years. A total of 17 respondents, or 30.4% of the total respondents, addressed this question. One respondent provided: “Midwest coalition for comprehensive design education workshops this summer 2009.” A complete list of responses is provided in Appendix O. Question 98 asked respondents what training/seminars they planned to attend in the next five years. A total of 11 respondents, or 19.6% of the total respondents, answered this question. One respondent stated that he or she planned to attend: “SolidWorks training.” Another respondent stated that they planned to attend: “PTC - PRO/Engineer university courses offered by PTC, INC.” See Appendix P for a complete list of responses.

Question 99 asked respondents if they had presented at any technical/engineering graphics education conference(s) in the last five years. The question was answered by 33 respondents, or 58.9% of the total respondents. Analysis showed that 18 of the 33 respondents, or 54.5%, stated “Yes,” while 15 respondents, or 45.5%, answered “No.” Question 100 addressed respondents who answered “Yes” to question 99, and asked them to list the conference titles and years of occurrence. A total of 14 respondents, or 25.0% of the total respondents, answered this question and the most common conferences were: American Society for Engineering Educators Annual Conference, and the Engineering Design Graphics Division Mid-year Conference. One respondent stated that he or she had presented at “ASEE Annual Conference 2003, 2004, 2005, 2006, 2008” and another presented at “EDGD Midyear (last five years) ASEE Annual (last five years) ASEE-SE Section (last five years).” See Appendix Q for a complete list of responses.

Question 101 asked respondents how many items related to graphics they had published in the last five years. A total of 21, or 37.5%, of the total respondents, answered some part of the question. For the number of articles published, 17 respondents, or 30.4% of those who answered question 101, replied. For the number of books published, 15 of the 21 respondents, or 26.8% answered. For the number of chapters published, 14 respondents, or 25.0% of those who answered question 101, replied. For the number of white papers published, 12 of the 21 respondents, or 21.4% answered. For the number of miscellaneous materials published, 12 respondents, or 21.4% of those who answered question 101, replied. For the average number of items reported see Table 4.19.

Table 4.19

Publications by Faculty over the last Five Years

Publication	Mean (n)	SD	Response Range	Median
# of Articles	5.6 (17)	5.1	0 – 17	7
# of Books	1.5 (15)	1.4	0 – 5	1
# of Chapters	0.9 (14)	1.2	0 – 3	0
# of White Papers	1.4 (12)	1.9	0 – 6	0.5
# of Misc. Materials	4.8 (12)	3.4	0 – 10	5

Question 102 asked respondents if they believed professional development training should be required for instructors in order to teach a technical/engineering graphics course through distance education. A total of 35, or 62.5%, of the total respondents, answered this question. Overall, 23 of the 35, or 65.7%, stated “Yes,” but 12 respondents, or 34.3%, answered “No.”

Question 103 asked respondents if they felt the need to establish a professional development certification for instructors. The question was answered by 33, or 58.9%, of the total respondents. Moreover, 11 of the 33 respondents, or 33.3%, answered “Yes,” while 22 respondents, or 66.7%, answered “No.”

Question 104 asked respondents what percentages (0-100%) of their time were devoted to teaching, service and research as a part of their duties as instructors. The percentages for these were supposed to total 100%. At least some part of the question was answered by 33, or 58.9% of the total respondents (see Table 4.20).

Table 4.20

Average Distribution of Faculty Duties

Area	Average %* (n)	SD	Response Range
Teaching	66.3% (33)	20.4	20% – 100%
Service	20.2% (30)	12.2	3% – 50%
Research	19.7% (26)	17.2	0% – 60%

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

Question 105 asked respondents what strategies they had implemented to deal with teaching problems (i.e. having to teach software, visualization, etc) over the last five years. A total of 22, or 39.3%, of the total respondents answered this question. One respondent stated that his or her strategy was to simply: “Sit down and learn it -- don't gripe.” Another participant in the survey stated: “I have created Flash animations of many of the teaching topics in 2 courses so that they can be viewed online.” Yet another strategy of one respondent to deal with teaching problems was to: “Learn the software, teach the software - integrate so that learning is holistic and as simple as possible.” See Appendix R for a complete list of responses.

The final question in this category, question 106, followed-up question 105, and asked respondents if they believed their implemented strategies had improved student achievement. A total of 26 respondents, or 46.4% of the total respondents, answered this question. Overall, 20 of the 26, or 76.9%, replied “Yes,” while 6 respondents, or 23.1%, answered “No.” Question 107 addressed respondents who answered “Yes” to question 106 and asked them to explain their answer. The question was answered by 19, or 33.9%, of the total respondents. One response suggested an improvement in student achievement in that:

> Students routinely return to NAU after graduation and their first employment stating either 1) "The CAD/CAM class was directly related to supporting me in my first job," or 2) "I wish I had taken the Advanced CAD/CAM class because it would have helped me get started." There is very little commentary outside either of those, related to Engineering graphics. Even the graduate students state that their own research experiences fall into one of those two categories. No one says engineering graphics is not applicable to their job, period.

See Appendix S for a complete list of responses.

Technical/Engineering Graphics Education

In the fourth category of this study, questions asked participants to provide information in regard to technical/engineering graphics education.

The first question in this category, question 108, asked respondents if their educational institution offered a major in technical/engineering graphics communication. A total of 39 respondents, or 69.6% of the total respondents, answered this question. Overall, 11 of the 39 respondents, or 28.2%, answered “Yes,” but 28 respondents, or 71.8%, answered “No.” Question 109 targeted respondents who answered “Yes” to question 108, and asked them to provide the areas of emphasis within their technical/engineering graphics communication major. The question was answered by 12, or 21.4%, of the total respondents. One respondent listed these areas of emphasis: “virtual product integration; animation and gaming; interactive media; construction graphics.” See Appendix T for a complete list of responses.

Question 110 asked respondents if their institution offered a minor in technical/engineering graphics communications. A total of 38 respondents, or 67.9% of the total respondents, answered this question. Overall, 11 respondents, or 28.9% of those who answered question 100, stated “Yes,” and 27 respondents, or 71.1%, answered “No.” Question 111 addressed respondents who answered “Yes” to question 110 and asked them to provide the total number of hours needed to obtain a minor at their institution. Overall, 8 of the 56 respondents, or 14.3%, answered this question. The number of hours required to obtain the minor varied from 15 hours to 30 hours. See Appendix U for a complete list of responses.

Question 112 asked respondents if their educational institution offered a graduate degree in technical/engineering graphics communications. The question was answered by 39, or 69.6%, of the total respondents. Analysis showed that 5 respondents, or 12.8% of those who answered this question, answered “Yes,” while 34 respondents, or 87.2%, answered “No.”

Question 113 asked respondents if their educational institution offered any visual or graphic communication degrees for students who wanted to teach technical/engineering graphics communications. A total of 38, or 67.9% of those who took the survey, addressed the question. Overall, 5 of the 38 respondents, or 13.2%, replied "Yes," but 33 respondents, or 86.8%, replied "No." Question 114 targeted respondents who answered "Yes" to question 113 and asked respondents what types of visual or graphics communications degrees their educational institution offered. A total of 6, or 10.7%, of the total respondents answered the question. Moreover, 5 respondents, or 83.3% of those who answered the question, stated that their educational institution offered a BS/BA, 6 respondents, or 100.0% of those who answered this question, responded that their educational institution offered a MS/M.Ed, and 2 of the 6 respondents, or 33.3%, reported that their educational institution offered a Doctorate. Question 115 asked respondents to provide the title/name of the technical/engineering graphics degree offered by their educational institution. A total of 10 respondents, or 17.9% of the total respondents, answered the question. Several names of the degrees included: Technology Education, Engineering Technology Design, and Design. See Appendix V for a complete list of responses.

Question 116 asked respondents to estimate how many students graduated from their program with a degree in technical/engineering graphics in a given year. The question was answered by 10, or 17.9% of the total respondents. Answers varied from 0 students to 100 students, with an average of 31.4 students who graduated with a degree in technical/engineering graphics each year per institution. See Appendix W for a complete list of responses.

Question 117 asked those respondents, who worked for an institution that offered a graphics degree, in which fields former students usually found work. A total of 13, or 23.2% of the total respondents, answered the question (see Table 4.21).

Table 4.21

Industries Where Former Technical/Engineering Graphics Students Found Work

Industry	Frequency (n = 13)	Response Rate
Industry	13	100.0
Manufacturing	8	61.5
Business	7	53.8
Education	6	46.2
Sales	6	46.2
Entertainment	3	23.1

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

The final question in this category, question 118, asked respondents if they thought a national honor society organization should be established. Overall, 32 respondents, or 57.1% of the total respondents, answered this question. Analysis showed that 7, or 21.9% of those who answered this question, replied “Yes,” but 25 respondents, or 78.1%, stated “No.”

Future Research Plans

In the final category of this study, questions asked participants to provide information in regard to future research plans.

The first question in this category, question 119, asked respondents to state what areas of research they were currently working on. A total of 24 respondents, or 42.9% of the total respondents, addressed this question. One respondent stated that he or she was currently researching: "Rapid product development methods, improving the efficiency of rapid prototyping processes and methods, Spatial Visualization Ability, and increasing energy efficiency of appliances." Another participant in the survey stated that he or she was working on: "graphics and engineering design curriculum development, rehabilitation and assistive technology." Still another respondent was researching: "Improving delivery of graphics skills and relating to overall educational performance." See Appendix X for a complete list of responses.

