Engineering Graphics Instruction Outside of the Lab: How prepared are our students?

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Abstract

The 1990's have seen a rapid expansion of the use of networked computers on college and university campuses. By the Fall of 1995, half of all college students and faculty had recurring instructional experience with information technology while more than half of all college students and three-fourths of faculty had access to the Internet and WWW. This infusion of computer technology has had a significant impact on how and what students are taught in engineering design graphics. Though the establishment of computer labs on campuses has hit near saturation, instructional issues concerning the use of computers in engineering graphics are still evolving. As more and more instructional activity takes place outside of traditional labs via distance education technologies, what access students have to computing resources at their homes or dorms and what computer skills they possess to use these computer-based tools becomes increasingly important. Instruction taking place outside of traditional computer labs provides fewer opportunities for instructors to provide remediation in computer skills. This paper will report on a survey of students enrolled in engineering design graphics courses at NC State University the Fall 1999 semester. The results of this survey provides a snapshot of how prepared students currently are to make use of computer-based instruction within and outside of traditional labs.

I. Introduction

The instruction of engineering design graphics has always been closely linked to technology. Whereas the technology used to be based on manual instruments such as compasses, T-squares, and triangles, in more recent years the tool of choice has been computer-based CAD systems. What has not changed at many institutions has been the centering of the engineering design graphics curriculum around the on-campus laboratory. While the focus of the lab has shifted from instruction in manual instruments to computer-based CAD software, pedagogically the strategy has continued to be one-on-one interaction in a laboratory environment between an instructor/tutor and the student. With the rapid expansion of networked computer technology on and off campus and the instituting of distance education courses, the question arises how this lab-based model will

evolve and whether our student body is prepared for a possible move away from the current one-on-one instruction they are receiving. This article outlines current trends in campus computing, the current state of computer literacy of students taking engineering graphics courses, and curricular issues impacted by these findings.

II. Current trends in academic computing

The new millennium closes a decade that has seen a rapid expansion of the use of networked computers on college and university campuses. By the Fall of 1995, half of all college students and faculty had recurring instructional experience with information technology while more than half of all college students and three-fourths of faculty had access to the Internet and WWW [1]. More recent surveys show a continuing upward trend in the usage and perceived importance of networked computing based activities. The Campus Computing Project [2] reports that 59.3 percent of all college courses now utilize electronic mail, up from 54.0 percent in 1999 and 20.1 percent in 1995. Similarly, 42.7 percent of college courses now use Web resources as a component of the syllabus, up from 10.9 in 1995.

Coupled with the trend of increased computer usage on campus is the requirement by some universities to require students to purchase a computer when they come to campus [3]. While currently only ten percent of campuses require computer purchases, this trend is expected to increase sharply. NC State University currently has a computer purchase requirement in place for a few of its professional programs; this is likely to expand to undergraduate programs, such as engineering, for the 2001-2002 academic year.

Mandatory computer ownership opens the doors for expectations of computer access that did not exist before. While at many institutions, there could be an expectation of computer access on campus; this expectation could not be extended to a student's place of residence. This fact made it difficult to structure courses with a distance education component (either partially or completely off-campus). With mandatory ownership, faculty designing courses can now make the assumption that students have access to computers while off-campus.

A recent survey of higher education faculty [4] found that one in ten faculty had taught a distance education course in the last five years that this number was expected to increase in the years to come. The group that conducted the survey noted that the stereotype that the only people taking distance education courses were older adults going to school part-time simply was not in line with the survey results [5]. While the Web and other Internet technology was increasingly being used for distance education courses, the typical student was taking the course in the same state as the college or university offering the course. The faculty surveyed had apprehensions about distance education but felt that if properly structured, it could offer a quality educational experience. Against this backdrop of optimism, though, is considerable hearsay evidence that drop-out rates in distance education courses are higher than they are in traditional courses [6]. Some point to the lack of regular face-to-face contact as one of the contributors to this higher drop-out rate. The lack of necessary computer skills is also seen as a roadblock to successful completion of a course [5].