Question 120 asked respondents to name the major sources of funding for the research in their program/department (i.e. NSF, NIH, DOD, etc). The question was answered by 16 respondents, or 28.6% of those who completed the survey. The responses are summarized in Table 4.22.

Table 4.22

Major Sources of Funding for Technical/Engineering Graphics Research

Source	Frequency (n = 16)	Mean %*
NSF	11	68.8
Private Industry	3	18.8
Internal	2	12.5
NREL	1	6.3
NASA	1	6.3
Keen	1	6.3
DARPA	1	6.3
DOE	1	6.3

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

Question 121 asked respondents to indicate what grants they were currently involved with. A total of 16, or 28.6% of the total respondents, answered this question. Some of the answers included: DOE, DOL, NSF ATE, and NASA biomedical imaging. See Appendix Y for a complete list of responses.

Question 122 asked respondents what types/topics of research they were interested in for the future. The question was answered by 16, or 28.6% of the total respondents. One respondent stated: “Distance education for engineering graphics instruction.” Another respondent stated that he or she was interested in researching: “Differences in Native American visualization techniques and results.” Still another participant wanted to pursue: “Engineering Education issues in student motivation, Rapid prototyping in metal formed products, Medical imaging and prototyping.” See Appendix Z for a complete list of responses.

Question 123 asked respondents what graphics related grants they had received in their career. A total of 17, or 30.4% of the total respondents, answered the question. Nine respondents, or 52.9% of those who answered the question, answered that they had not received any graphics related grants. On the other hand, one respondent received a grant for "VisTE: Visualization in Technology education," and another individual received a grant from the "NSF STEM Pipeline fund." A reference can be made here to question 104, which found that only 19.7% of instructors' duties were related to research. See Appendix AA for a complete list of responses.

Question 124 asked respondents if they collaborated with instructors outside of their program but within their institution. A total of 31, or 55.4% of the total respondents, answered this question. Overall, 22 respondents, or 71.0% of those who answered question 124, replied "Yes," while 9 respondents, or 29.0%, answered "No."

Question 125 asked respondents if they collaborated with instructors outside of their institution. The question was answered by 32, or 57.1% of the total respondents. A total of 18 of the 32 respondents, or 56.3%, answered "Yes," but 14, or 43.8%, answered "No."

Question 126 asked respondents what they believed to be the main topics of research needed for the field. The question was answered by 18, or 32.1% of the total respondents. For one respondent, a research topic of need included: "How to integrate visualization and graphic communication throughout curricula (like reading through the curriculum) in an environment where free-standing graphics courses will become a thing of the past." Another respondent in the survey stated that the field needed to research "How to best teach the use of software along with graphics fundamentals -- is software use best taught through instructor-led group instructor, through self-paces individual tutorials, through small-group learning, though other means?" See Appendix BB for a complete list of responses.

The final question in this category, question 127, asked respondents what they believed to be the future role of graphics in game art and design. A total of 18, or 32.1% of the total respondents, answered this question. One participant seemed to think that graphics would not play a significant role in game art and design. The respondent stated:

> From an "Engineering" point of view, very little (except for human factors/vision). I suspect it will lay solidly in the Computer science area for research, as the topic is very much involved with data processing, not engineering in the classic sense.

Another respondent seemed to indicate that graphics would not play a role at all. The individual stated: "Since 90% of the production is out-sourced from this country, its got to be product planning, marketing, and the business of gaming." See Appendix CC for a complete list of responses.

SUMMARY

This survey explored trends of technical/engineering graphics education through a survey instrument which contained a myriad of questions and topics. The data reported in this chapter was descriptive at best and was, therefore, completely dependent on the respondents that participated in this study. The individual question response rate was acceptable for research papers with many of the questions having 30 or more responses. In addition, some open-ended questions garnered responses that resembled paragraphs and contained vast amounts of insightful information. Finally, some data was found to be best presented in table format, which helped to eliminate possible confusion.

CHAPTER FIVE

INTRODUCTION

Chapter five provides an overview of this study, summarizes conclusions drawn from comparisons of the findings from this study to the findings of the two previous studies, discusses the possible implications of this study, and recommends future research. Comparisons of findings were made in order to help qualify the results of this study and frame an informed prediction of the future for technical/engineering graphics education.

PREVIEWS

The topics taught in technical/engineering graphics education change over time and the results of this study attempt to provide a benchmark against which future changes may be compared. The review of literature indicated that the methodological procedures used in this study were common procedures in peer literature, but those studies that shared an identical combination of methodological procedures to this study were scarce.

The review of literature also found that trends identified in the two previous studies has started to be adapted by the field at large, which meant the field had progressed to a point where further research would be useful. The survey was hosted online, using an established web-based survey company, and was controlled through a unique online account. The survey used a collection of open-ended and selected response questions to collect the most complete data set possible. The data set also allowed for analysis and comparisons against the findings of the previous studies. The participants in the survey were members of EDGD, had provided their email address to ASEE, and met other demographics requirements.

The survey instrument for this study was based on the survey instrument used in the 2004 study by Clark and Scales. The 2004 survey instrument was modified to include additional questions that covered distance education and professional development topics in more detail. The revised instrument was then reviewed by technical/engineering graphics educators at NCSU and modified in accordance to the provided suggestions. Contact was made with EDGD members via emails sent out by the Chair of the executive committee for EDGD. Responses to the online survey instrument were collected by Surveymonkey™. Analysis of the data began after the being downloaded and formatted. Finally, the findings were reported.

DISCUSSION

The 2008 data set was compared to that of the two previous studies and any resulting anomalies were documented. Overall, the data for 16 questions, which appeared on all three surveys, were compared. The comparisons regarding those 16 questions will be discussed in the following part of this chapter.

The third question asked the survey respondents if their program offered GD&T instruction. The percentage of respondents who stated their educational institution offered GD&T declined in each progressive data set. The reported percentage was 71.2% in 1998, 68.6% in 2004, and 66.0% in 2008 (see Table 5.23). The sixth question asked respondents if their program offered instruction in the use of manual instruments. After data analysis, the reported percentage of manual instrument instruction declined over the three data sets. The percentage peaked at 71.2% in 1998, then dropped to 54.9% in 2004, and dropped again to

49.1% in 2008 (see Table 5.23). Additionally, question 10 asked respondents if their educational institution offered any course that covered 2-D CAD. Once again, a drop in the percentages of offerings was reported over the progressive data sets. Course offerings in 1998 were reported to be 93.6%, 88.2% in 2004, and 86.8% was reported in 2008 (see Table 5.23).

Furthermore, question 16 asked respondents if their educational institution offered any course that covered non-constraint based 3-D modeling. The reported data from 1998, 2004, and 2008 indicated a decline in the amount of course offerings in the area over time. The reported percentage was highest in 1998 of 65.3%, but dropped to 52.9% in 2004, and then dropped again to 50.0% in 2008 (see Table 5.23). Question 20 asked respondents if their educational institution offered any course that covered constraint-based 3-D modeling. The survey in 1998 garnered the lowest percentage, at 49.5%. However, the reported percentage rose to 74.5% in 2004 and stayed the same, at 74.5%, for the 2008 survey. Question 27 inquired if respondents' programs offered any course that covered CAM. The percentage peaked at 59.0% in 1998, then dropped to 47.1% in 2004, and dropped again to 46.9% in 2008 (see Table 5.23). Question 44 asked respondents if their educational institution offered any course that covered animation. The percentage started at 35.8% in 1998, increased to 51.0% in 2004, and increased again to 58.3% in 2008 (see Table 5.23). Animation was the only course topic that increased in percentage over all three surveys.

Table 5.23

Technical/Engineering Graphics Subjects Offered at Educational Institutions

Subject	1998 %	Change %	2004 %	Change %	2008 %
GD&T	71.2	-2.6	68.6	-2.6	66.0
Manual Instruments	71.2	-16.3	54.9	-5.8	49.1
2-D CAD	93.6	-5.4	88.2	-1.4	86.8
3-D Modeling	65.3	-12.4	52.9	-2.9	50.0
3-D Constraint	49.5	+25.0	74.5	0.0	74.5
CAM	59.0	-11.9	47.1	-0.2	46.9
Animation	35.8	+15.2	51.0	+7.3	58.3

Note: Maximum percentage for each subject was 100% per year.
Note: % is percentage of responses that offer the subject.

Question 75 asked respondents what percentage (0-100%) of their student population, within graphics courses, were women. The reported percentage was 16.4% in 1998, then rose to 17.0% in 2004, and declined in 2008 to 16.1% (see Table 5.24). Question 77 asked respondents what percentage (0-100%) of their student population enrolled within graphics courses, were of a minority (excluding gender). The reported percentage was 14.2% in 1998, dropped to 13.0% in 2004, and increased to 21.1% in 2008 (see Table 5.24).

Table 5.24

Minority Students Enrolled in Graphics Courses

Type	1998 %	Change %	2004 %	Change %	2008 %
Gender minority	16.4	+0.6	17.0	-0.9	16.1
Ethnic minority	14.2	-1.2	13.0	+8.1	21.1

Note: Maximum percentage for each type is 100% per year.
Note: % is percentage of responses.

Question 79 asked respondents to report the percentages of their students enrolled in various majors. Engineering and Technology were the top two reported majors of students enrolled in technical/engineering graphics courses among all three studies. In 1998, Engineering students made up 46.9% of the course population and Technology students consisted of 31.6%. In the 2004 study, it was reported that 66.7% of the students were enrolled in Engineering and 20.0% were enrolled in Technology. In this study, respondents reported that Engineering students made up 67.4% of their course enrollment and Technology students made up another 24.0%.

Question 80 asked respondents how many full-time faculty members taught technical/engineering graphics as their primary responsibility at the respondents' educational institutions. The reported average was 2.19 faculty members in 1998, 2.15 faculty members in 2004, and 3.15 faculty members in 2008. Question 82 asked respondents how many full-time faculty members taught technical/engineering graphics courses at their educational institution but not as their major instructional load. The average was 1.97 faculty members in 1998, 2.94 faculty members in 2004, and 2.05 faculty members in 2008.

Question 88 asked respondents what their current major concerns were related to teaching technical/engineering graphics communications at the post-secondary level. The top three reported concerns in 1998 were: high or increasing costs of adequate funding, software emphasized over basics/problem-solving skills, and difficulty keeping hardware/software up-to-date. In 2004, the top three common concerns of respondents were: preparedness of students entering the program, keeping up with changes in technology, and issues regarding graphics as an area of study. In the 2008 study, the top three reported concerns were: the phasing out of graphics instruction from the undergraduate engineering curriculum, the preparedness and abilities of incoming students, and the need of instructors to have more industrial experience.

Question 89 asked respondents what future trends they thought would occur within the next five years in relation to the instruction of technical/engineering graphic communications. The top three future trends reported in 1998 were: an increase in 3-D parametric modeling, more sophisticated/integrated software programs, and a decreased reliance on technical drawing. In the 2004 study, the top three concerns of respondents were: online and distance education instruction, more emphasis on 3-D CAD, and more 3-D prototyping. In the 2008 study, the top three reported concerns were: increased software related instruction, less instruction using manual instruments, and a migration to online and distance education.

Question 108 asked respondents if their educational institution offered a major in technical/engineering graphics communications. The reported percentage was 23.6% in 1998, 36.0% in 2004, and 28.2% in 2008 (see Table 5.25). Question 110 asked respondents if their educational institution offered a minor in technical/engineering graphics communications. The reported percentage was 15.2% in 1998, the average was 10.2% in 2004, and the average was 28.9% in 2008 (see Table 5.25).

Table 5.25

Degree Offerings for Technical/Engineering Graphics Communications

Type	1998 %	Change %	2004 %	Change %	2008 %
Major	23.6	+12.4	36.0	-7.8	28.2
Minor	15.2	-5.0	10.2	+18.9	28.9

Note: Maximum percentage for each type is 100% per year.
Note: % is percentage of responses.

CONCLUSIONS

Conclusions were drawn only from the questions that were covered in all three studies, and the data from this study were compared to the data sets from the two previous studies. Possible trends among the data sets were identified and conclusions were made based on the trends. The conclusions drawn from the studies were solely a product of the answers provided by respondents; therefore no trends can be proven based on this research and data analysis.

After the three data sets were compared, some common answers were garnered from the 1998, 2004, and 2008 surveys regarding question 88 in the 2008 study, which asked respondents to provide their major concerns. The first common concern of respondents appeared in the top three responses in the 2004 and 2008 data sets. Respondents were concerned about having difficulty keeping up-to-date with the changes in the field and linked their difficulties to hardware and software updates. This concern is important to the field because instructors are relied upon to train the next generation of graphics professionals. If instructors are unable to remain current with changes, then the field is going to ultimately be held back as students graduate without being exposed to current trends.

The second main concern of respondents supported research into the current standing of the field and possible future directions of the field. This concern is important because if the current and possible future subjects are not centered on the fields' foundational subjects, then steps will need to be taken to ensure the survival of the field. A large shift in subjects could force the field to refocus, or potentially redefine itself. Considering this possibility, the more time the field has to prepare for such a scenario, the better suited the field will be for such a change. It is a positive sign that respondents supported this type of research.

The third major concern reported by respondents was the skills level and preparedness of incoming students. This concern was the fifth major concern in 1998, the first major concern in 2004, and the second major concern in 2008. This concern for students questioned the existing quality of instruction that prepares graphics students for post-secondary education. If the existing infrastructure for the field is not properly preparing students for post-secondary instruction, then research must be conducted to find the deficient areas. Then efforts must be taken to either restructure the deficient areas, or eliminate the areas completely. These efforts will impact the field in unpredictable ways as changes are implemented and the field evolves.

Next, two possible future trends in the curriculum of the field came from responses to a question in all three surveys, specifically question 89 in the 2008 study, which asked respondents to report their thoughts on future trends in the field. The reported future trends, which appeared in more than one data set, were an increased emphasis on 3-D CAD, and a migration to online and distance education.

The first of the possible future trends, an increased emphasis on 3-D CAD, was based on responses to the 1998 and 2004 studies and has been supported by the greatest reported increase, percentage wise, of any subject across all three studies (see Table 5.24). The second possible future trend, a migration to online and distance education, was based on reported trends from the 2004 and 2008 studies. Also, the listing of this possible trend as the top concern of respondents in the 2004 study, led to an increased number of questions covering online and distance education in the 2008 study. Questions 50 through 74, in the 2008 study, specifically focused on online and distance education. The responses to questions 55, 56, and 58 supported the validity of the concern surrounding the possible trend. Question 55 had 45 respondents answer, and 46.7% of respondents stated they had already received retraining focused on distance education. Question 56 had 44 respondents, and 29.5% of respondents were scheduled to obtain training focused on distance education within the next year. Finally, question 58, had 26 respondents and found that 34.6% of respondents had already used distance education to instruct a technical/engineering graphics course.

A third possible trend was identified from the responses to a question in all three studies, but specifically question 44 in the 2008 study, which asked if respondents, or their faculty peers, taught animation. The reported amount of animation instruction in the technical/engineering graphics curriculum had increased across the three studies. Reported animation instruction rates started at 35.8% in the 1998 study, then rose 15.2% in the 2004 study, and then rose another 7.3% in the 2008 study to a final total of 58.3%. This is important because the increased instruction of animation shows the incorporation of a new topic into the field.

The three possible future trends aforementioned would influence the instruction of various specific software packages. This change could shift the instructional focus of the field and displace more traditional software-based topics, such as 2-D CAD and CAM. However, a shift in software packages would not necessarily mean a loss of all the older software-based subjects, as some older subjects have been integrated into more advanced subjects. An example of this integration is that 2-D CAD has remained a part of the 3-D CAD process in the object creation step.

The most impact that an increased emphasis on 3-D CAD instruction and the amount of instruction related to animation would have on the field is related to the topics that would be taught. For institutions, that already offer instruction on these subjects, they could offer more courses and sections. However, for institutions that do not already offer the subjects, they would have to develop and establish the required courses. These actions could possibly lead to the elimination of some existing subjects, courses, and sections. This could displace some traditional subjects, and it could also displace experienced instructors who specialized in the traditional subjects.

Even though the shift towards 3-D CAD and animation would have a great impact on the field, the possible trend towards online and distance education could have an even greater impact. The trend, if it occurs, would not only impact the software utilized in the profession, but it could also impact the role and requirements of instructors. The use of online and distance education at institutions would require courses that were originally setup for a traditional format, to be reworked. Additionally, the professional culture at institutions could change from one where instructors interact with students in face-to-face situations, to one where instructors might never meet their students. This chance would impact: how assignments are graded, how tests are administered, how instructors lead courses, and the social culture of institutions. These possible impacts would affect the university in a greater way than the updating of some courses, as they could shift the culture and community of instructors. The culture could change from a community traditionally associated with brick and mortar institutions to a community associated with web-only institutions.

RECOMMENDATIONS FOR FUTURE RESEARCH

The following recommendations were developed in the best interest of the technical/engineering graphics communications field and were based on the results of this study. The first recommendation is that a study of this nature should be replicated on a consistent basis. In accordance with the previous intervals between studies, the next instance would occur in 2013 and integrate the most up-to-date topics. The format of data reporting should remain the same as found in the previous studies.

The second recommendation is that future research should include emergent topics that experience growth around that time but were not previously part of this research (i.e. Gaming). This consideration is important because all emergent topics could not be identified and included in this research study and the integration of emergent topics would allow up-to-date data to be collected, baselines for the data to be established, and changes to be observed While the emergent topics may not have been a part of this study, they should not be excluded from future research.

The third recommendation is that research should also be focused on what traditional topics should remain as a part of the field. Traditional topics will either have to be dropped or integrated into advanced topics as new topics emerge, due to the restricted amount of class time. If changes lead to a domination of software within the field, then efforts must be taken to increase the amount of instruction using manual instruments. Regardless of the fact that manual instrument instruction can not currently be incorporated into software; instructors must preserve the viability of this important tool.

The final recommendation is that research should examine the reasons behind unprepared incoming post-secondary students. If the “weak link” in the system can be identified and amended, then the field will become stronger or more capable. Otherwise, more remedial courses will need to be created in the future if students enrolled in entry level technical/engineering graphics courses remain unprepared for the coursework. These new remedial courses would require instructors to spend additional time on introductory topics and less time on advanced topics. A lack of instruction in advanced topics could lead to students not being prepared for industrial work.