Trends in computer ownership and use among students and the increased offerings in distance education point to the opportunity to offer engineering design graphics courses where students complete some or all of their work from their residence using their computers. The question arises as to how easy it will be to translate what currently takes place is a more traditional lab setting (including those that make heavy use of computers) to a asychronous, distance education format. To take NC State University as an example, students taking all levels of engineering design graphics courses spend one half or more of their class time in lab. Of this time, a majority of it is in computer labs on campus. During these sessions, students receive considerable one-on-one, small group, or whole class instruction on the use and application of CAD software. If these courses were to move labs to being delivered via computer in an asynchronous format, some of the immediate questions that would arise would be:

- Even if the College of Engineering is to require computer ownership, other Colleges, which have students taking graphics classes, may not. Will a majority of students have computers to use to complete the course in their place of residence?
- If students currently own a computer, how are they currently being used, and does this usage differ based on their major and which engineering graphics courses they are enrolled in?
- Do students currently have the computer skills necessary to use computer-based instructional material? In addition to CAD software, are they well familiarized with email, WWW and related Internet applications increasingly being used in distance education courses?

A survey of students enrolled engineering design graphics courses at NC State University in the Fall of 1999 was conducted to address these and other questions.

III. Results

Table 1 shows key demographics of the survey respondents. Of the 281 respondents, a large majority already owned a computer and were full-time students. A large majority were also enrolled in the College of Engineering, primarily in the departments of Mechanical, Aerospace, Civil, and Industrial Engineering. Students outside of the College of Engineering came from a variety of disciplines, including Technology Education, a degree program housed in the home department of the engineering design graphics faculty. Of the students taking graphics class and responding to the survey, a large majority were enrolled in one of 3 lower level (introductory) courses with the rest enrolled in one of 5 upper level courses being offered the Fall 1999 semester. Following national trends, a large majority of the students responding to the survey were white males.

Table 1. Demographics of survey respondents

	Yes	No
Own Computer?	231 (82.2%)	50 (17.8%)
Full Time?	273 (97.8%)	6 (2.2%)
Engineering Major?	233 (82.9%)	48 (17.1%)
	Lower	Upper
Course level	226 (80.4%)	55 (19.6%)
	Male	Female
Gender	245 (87.8%)	34 (12.2%)
	White	Non-White
Race	235 (84.8%)	42 (15.2%)

Another demographic factor of interest was the age of the respondents. Figure 1 shows that a majority of students are young adults who entered college directly out of high school. Both the engineering and non-engineering majors show the same trend of clustering around the 19-21 year age range with engineering majors showing a few students in the older adult ages.