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APPENDICIES

APPENDIX A
Message to Population

Dear EDGD member:

This survey is part of my graduate studies at North Carolina State University, and is a replication of a 2004 study by Dr. Clark, Dr. Scales and Dr. Petlick. The purpose of the study is to establish a census of what is happening within the profession of technical/engineering graphics and collect opinions on where the field is heading. It is intended to collect information concerning the student population, course offerings, and what training needs exist for instructors who teach technical/engineering graphics at the post-secondary level. This study is limited to individuals who have a Bachelors degree, are employed at a post-secondary institution in the United States and teach at least one graphics course per year.

The instrument will take approximately 15 minutes of your time to complete. Anonymity and confidentiality are provided through the use of a universal login and no IP tracking. If you wish to participate, please click on the link below. A new browser window should open containing the research instrument. Please be as accurate as possible in responding to each question. Thank you for your time!

http://www.surveymonkey.com/s.aspx?sm=szyjgnfaerAmsnbHBmlnLg_3d_3d

Sincerely,

Brian W. Downs, Aaron C. Clark, & Alice Y. Scales

APPENDIX B
Survey Instrument

Technical/Engineering Graphics Communication Survey 2008

1. Introduction

North Carolina State University
INFORMED CONSENT FORM for RESEARCH
Title of Study: What is the future of Technical/Engineering Graphics Education? A survey of post-secondary graphic professionals focused on the emerging themes of Technical/Engineering Graphics Education in the United States.

Principal Investigator: Brian W. Downs
Faculty Sponsor: Aaron C. Clark

What are some general things you should know about research studies?
You are being asked to take part in a research study. Your participation in this study is voluntary. You have the right to be a part of this study, to choose not to participate or to stop participating at any time. The purpose of research studies is to gain a better understanding of a certain topic or issue. You are not guaranteed any personal benefits from being in a study. Research studies also may pose risks to those that participate. In this consent form you will find specific details about the research in which you are being asked to participate. If you do not understand something in this form it is your right to ask the researcher for clarification or more information. A copy of this consent form will be provided to you. If at any time you have questions about your participation, do not hesitate to contact the researcher(s) named above.

What is the purpose of this study?
To find out what instructors in the field of Graphics Communications believe the field in the United States will be like in 5 years.

What will happen if you take part in the study?
If you agree to participate in this study, you will be asked to respond to questions form a modified research instrument that was originally developed by Dr. Clark and Dr. Scales. The research instrument is hosted on surveymonkey.com and should approximately take between 25 and 30 minutes to complete the study. A link to the study and a universal anonymous login has been provided.

Risks:
Since survey responses will be anonymous, the greatest potential risk to participants would occur if the data were inadvertently compromised and the mailing list acquired. Determined individuals could try and link responses to questions centered on employment information with the mailing list.

Benefits:
There is no direct benefit provided with this study, but knowledge may be gained that could help others.

Confidentiality:
The information in the study records will be kept strictly confidential. During the course of the study, data will be stored on surveymonkey.com servers and survey responses will not be in any way linked to email address or IP addresses. Data will be backed up securely, in electronic format, on my personal laptop which is protected through the use of biometrics passwords that are linked only to my fingerprints. No reference will be made in oral or written reports which could link you to the study.

Compensation:
You will not receive any compensation for participating.

What if you have questions about this study?
If you have questions at any time about the study or the procedures, you may contact the researcher, Brian W. Downs, at 156 Pineland Circle, Raleigh, NC 27606, or 919-264-8593.

What if you have questions about your rights as a research participant?
If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Deb Paxton, Regulatory Compliance Administrator, Box 7514, NCSU Campus (919/515-4514), or Joe Rabiega, IRB Coordinator, Box 7514, NCSU Campus (919/515-7515).

2. Course Offerings

The purpose of this survey is to establish a census of what is happening within the profession of technical/engineering graphics. It is intended to provide information concerning our student population, course offerings, and to indicate what needs exists to train instructors for teaching technical/engineering graphics at the post-secondary level. The instrument will take approximately 15 minutes of your time. Please be as accurate as possible in responding to each question. Thank you for your time!

(1) 1. How many different technical/engineering graphics courses does your institution offer on a regular basis (at least once every two years)?

- 1
- 2
- 3
- 4
- 5 or more

(2) 2. What are the top 3 CAD/Modeling/CAM/Animation software packages your institution uses?

1.

2.

3.

(3) 3. Does your program offer instruction in Geometric Dimensioning and Tolerancing (GD&T)?

- Yes
- No

(4) 4. If yes, is it a separate class or is it integrated into the content in other graphics courses?

- Separate
- Integrated

(5) 5. In how many different courses is GD & T presented?

- 1
- 2
- 3
- 4
- 5 or more

(6) 6. Do you, or your faculty, teach the use of manual instruments in your course offerings?

- Yes
- No

(7) 7. If yes, is it a separate class or is it integrated into the content of other graphics courses?

- Separate
- Integrated

(8) 8. In how many different courses is manual equipment used?

- 1
- 2
- 3
- 4
- 5 or more

(9) 9. What operating system(s) do you use for these areas? (ie. Windows, unix, mac)

2D CAD

3D modeling

CAM

Desktop publishing

Website development

Animation

(10) 10. Do you, or your faculty, teach 2-D CAD in your course offerings?

- Yes
- No

(11) 11. If yes, is it a separate class or is it integrated into the content for other graphics courses?

- Separate
- Integrated

(12) 12. In how many different courses do you use 2-D CAD?

- 1
- 2
- 3
- 4
- 5 or more

(13) 13. If yes, what software(s) do you use for 2-D CAD?

(14) 14. Do you, or your faculty, teach any engineering/technical graphics courses using only sketching (no instruments)?

- Yes
- No

(15) 15. What is the overall percentage of courses you and your faculty offer that teach technical/engineering graphics using sketching and computer graphics and/or just computer graphics (0-100%)?

3. Course Offerings - 3-D

(16) 1. Do you, or your faculty, teach any non-constraint based 3-D modeling in your course offerings?

- Yes
- No

(17) 2. If yes, is it a separate class or is it integrated into content for other graphics courses?

- Separate
- Integrated

(18) 3. How many different courses in 3-D modeling do you offer?

- 1
- 2
- 3
- 4
- 5 or more

(19) 4. If yes, what software(s) do you use for 3-D modeling?

(20) 5. Do you, or your faculty, teach 3-D constraint-based modeling (i.e. parametric, variational) in your course offerings?

- Yes
- No

(21) 6. If yes, is it a separate class or is it integrated into the content for other graphics courses?

- Separate
- Integrated

(22) 7. In how many different courses do you teach 3-D constraint-based modeling?

- 1
- 2
- 3
- 4
- 5 or more

(23) 8. If yes, what software(s) do you use for parametric modeling?

4. Course Offerings - Ethics & Descriptive Geometry

(24) 1. Do you, or your faculty, teach any ethics related to graphics (i.e. copyright, patents, etc.) in your course offerings?

- Yes
- No

(25) 2. If yes, is it a separate class or is it integrated into the content for other graphics courses?

- Separate
- Integrated

(26) 3. In how many different courses do you teach ethics related to graphics?

- 1
- 2
- 3
- 4
- 5 or more

(27) 4. Do you, or your faculty, teach CAM in your course offerings?

- Yes
- No

(28) 5. If yes, is it a separate class or is it integrated into the content for other graphics courses?

- Separate
- Integrated

(29) 6. In how many different courses do you teach CAM?

- 1
- 2
- 3
- 4
- 5 or more

(30) 7. If yes, what software(s) do you use for CAM?

(31) 8. Do you, or your faculty, teach descriptive geometry in your course offerings?

- Yes
- No

(32) 9. If yes, is it a separate class or is it integrated into the content for other graphics courses?

- ☐ Separate
- ☐ Integrated

(33) 10. In how many different courses do you teach descriptive geometry?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5 or more

(34) 11. If yes, do you use any software as part of your teaching of this subject?

- ☐ Yes
- ☐ No

(35) 12. If yes, what software(s) do you use to teach descriptive geometry?

5. Course Offerings - Desktop Publishing & Web Site Development

(36) 1. Do you, or your faculty, teach a course in desktop publishing in your course offerings?

- ☐ Yes
- ☐ No

(37) 2. If yes, is it a separate class or is it integrated into the content for other graphics courses?

- ☐ Separate
- ☐ Integrated

(38) 3. In how many different courses do you use desktop publishing?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5 or more

(39) 4. If yes, what software(s) do you use to teach desktop publishing?

(40) 5. Do you, or your faculty, teach a course in website development and design in your course offerings?

- ☐ Yes
- ☐ No

(41) 6. If yes, is it a separate class or is it integrated into the content for other graphics courses?

- ☐ Separate
- ☐ Integrated

(42) 7. In how many different courses do you teach website development and design?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5 or more

(43) 8. If yes, what software(s) do you use as part of teaching this subject?

(44) 9. Do you, or your faculty, teach animation in your course offerings?

- Yes
- No

(45) 10. If yes, is it a separate class or is it integrated into the content for other graphics courses?

- Separate
- Integrated

(46) 11. In how many courses do you teach animation?

- 1
- 2
- 3
- 4
- 5 or more

(47) 12. If yes, what software(s) do you use for animation?

(48) 13. If yes, what is the main focus of your animation? (Check all that apply)

- Technical
- Simulation
- Artistic
- Scientific
- Web
- Gaming

(49) 14. If no, do you plan to teach an animation class in the future?

- Yes
- No

6. Course Offerings - Distance Education

(50) 1. Do you, or your faculty, teach any or part of your classes on-line or using distance education?

- Yes
- No

(51) 2. If yes, how many classes are taught ON-LINE:

(52) 3. If yes, how many classes are taught through OTHER Distance Education formats:

(53) 4. Does your program offer any on-line/distance education degree programs, or certification related to graphics?

- Yes
- No

(54) 5. If yes, what subjects are taught this way?

(55) 6. Have faculty in your program received any training focused on Distance Education in the last 5 years?

- Yes
- No

(56) 7. Are you scheduled to have any training focused on Distance Education in the next year?

- Yes
- No

(57) 8. Have you taught any course using online/distance education?

- Yes
- No

(58) 9. If yes, have you taught a distance education course for technical/engineering graphics education?

- Yes
- No

(59) 10. Does your program plan to teach a distance education course for technical/engineering graphics education in the next 5 years?

- Yes
- No

(60) 11. Do you consider yourself prepared to teach a technical/engineering graphics education course through online/distance education?

- Yes
- No

(61) 12. Do you consider yourself prepared to single handedly retool a traditional course to be online/distance education ready?

- Yes
- No

(62) 13. What unique hurdles do you believe exist for teaching technical/engineering graphics education content through online/distance education?

(63) 14. Does your program treat teaching an online/distance education course any differently than teaching a traditional course during tenure considerations?

- Yes
- No

(64) 15. If yes, please detail the differences.

(65) 16. Does your program compensate teachers of online/distance education any differently than teachers of traditional courses?

- Yes
- No

(66) 17. If yes, please detail the differences.

(67) 18. Would you go out of your way to teach a course that you are interested in even if you were required to teach through online/distance education?

- Yes
- No

(68) 19. Do you believe a teacher using online/distance education should be required to be available 24/7?

- Yes
- No

(69) 20. Within the next 5 years, do you see the instructor role within the classroom of a major university being outsourced?

- Yes
- No

(70) 21. If communication was sufficient, would you consider outsourcing an instructor radically different from having a Teaching Assistant lead a class?

- Yes
- No

(71) 22. If yes, please detail the differences.

(72) 23. Does your program offer any courses in a hybrid format?

- Yes
- No

(73) 24. If yes, please provide percentages of courses offered in traditional/hybrid/online format. (For a total of 100%)

Traditional

Hybrid

On-line

(74) 25. With online/distance education becoming increasingly more common, do you believe the amount of hybrid courses will increase over the next 5 years?

- Yes
- No

7. Student Population

(75) 1. What percentage (0-100%) of your student population in graphic courses are women?

(76) 2. In the last 5 years, has this percentage:

- Increased
- Decreased
- Stayed steady

(77) 3. What percentage (0-100%) of your student population taking graphic courses are minorities (excluding gender)?

(78) 4. In the last 5 years, has this percentage:

- Increased
- Decreased
- Stayed steady

(79) 5. What are the percentages of your student populations that makeup your technical/engineering graphics communications classes? You can identify more than one area: (Write numbers from 1 to 100 in one or more boxes to total 100%)

Engineering	
Design	
Education	
Humanities	
Agriculture	
Mathematics	
Business	
Psychology	
Computer Science	
Sciences (i.e. biology, chemistry)	
Technical/Technology	
Liberal Arts	
Other	

8. Professional

(80) 1. How many full-time faculty members does your institution have that teach technical/engineering graphics as their primary responsibility?

(81) 2. What is the percentage of faculty at your institution with engineering/technical degrees?

[ ]

(82) 3. How many full-time faculty members teach technical/engineering graphics, but not as their major teaching load?

[ ]

(83) 4. How many part-time instructors do you have teaching technical/engineering graphics?

[ ]

(84) 5. How many faculty members from each of the fields listed below teach technical/engineering graphics for your college?

Education [ ]

Technology [ ]

Engineering [ ]

Design [ ]

Other [ ]

(85) 6. Merit pay for increases/tenure/promotions. What is the breakdown percentage for each of the following areas that are considered? (For a total of 100%)

Teaching [ ]

Research [ ]

Service [ ]

(86) 7. Do you see an increase or decline of tenured positions at your institution?

- Increase
- Decline
- Do not know

(87) 8. How many faculty in your program/department are classified in the following status and what is the range of salary for each position in your department or program? (your estimate)

Full Professor

Salary Range (Full Professor)

Associate Professor

Salary Range (Associate Professor)

Assistant Professor

Salary Range (Assistant Professor)

Instructor

Salary Range (Instructor)

Lecturer

Salary Range (Lecturer)

Adjunct

Salary Range (Adjunct)

(88) 9. In general, what are some of the major concerns you currently have related to the teaching of technical/engineering graphics communications at the post-secondary level?

(89) 10. In general, what are some of the future trends you see happening within the next 5 years as it relates to the teaching of technical/engineering graphic communications?

(90) 11. What type of professional activities do you and your faculty participate in on a regular basis that relate to graphic communications? Please describe each activity.

Conferences [ ]

Workshops [ ]

Training/Seminars [ ]

(91) 12. How do you keep up with changes in the curriculum?

[ ]

(92) 13. How do you keep up with the changes in software?

[ ]

(93) 14. Have you undergone retraining associated with professional development in the last 5 years?

- Yes
- No

(94) 15. Are you currently scheduled too attend any professional development related courses/seminars/workshops in the next year?

- Yes
- No

(95) 16. To keep up with the changes in the field of technical/engineering graphics education do you believe that you will need to attend a professional development course in the next 5 years?

- Yes
- No

(96) 17. Which conferences do you plan on attending in the next 5 years?

(97) 18. Which workshops do you plan on attending in the next 5 years?

(98) 19. Which training/seminars do you plan on attending in the next 5 years?

(99) 20. Have you presented at any technical/engineering graphics education conference(s) in the last 5 years?

- Yes
- No

(100) 21. If yes, please list the conference title(s) and the year(s).

(101) 22. In the last 5 years, how many items have you published related to graphics?

# of articles

# of books

# of chapters

# of white papers

# of miscellaneous materials

(102) 23. Do you believe professional development training should be required for a teacher to instruct a technical/engineering graphics education through distance education?

- [ ] Yes
- [ ] No

(103) 24. Do you feel we need to establish a professional development certification for instructors?

- [ ] Yes
- [ ] No

(104) 25. As part of your duties, what percentage of time do you devote to the following (should total 100%):

Teaching ______

Service ______

Research ______

(105) 26. Over the last five years, what strategies have you initiated to deal with teaching problems (i.e. having to teach software, visualization, etc.)?

(106) 27. Do you feel that those strategies have made a change in student achievement?

- [ ] Yes
- [ ] No

(107) 28. If yes, please explain.

9. Technical/Engineering Graphics Education

(108) 1. Does your institution offer a major in technical/engineering graphic communications?

- Yes
- No

(109) 2. If yes, what are the areas of emphasis?

(110) 3. Does your institution offer a minor in technical/engineering graphic communications?

- Yes
- No

(111) 4. If yes, what is the total number of hours needed to obtain the minor?

(112) 5. Does your institution offer a graduate degree in technical/engineering graphic communications?

- Yes
- No

(113) 6. Does your institution any visual or graphic communication degrees for students who want to teach technical/engineering graphic communications?

- Yes
- No

(114) 7. If yes, what type of degree does your college offer (please check)?

- BS/BA
- MS/M.Ed
- Doctorate

(115) 8. What is the title/name of the degree?

(116) 9. How many students do you estimate graduate with your programs' degree in graphics in a given year?

(117) 10. If a degree is offered, in what type(s) of jobs does your students usually find work?

- Business
- Education
- Entertainment
- Industry
- Manufacturing
- Sales

(118) 11. Do you feel a national student honor organization needs to be established?

- Yes
- No

10. Future Research Plans

(119) 1. What areas of research are you working on?

(120) 2. Who is the major funding source for research in your program/department? (ie. NSF, NIH, DOD, etc.)

(121) 3. What grants are you currently involved in?

(122) 4. What types/topics of research areas are you interested in for the future?

(123) 5. What graphics related grants have you received in your career?

(124) 6. Do you collaborate outside of your program area within your institution?

- Yes
- No

(125) 7. Do you collaborate outside of your institution?

- Yes
- No

(126) 8. What do you feel are the main topics of research that are needed for our field?

(127) 9. What role do you think graphics will play in game art and design?

11. Thanks

Thank you for taking this survey. If you are interested in receiving a copy of the results, please indicate below. All names and addresses will be strictly confidential.

Again thank you for helping the profession grow towards new endeavors!

Professionally yours,
Brian W. Downs
Graduate Student
Graphic Communications

Professionally yours,
Aaron C. Clark, Ed. D
Associate Professor
Graphic Communications

Professionally yours,
Alice Y. Scales, Ed. D
Assistant Department Head and Coordinator of the Graphic Communications Program
Graphics Communications

1. If you would like to receive a copy of the results, please give your name and address here:

Name: __________

Email address: __________

APPENDIX C
Complete Responses to Question 52
If yes, how Many Classes are taught through OTHER Distance Education Formats?

Number	Response Text
1	0
2	OTHER???
3	0
4	10
5	0
6	none
7	2
8	0
9	0
10	0 (unless you are counting course delivery software such as WebCT or DesiretoLearn, in which all the CAD are supported with this format

APPENDIX D
Complete Response to Question 54
If yes, What Subjects are taught this Way?