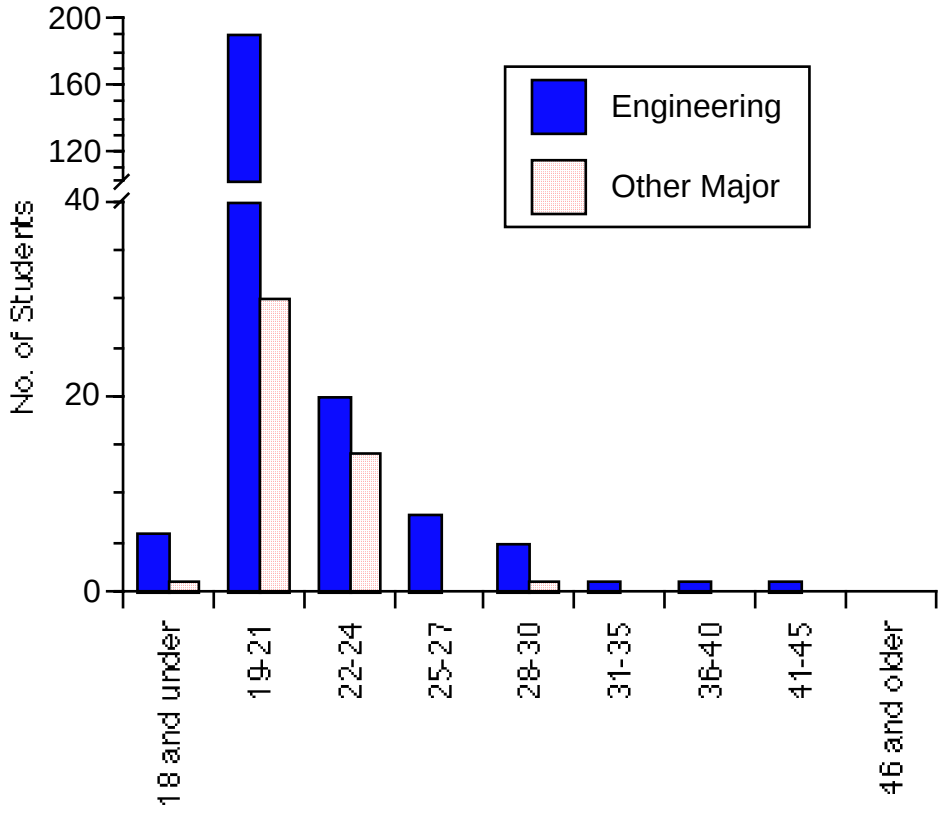

Figure 1. Respondents by Age

Looking more closely at computer ownership, a two-way analysis of variance showed no significant difference in computer ownership between engineering and non-engineering majors or between students enrolled in a lower-level (introductory) graphics course or an upper level course. For example, 18.5% (N=43) engineering students did not own their own computer while 14.5% (N=7) non-engineering students did not. Also of importance was the age of the computer the students own, where age provided a rough approximation of the power and capability of the computer. As seen in Figure 2, a large majority of engineering students owned computers that were no more than 2 years old, while non-engineering students had computers that were more widely distributed in age. Even though a majority of engineering students had relatively new computers, approximately 40 engineering students had computers 3 years or older. A Spearman correlational analysis showed a significant positive correlation ($p < .013$) between the age of the student and the age of the computer.

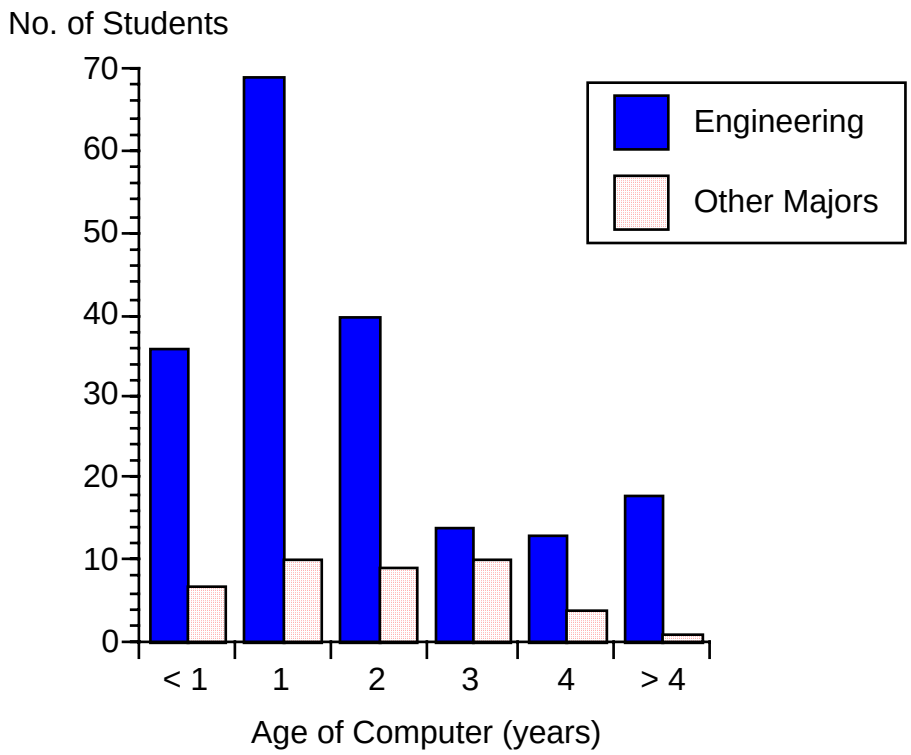

Figure 2. Computer Age

Looking at self-reported usage of computer software for all students, 51.6% of respondents indicated they used e-mail software 0-1 hours/week and 21.7% between 1-2 hours/week. Of the students responding to the survey, 21.4% of respondents indicated they used web browsers 0-1 hours/week and 14.9% between 1-2 hours/week.