Number	Response Text
1	PLM
2	Intor to CAD and Intro To parametric design
3	Engineering Design and other computer science based courses
4	BAS in Digital Media Management; MS in Technology-Graphic Information Technology concentration.

APPENDIX E
Complete Responses to Question 62
What Unique Hurdles do you Believe Exist for Teaching Technical/Engineering Graphics Education Content through Online/Distance Education?

Number	Response Text
1	software compatability, internet virus
2	Timely feedback to the students and implementing practical CAD exams.
3	teaching lab over the net
4	Learning by direct interaction with the student. You can't teach sketching or instrument drawing by a book/TV anymore then you can teach judo from a book?TV.
5	Maintaining the quality of the teaching and learning environment
6	Students need access to expensive software to complete assignments associated with distance learning. Parametric modelers running on a consistent platform between instructor and various remote student users is difficult to maintain; use of networks for student software access is rather limited when considering performance (computing and graphics) needs.
7	Developing good interactive content.
8	bandwidth, faculty/student interaction
9	grading issues and lecture topics
10	teaching 3D visualization through a 2D medium
11	real time visual interaction is limited. cad software installs.
12	Technology of distance ed
13	Having the time to do. We possess the technology and support to do. Key the time needed to do.
14	No physical contact
15	The decision to use it
16	NonTraditional Students
17	No perceived demand for the distance learning course
18	Time
19	software licensing issues; student access to software; consistence in student tool accwaa
20	Student access to software.
21	I think that there is a necessity for demonstration and personal attention that is not available in on-line/distance education. All of our classes include a lab component with an instructor present. I feel this is a vital experience for the students in learning this material.
22	network banwidth; graphis processing; level of user interactivity; user interaction/group participation
23	Grading takes 1.5X longer than Face to Face courses
24	You need training on how to teach an online course. Blackboard is a must. Also, your administration needs to know that online courses take longer to prepare and to support than an on the ground course
25	Provide students with alternative learning style opportunities. Making the course as interactive and media-rich as a traditional course.
26	1) Licensing of CAD for remote students. This can be handled through cooperation of CAD companies, using 'student versions.' SolidWorks and SolidEdge are very cooperative in this fashion.

	2) Lack of adminstrative/staff support in handling the additional workload typically associated with distance courses. 3) Increased computing requirements, associated with a) bandwidth and b) storage. CAD files are typically much larger and more complicated that what the Distance Education staff are accustomed to. 4) IT policies on servers and faculty access. Due to item 3 above, it is simpler for me to set up and run my own download/upload site separate from the university WebCT/Blackboard system. However, the university frowns on 'independent' faculty distance resources (mostly organizational turf protection issues, which I frequently ignore).
27	Time to develop the new delivery method and time to interact with students once the course is underway. I use D2L in all my classes and it is nice for getting information to the students, but increases dramatically the workload.
28	Have not thought about it.
29	The validity of testing and also could be difficult to answer software specific problems/questions without seeing what the students are actually doing at the time because often what the students say the problem is, and what the problem actually is, are two different things.
30	attitude of management , the dominance of indians so there is only one way of doing the job ,their way , no risks alowed
31	Use of Lecturn and other technology in communicating
32	Providing software for student use.
33	Evaluating sketching assignments.

APPENDIX F
Complete Responses to Question 64
If Yes, Please Detail the Differences.

Number	Response Text
1	more visual / explaination input
2	separate from traditional courses for funding and faculty load
3	Adminstration believe that online courses take fewer hours. But it is actually more.
4	And this is the problem. There is a tremendous start-up overhead for online instruction that is not considered in tenure and promotion decisions. At my institution, no release or extra resources are given to develop an new course or roll an existing course over online. It's just part of your job.
5	Yes, but only a little recognition for the extra work. There is on-going discussion about that issue and proposed changes to the workload document under consideration.

APPENDIX G
Complete Responses to Question 66
If Yes, Please Detail the Differences.

Number	Response Text
1	paid by number of students
2	We don't offer any online courses
3	less in contact hours
4	See above.
5	There is a additional charge per credit hour per student (above straight tuition), of which a fraction (40% or so) is returned to the faculty for expenses. The Engineering course sizes (particularly for those with highly technical content) are never large, so funds are not much. $100's per offering, typically, back to the faculty.
6	do not know

APPENDIX H
Complete Responses to Question 71
If Yes, Please Detail the Differences.

Number	Response Text
1	With a TA, there is typically more contact and control over the course
2	need the expertize
3	Don't understand the question.
4	Difficult to quantify "If communication was sufficient..."
5	Availability, ability to help the student connect with institution, peers, and profession, decreased mentorship role, role in department, communication between dept and instructor regarding student and course needs...
6	A TA often does not have the same frame of reference as anogher nstructor
7	N/A; we do not have teaching assistants lead classes.
8	TAs have a measure of built-in quality control; some things cannot be replicated digitally (non-specific)
9	It would be like the University of Phoenix--you have very little quality control.
10	What does "If communication was sufficient," mean? We don't use TA's for leading classes, anyway, so having an 'outsourced' instructor would be radically different from what we currently do today, anyway. You all need to work on your survey clarity. For example, you don't describe "hybrid" at all. Clueless as to what that means.
11	This really depends on who the course is outsource to. If it is a highly qualified individual in another state, or city that is different than a Teaching Assistant.
12	face to face contact and instructor qualifications could be different
13	Lack of personal contact.
14	background knowledge of the instructor
15	Qualifications and experience of an "outsource" would be held to higher standards. Availability also - TA is generally on-campus full time.

APPENDIX I
Complete Responses to Question 88
In General, What are some of the Major Concerns You Currently have related to the Teaching of Technical/Engineering Graphics Communications at the Post-Secondary Level?

Number	Response Text
1	need to be required more for all engineering majors
2	Route learning memorizing Vs thinking : As many of the staff are Indian the indian style is by memory pass exam but no understanding , just routine . The people who teach drawing have no industrial exposure that has a high drawing content - role of design engineer - appropiate BUT often the lecturer was sales / admin but no drawing
3	Disregard for 3D thinking skills because students cannot draw or relate to 3D images
4	Graphics instruction is being pushed out of a very full undergraduate engineering curriculum. Graphics skill is seen as a tool that can be picked up once the engineer is in the workforce, not as a crucial part of their education.
5	Quality of student leaving high school
6	availability of sections for increasing number of students
7	Will it be phased out of engineering ed
8	None
9	Since we are an engineering program, it is the perception that graphics communications are not necessary in a more and more theory based degree.
10	Cost of Software
11	None
12	Acceptance or importance and relavance
13	the presence of 2D; unwillingness of facultty to change; lack of technical literacy among faculty in the profession
14	Varied background of students wrt 1) previous use of graphics software and 2) reading
15	continued use of manual tools/techniques; some programs lack a strong tie to industry; some programs donot acknowledge the roll of technology in the process
16	Student in the program and retention
17	Perceived lack of relevance.
18	Inability to acquire industry-standard computing and reproduction technologies so that their management can be taught.
19	Engineering Graphics is being belittled as a legitimate area of instruction at most Engineering programs with doctoral degrees, and even with masters as the terminal degree. The reason is that the tenured and tenure-track professors have never actually worked in industry and thus have never used CAD as a communication tool. Related to that issue is the fact that in Engineering programs CAD instruction is not seen as being supported by funded research. That is: Whereas faculty and administrators see fundamental courses such as Statics and thermo to support higher-level courses which can educate students to, in turn, be research assistants,

	and thus bring in research, they do not view engineering graphics in that manner.
20	Workloads are high. Technical research is valued higher than teaching. Classes sizes are growing without additional resources. Students want on-line courses. Adminstration wants on-line courses.
21	At my university, it is not considered a priority and the number of offerings has become fewer and fewer.
22	declining visualization skills of incoming students ABET has removed graphics communication from its list of key skills for engineers continued problems with interoperability
23	a dominance of indian teaching staff have no industry contact but teach from the textbook, all by memory none by thinking , same rigid methods
24	Finding common themes in professional organizations. Increasing the number of research based papers in our journal.

APPENDIX J
Complete Responses to Question 89
In General, What are some of the Future Trends You see Happening within the Next 5 Years as it relates to the Teaching of Technical/Engineering Graphic Communications?

Number	Response Text
1	more desktop, animation, simulation, and technical presentation
2	less value on manual drawing , more on Autocad - industry expectation , subject becomes a routine
3	Depts will cut back for more sexy programs
4	I think students will be expected to "pick up" graphics skills online. There will be a greater need for self-paced online instruction catering to particular industries and fields.
5	synthesis of knowledge across related courses - interdisciplinary learning and use of multiple technologies
6	on line
7	The most significant would be efficiency (vs effective[ness]) of delievery and the continued migration to online and distance delievery of instruction.
8	Hardware
9	More graphics Application Using Technology
10	assuming the knowledge of projection theory to be done by computer
11	Less hands on drawing & sketching and more computer
12	increased 3D interoperability; enhanced user interfaces
13	don't know!
14	CAD will continue to be a commodity; geometry automation will make emphasis on geometry creation less important; simulation and other PLM-related activites will increase
15	Integration with the math and sciences to provide applied learning opportunities in the traditional math and science classes.
16	fewer full time faculty
17	Improved CAD pagages.
18	Technical/engineering graphics will become less of a field of study and more the result of something else (manufacturing, simulation, process control, PLM, etc.)
19	I see CAD instruction as a class in itself vanishing in our program offering. Students will instead be given an instruction manual and told to do the tutorials as all they need to do. Then, after 4 years when the industrial advisors scream that our students are completely clueless at how to actually do real engineering work, we will bring it back.
20	Can't afford the software costs and we are going to a laptop program which will add its own set of challenges.
21	increased capabilities of computer systems for 3D displays and input technologies (holography, VR, force-feedback devices, etc) better integration of CAD/solid modeling with analysis and manufacturing applications more "smart" modeling and analysis systems - building in design rules and checking designs
22	more computer graphic less manual drawing, greater industry related courses

23	Less on pencil-paper exercises, more on CAD
24	More with online learning.

APPENDIX K
Complete Responses to Question 90
What Type of Professional Activities Do You and Your Faculty Participate in on a Regular Basis that Relate to Graphic Communications? Please Describe Each Activity.