Students in lower-level courses reported significantly ($p < 0.004$) more use of web browsers (M=6.4 hours/week for lower-level students versus 4.4 hours/week). There was also a significant difference ($p < 0.0001$) in the self-reported usage of CAD software between lower and upper-level students (M=6.6 hours/week for upper-level students versus 2.7 hours/week). A two-way analysis of variance also showed a significant difference in the self-reported usage of spreadsheet/database software between engineering and non-engineering majors ($p < 0.006$) and lower and upper level students ($p < 0.006$). There was no significant interaction between these two factors. No significant difference in e-mail, word processing, or presentation graphics software was seen based on either major or course level.

Coupled with the above findings, a significant negative correlation was found between age and e-mail usage ($p < 0.017$) and Web usage ($p < 0.028$). Conversely, a significant positive correlation was found between age and spreadsheet/database usage ($p < 0.002$).

Focusing in on CAD usage, survey respondents were also asked to report on their perceived level of skill and perceived importance of CAD software to their major. There was a significant correlation between reported usage level and perceived skill ($p < 0.0001$) and between reported usage level and perceived importance ($p < 0.001$).

Survey respondents who owned computers were asked questions concerning how much they used their own computers for specific activities, namely: school, (paid) work, and leisure (see Figure 3). There was no significant difference in school and work usage of their home computers on the basis of major or course level. However, a two-way analysis of variance did reveal a significant difference in leisure usage based on course level ($p < 0.001$) and a marginally significant difference on the basis of major ($p < 0.053$, M=7.5 hours/week for non-engineering students versus 5.9 hours/week). It follows that there was a significant negative correlation between age and leisure usage ($p < 0.002$) and between age and total usage of their home computer ($p< 0.004$).

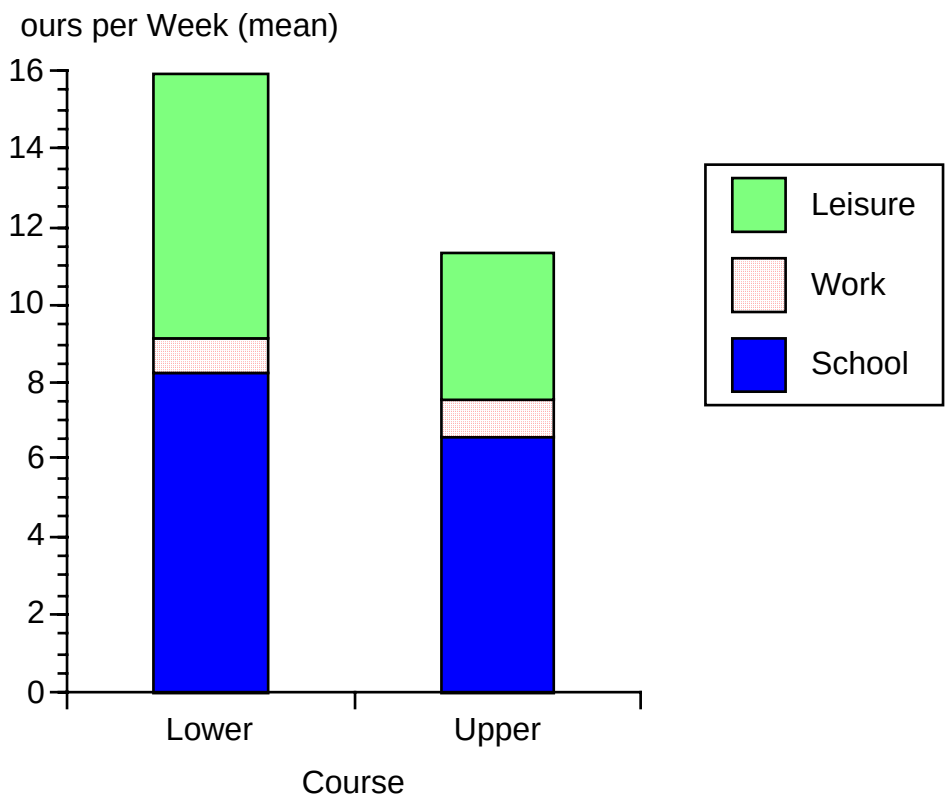

Figure 3. Home computer usage by lower/upper level course

IV. Discussion

Results of the survey of NC State University students taking engineering design graphics courses the Fall of 1999 clearly reveal a population well versed with using computers. Still, if this population is representative of students at other large universities across the country, it does raise issues regarding the questions asked earlier in the paper.