Number	Conferences	Workshops	Training/Seminars
1	ASEE		
2	none	none	none
3	Publishing and presenting	we offer and attend workshops (3D constraint based modeling and rapid prototping)	(3D constraint based modeling and rapid prototping)
4	ASEE Annual Conference		
5	ASEE conferences		
6	50	90	50
7	yes	yes	yes
8	EDGD conf & ASEE		
9	Attend and participate	Rarely	Rarely
10	EDGD, ASEE		
11	ASEE - EDGD		
12	NAIT, ASEE ADGD, ACAT		
13	2 ASEE Meetings	1 Every 5 Years	1 Every 5 Years
14	goint to them	attending them	attending them
15	yes	yes	yes
16	yes	yes	sometimes
17	EDGD, NAIT, ASEE, IEEE	NSF	industry-led training (take and provide)
18	attend and present	develop and deploy	
19			skills for software
20	EDGD		
21	Yes, several each year	Ocassionally when a topic is of interest	Ocassionally when a topic is of interes
22	0	0	0
23	Rare.	When close and travel costs are reasonable.	When close and travel costs are reasonable.

24	ASEE and NAIT conferences	Give workshops for high school teachers	
25	ASEE/EDGD		Software User Group meetings
26	0	0	0
27	Attend and present papes		Software training
28	Yes	Online learning tools	Online learning tools
29	yes	yes	many

APPENDIX L
Complete Responses to Question 91
How do you keep up With Changes in the Curriculum?

Number	Response Text
1	Conferences and learn on own
2	Reading journals and professional magazines. Contact with professional engineeirng personnel in industry
3	I don't
4	Read publications, conference proceedings
5	EDG journal, ASEE confernces
6	Change as change is needed.
7	attend workshops
8	yes
9	Reading, practice, visiting with others, working with others, listservs, emails, conferences, conventions, online resources....
10	Attend Conferences and keep up with software changes
11	Mailing, Journals
12	Self-Taught
13	Listen to my industrial advisory board and work in industry
14	reading journals, trade magazones, att4nding proessional conferences
15	Mostly learn on my own.
16	reading technical publications, trade magazines, relevant journals
17	attend conference read materials and web
18	online training and local users group meetings
19	Read, attend conferences, talk with our advisory committee, serve on accreditation visiting committees.
20	Review technical and industrial articles. Attend occasional presentations at more general Engineering Education conferences (such as ASEE or FIE).
21	Read journals and websites.
22	Follow whatever changes are implemented by the chair and update courses as necessary
23	EDGD conferences
24	- professional memberships, international correspondence
25	Lots of hours working to keep up with new technology, training courses, etc
26	Review and revise.

APPENDIX M
Complete Responses to Question 92
How do you keep up with the Changes in Software?

Number	Response Text
1	learn on own
2	technical journals
3	I don't
4	very difficult with high priced software
5	Get the new versions and teach myself to use them.
6	Conferences, journals
7	Review the software before each offering.
8	check out the software ahead of time
9	training/seminars/conferences
10	Learn it on your own
11	Reading, practice, visiting with others, working with others, listservs, emails, conferences, conventions, online resources....
12	Rewrite our workbooks each year to keep current with the new releases.
13	Mailing, Journals, Trade Shows
14	Self-Taught
15	New software comes, I use it/
16	vendor demois
17	Mostly learn on my own.
18	out of my hide
19	Be self directed and learn it.
20	go through what's new and local users groups
21	Follow new issues, conferences, seminars.
22	Work on the weekends and over summer with new releases.
23	Take an occasional local workshop which is sponsored by the CAD commercial provider.
24	Some training, but largely on my own.
25	Make sure I attempt all of the projects I assign my students so I can know where the problems may occur and also update the tutorials I use to reflect the new version of the software. Sometimes I am barely one step ahead of my students in learning how to use the software. However, the focus of my courses is not on software, it is on the theory behind engineering graphics so the students will be prepared for their future jobs regardless of the software that they will be using.
26	User groups
27	try out the new trial editions
28	Users groups. Visit industry.
29	constant training and tutorials

APPENDIX N
Complete Responses to Question 96
Which Conferences do You Plan on Attending in the Next 5 Years?

Number	Response Text
1	asee
2	- engineeirng education confrences - seminar -
3	none
4	ASEE, ASME, IJME,
5	ASEE Annual
6	ASEE
7	EDGD
8	ASEE annual, ASEE-EDGD midyear
9	NAIT, ASEE-SE, ASEE, EDGD at the very least.
10	ASEE, EDGD
11	ASEE-EDGD AutoDesk University
12	NAIT, ASEE ADGD
13	ASEE, CGEE, ASME, NI Week
14	Autodesk University
15	COE; PLM Connection Americas; SIGGRAPH
16	don't know
17	ASEE, EDGD, NAIT, 3D Interop, CIEC, CADA, COE, PLM Americas
18	ASEE, ATECON, NAIT, Autodesk University
19	SolidWorks World
20	EDGE Midyear
21	ASEE. EDGD, NAIT
22	FIE ASEE ASME region 9 student leadership conference, as advisor
23	ASEE 2009 midyear
24	ASEE Annual Conference NAIT Annual Conference
25	ASEE annual meetings, EDGD midyear meetings, EPICS conferences, perhaps ASME annual meeting, perhaps ISGG meetings
26	engineering, education,graphics , HSE
27	ASEE, IIE, CIE
28	EDGD Midyear

	ASEE Annual ASEE-SE Section ITEA ICGG UNC-TLT

APPENDIX O
Complete Responses to Question 97
Which Workshops do You Plan on Attending in the Next 5 Years?

Number	Response Text
1	nsf
2	none
3	PTC - PRO/Engineer university courses offered by PTC, INC.
4	cad & DE
5	online, Moodle, etc
6	any given at the midyear
7	No plans.
8	Autodesk University
9	don't know
10	IEEE VR
11	Midwest coalition for comprehensive design education workshops this summer 2009
12	What new through local reseller
13	unknown--I don't think that far ahead.
14	Course delivery workshops D2L.
15	don't know - will decide as they become available
16	HSE
17	Online tools.

APPENDIX P
Complete Responses to Question 98
Which Training/Seminars do You Plan on Attending in the Next 5 Years?

Number	Response Text
1	solidworks
2	none
3	PTC - PRO/Engineer university courses offered by PTC, INC.
4	No plans.
5	SolidWorks training
6	Autodesk University and locally available
7	don't know
8	PROE training.
9	ditto
10	Delmia, Catia
11	Online tools.

APPENDIX Q
Complete Responses to Question 100
If Yes, Please List the Conference Title(s) and the Year(s).

Number	Response Text
1	asee itea
2	ASEE-Nashville IJME- Nashville many others
3	NAIT, EDGD, ASEE-SE, and ASEE
4	ASEE-EDGD Mid-Year conferences
5	ASEE Annual ASEE EDGD Midyear ASEE GSW Section
6	Local users groups
7	EDGD 2005, 2006, 2007 ASEE 2006 NAIT 2006 IJME 2006, 2008
8	ASEE collaborative communications -- Autodesk unvirsity Collaborative design techniques
9	EDGD and ICGG
10	EGGD Midyears
11	Oh, come on!
12	FIE (all years since 2002, I think) ASEE national, 2004 and 2007
13	ASEE Annual Conference 2003, 2004, 2005, 2006, 2008
14	EDGD and ASEE annual meetings, most years
15	EDGD Midyear (last five years) ASEE Annual (last five years) ASEE-SE Section (last five years) ICGG (this year) UNC-TLT (2006)

APPENDIX R
Complete Responses to Question 105
Over the Last Five Years, What Strategies have You Initiated to Deal with Teaching Problems (i.e. having to Teach Software, Visualization, etc.)?

Number	Response Text
1	using blackboard or related software
2	digital photography - and powerpoint - more visual for students with english as second language, student teach student - learning process, use of small presentations such as the Chemical safety Board , use of websites for reference rather than textbooks
3	use of physical models out of paper or cardboard
4	More online instruction with videos
5	Learn the software, teach the software - integrate so that learning is holistic and as simple as possible
6	Use online instruction to supplement inclass lectures.
7	wrote books on the software
8	gone to workshops and week long training sessions
9	Self-Taught Studies
10	I've been doing this for nearly forty years, dealing with problems requires individual solutions and constant work, same as ever.
11	Additional access to lab/software outside of class hours.
12	obtain more funding to hire more TAs
13	Sit down and learn it -- don't gripe
14	Take time out for professional development in training how to use these software tools well
15	Emphasize sketchin techniques of pictorial sketches to aid visuzlization
16	I have created Flash animations of many of the teaching topics in 2 courses so that they can be viewed online.
17	I teach an elective "Advanced CAD/CAM" class, which is evenly divided between advanced Engineering Graphics and Computer-aided manufacturing topics. I insert 'remedial tutorials' for seniors in the ME Capstone design class, as these students are not challenged to use CAD since their freshman year (unless they take my Advanced CAD/CAM class).
18	?
19	Due to problems with computers and other lab equipment, have worked more with sketching and hands on activities, also have relied less on certain software and more on theory
20	using peer tutors in CAD lab
21	peer learning, use of models , use powerpoint rather than the writing on hte board
22	Spend more time outside of class offering help sessions in open lab.
23	Go to workshop, learn on my own, ask questions.