While a majority of students taking graphics courses do own computers, this number is not at 100%. If computer lab activities were restructured with the expectation that students had access to computers at their place of residence, roughly 15% of students currently taking graphics courses would not meet this. Unless a university-wide computer purchase requirement was put in place, there would be a percentage of students who are likely to be restricted to on-campus labs. While the percentage of students owning computers has certainly grown considerably over the last 5 years without mandatory purchase requirements, it could very well be that closing the last few percentage points at public colleges and universities will be difficult without financial aid.

Related to the ownership of computers is the age of the computers owned by students. The results of the survey indicate that the majority of computers owned by students are relatively new and are likely to be able to handle the computationally and graphics intensive CAD software often being used in graphics courses. Still, a significant minority of students (especially non-engineering majors) do own older machines that may not be capable of running the latest 3D modeling packages. Also of note is the correlation between the age of the student and the age of the computer. One way to interpret this result is to assume that many students buy their computer as freshmen and hold them through their senior year. Given that many of the upper-level courses taken by upper-classmen involve the most computationally intensive CAD work, some juniors and seniors may find themselves without computers capable of handling the work. Discussions of mandatory computer purchases at NC State have also included proposals for leasing arrangements for swapping machines out after two years. This seems to be a wise course of action.

One way of measuring students' readiness to conduct schoolwork using computer-mediated communication is to look at their current use of Web and e-mail software. While a large percentage of students surveyed own computers, it turns out that it would be a bad assumption that these students were heavy users of the Web and e-mail. Over half the respondents reported rarely ever using e-mail while more than 35% reported using the Web less than 2 hours per week. Clearly these sorts of numbers would have to change if students are to take courses that relied on the Internet for a large percentage of the instructor/student interchange. While many people consider e-mail and Web browsers to be intuitive tools, there is reason to believe that it takes time and experience for students to be able to use these tools effectively. This time may not be available during a rapidly moving course. This experience level also seems to be tied to some degree to age as witnessed by the heavier use of the Web by lower-level students and the negative correlation of age and Web and e-mail usage. This result may indicate the arrival on campus of a more Internet-savvy student population.

CAD software usage clearly went up as students moved from the lower-level courses to the upper-level courses. This result parallels the current structure of our courses. Not surprisingly, the students' reported skill level and perceived importance of CAD skills to their major also increased as their usage went up. What this survey does not do is specifically provide guidance as to how critical CAD usage in the context of a traditional lab is for developing this ability and appreciation for CAD expertise.

Building on the finding that younger students were bigger users of e-mail and Web tools, there was also a negative correlation between total usage of their home computer and age. Interestingly, this difference between the lower-level (presumably younger) students and the upper-level students had less to do with the amount of time spent on school work, but in using the computer for leisure activities. It seems that the new wave of students are bringing computers to school not just for academics, but for their all-around school experience.

V. Conclusion

While this survey and article has addressed many of the basic, functional issues concerning the preparedness of the current student body at NC State to move to asynchronous, computer-mediated courses, it does not address key pedagogical issues concerning the content, media, delivery, and logistics of managing such a course. Recent literature by Brown, Carr, the NEA and others [4,6,7] clearly indicate the holistic approach that needs to be taken to transforming traditional courses to using asynchronous, computer-mediated technologies.

Most of the discussion has been on the conversion of traditional lecture-based courses to distance education courses being offered nationally. At NC State, there are quite a few students who struggle to schedule lab-based engineering graphics courses, either because of lack of available slots in small-section lab courses or because of scheduling conflicts arising from the large time slots occupied by the lab courses. For most engineering graphics instructors, the task is a different one that involves the transformation of a lab-only or lecture/lab course to be offered to full-time students at the home institution or living in-state. This could be seen as a hybrid course, involving the use of distance education technology combined with some face-to-face meeting with students. Such a course involving both lecture and lab components will take even more thought concerning the computer capabilities of the students and the transformation of lab activities that provide a positive learning experience for the students.

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