APPENDIX S
Complete Responses to Question 107
If Yes, Please Explain.

Number	Response Text
1	The visual commuicates and the process of student explain to the next student When the student explains to another student learnig takes place
2	Students can see what they are drawing
3	Student have said this was helpful
4	It connects with a wider range of learning styles.
5	students review you as the expert
6	allows me do understand issues and be a better prepared teacher
7	Get Good Student Ratings in Graphics Courses
8	Any other opinion implies wasted effort. Of course a change in student achievement is not necessarily an improvement in student achievement
9	Students are able to become more comfortable with the software tools.
10	student environment more readily linked to relevant industry research
11	Student results show vast improvement
12	Students respond better when you are self confident. Results were far better when we switched to teacher SolidWorks first for visualization
13	Producing a sketch gives a tactile aid to visualization, to attempt to jump from a though, directly to a virtual solid model is more difficult for most students.
14	Online students have access to the same software demonstrations I deliver to face-to-face students.
15	Students routinely return to NAU after graduation and their first employment stating either 1) "The CAD/CAM class was directly related to supporting me in my first job," or 2) "I wish I had taken the Advanced CAD/CAM class because it would have helped me get started." There is very little commentary outside either of those, related to Engineering graphics. Even the graduate students state that their own research experiences fall into one of those two categories. No one says engineering graphics is not applicable to to their job, period.
16	Students seem to be able to build more robust solid models and make neater drawings.
17	use of models of foam made from foam packing scrap has shown hte idea of 3D and 3rd angle projection , peer learning , photographs and powerpoing presentations combine to effectively teach drawing
18	Increase student contact with the software/material in a structured environment.
19	Spent more time using learning objectives.

APPENDIX T
Complete Responses to Question 109
If Yes, What are the Areas of Emphasis?

Number	Response Text
1	general engineering design
2	industry , the grapics forms the basis
3	graphics etc
4	Mechanical and Architectural
5	virtual product integration; aniamtion and gaming; interactive media; construction graphics
6	none (Drafting A.S.)
7	virtual product integration, interactive media, animation & gaming
8	Mechanical Engineering
9	2 year degree in Engineering Design
10	BAS in Technical Graphics with an emphasis on document management.
11	industry related , graphics is one of the subjects in a diploma
12	Technical graphics and some softer graphic technologies.

APPENDIX U
Complete Responses to Question 111
If Yes, What is the Total Number of Hours Needed to Obtain the Minor?

Number	Response Text
1	15
2	15
3	15
4	15
5	30
6	Tech Block in ME
7	15
8	15
9	-----
10	15

APPENDIX V
Complete Responses to Question 115
What is the Title/Name of the Degree?

Number	Response Text
1	technology education
2	teach at Diploma in Engineering (one level below degree)
3	we are community college
4	Design
5	AAS in Engineering Technology Design
6	Associate of Science in Engineering Design
7	Maste of Science in Technology
8	certificates and diploma
9	AS Engineering
10	Technology Education

APPENDIX W
Complete Responses to Question 116
How Many Students do You Estimate Graduate with Your Programs' Degree in Graphics in a Given Year?

Number	Response Text
1	12
2	20
3	30
4	100
5	10
6	90
7	12
8	20
9	15-20
10	0
11	20

APPENDIX X
Complete Responses to Question 119
What Areas of Research Are You Working On?

Number	Response Text
1	visualization and materials development
2	Health and Safety - student projects to serve the local hospital
3	Improving delivery of graphics skills and relating to overall educational performance.
4	My title is Director of Engineering Graphics, an administrative position, I don't do research
5	Rapid product development methods, improving the efficiency of rapid prototyping processes and methods, Spatial Visualization Ability, and increasing energy efficiency of appliances
6	None
7	Educational
8	none
9	Student recruitment and retention.
10	Textbook development
11	Computer Graphics Modeling
12	data interoperability; PDM interoperability; graphics standards; lightweight data formats
13	none (teaching institution)
14	3D data interoperability; PDM interfaces; 3D scanning; geometry automation
15	PLM techniques
16	STEM education for K-12
17	Armour
18	Visualization
19	Engineering Education Rapid prototyping Medical imaging and processing Small engine performance
20	-
21	Visualization
22	graphics and engineering design curriculum development rehabilitation and assistive technology
23	HSE , Mechatronics, biomedical
24	Innovative approaches to teaching collaborative design
25	Online instruction.

APPENDIX Y
Complete Responses to Question 121
What Grants Are You Currently Involved In?

Number	Response Text
1	GRIDc, and private funding
2	no grants
3	none
4	DOE
5	None
6	0
7	Step grant
8	None
9	NSF ATE; Dept. of Labor; 4 industry grants
10	n/a
11	NSF-ATE (PPLM curriculum) DOL (PLM curriculum; distance delivery) ATI/NIST (3D data formats) Other industry-based research
12	Small State grant
13	The EnViSIONS grant with Sheryl Sorby
14	NASA biomedical imaging Others are not for public release at this time.
15	-
16	funding for EPICS program
17	--
18	Blended learning

APPENDIX Z
Complete Responses to Question 122
What Types/Topics of Research Areas Are You Interested in for the Future?

Number	Response Text
1	developing a teaching program for graphics educaiton
2	Industry focused / problem solving
3	Most higher ed. engineering graphics is mechanical cnetric. More should be done for AEC applications!
4	Same
5	None
6	Educational
7	Student recruitment and retention.
8	Differences in Native American visualization techniques and results.
9	CAD & VR; graphics standards
10	n/a
11	3D interoperability/collaboration Knowledge mapping/modeling Distance delivery mechanisms
12	Distance education for engineering graphics instruction
13	I'm getting ready to retire so my research interests are few.
14	Engineering Education issues in student motivation Rapid prototyping in metal formed products Medical imaging and prototyping
15	Health and safety and environment, drawing / graphics/ biomedical
16	same as above

APPENDIX AA
Complete Responses to Question 123
What Graphics Related Grants have You Received in Your Career?

Number	Response Text
1	VisTE: Visualization in Technology education
2	none
3	none
4	0
5	None
6	0
7	none
8	n/a
9	NSF (4-5 grants in past)
10	too many to name
11	n/a
12	5 totaling over $2 million
13	NSF STEM Pipeline fund
14	Only the above--NASA Biomedical imaging. It was limited funding for student support only.
15	-
16	software grants
17	0
18	spatial visualization grants

APPENDIX BB
Complete Responses to Question 126
What do You Feel are the Main Topics of Research that are needed for our Field?

Number	Response Text
1	more emperical based research for how to better teach visualization
2	no , the college is application - industry problem solving
3	realting visual graphics to college educational performance
4	true reverse engineering
5	integrated design projects
6	Graphics Applicatiions Using New Technologies for Visualization and Presentation of Ideas and Models
7	See 4 above.
8	Women thinking and graphics skills
9	use-inspired research; rgaphics implementation more aligned with industry; visualization
10	How to best teach the use of software along with graphics fundamentals -- is software use best taught through instructor-led group instructor, through self-paces indivudal tutorials, through small-group learning, though other means?
11	data interoperability; techniques for accurate geometry automation; spatial abilities as they relate to geometric modeling; memory parsing techniques for CAD systemes to handle large assemblies
12	Updating topics taught in the classroom to be more aligned with industry requirements
13	Manufacturing standards and interface
14	How to integrate visualization and graphic communication throughout curricula (like reading through the curriculum) in an environment where free-standing graphics courses will become a thing of the past.
15	Medical imaging. Simulation data processing (CFD, for example, is a very hot area).
16	Improving below average visualization abilities in underserved populations
17	better methods for student assessment
18	Long distance collaboration on design projects
19	graphics education

APPENDIX CC
Complete Responses to Question 127
What Role do You Think Graphics Will Play in Game Art and Design?

Number	Response Text
1	It is a future area for our profession
2	effective communication
3	don't know
4	no idea
5	as a tool for visualizing and illustration
6	minimal. Art lays claim to this.
7	Big Time
8	Graphcs is game art design.
9	A lot
10	a big one
11	don't know
12	a big one
13	Make it more real - eventially involve physics and 3D at a higher level
14	Since 90% of the production is out-sourced from this country, its got to be product planning, marketing, and the business of gaming.
15	From an "Engineering" point of view, very little (except for human factors/vision). I suspect it will lay solidly in the Computer science area for research, as the topic is very much involved with data processing, not engineering in the classic sense.
16	What role will gaming and art play in graphics education? computer graphics for the entertainment industry has provided much of the research that has gone into displays for CAD systems. Engineering graphics benefits from that research much more than the converse.
17	communicate HSE issues
18	don't know