

A Survey of Graduate Students as End Users of Computer Technology: New Roles for Faculty

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This survey research study used an extensive questionnaire to examine the academic computing attitudes, uses, needs and preferences of a sample of over 300 graduate students in four programs of an education department in a northeastern U.S. university. The results demonstrated that, overall, students were positive about the use of computers in their graduate work and used computers frequently for various academic purposes. They had completed instruction in a range of applications and wanted much more computer-related instruction, primarily through university workshops and the integration of computer use in their courses. The study also indicated that age and graduate degree status had little effect on differences found among students on these variables and that gender had no effect. Noteworthy program effects were uncovered. Concluding comments and implications are presented regarding the changing instructional role of faculty in the growing computer climate in higher education.

The role of computers in the academic lives of college and university students is a relatively new phenomenon (Anglin, 1995; Henry & De Libero, 1996; Saettler, 1990). As recently as the early 1990s, paper, pencils, pens, and typewriters remained the tools most students used to record ideas. Libraries, bookstores and the postal system were their sources for texts and periodicals, along with image archives and television for visual media. Classrooms, offices, lounges and coffee shops were their options for meeting with professors, peers, and visiting professionals and scholars—extended by telephones and answering machines, notes, and letters for communication at a distance. Most students' exposure to computers, if at all, was restricted to mysterious, room-size mainframes at the data analysis stage of master's theses or doctoral dissertations. However, with the diffusion of personal computers, productivity software, multimedia and network resources over the last decade, all that has changed dramatically. The Campus Computing Project's recent survey shows that computer technologies have become "core components of the campus environment and the college experience" (Green, 1998, p. 3). And according to a current survey of first-year students,

sponsored by the University of California and the American Council on Education, computer network use "has become a way of life for the majority of students" (Sax, Astin, Korn, & Mahoney, 1998, p. 3).

Recent studies suggest that many undergraduates spend more time in computer environments than in classrooms, viewing personal computers and network connectivity as equally essential to their studies as professors and libraries (Corporation for Public Broadcasting, 1994; Green, 1998; Sax et al., 1998). They use computers around the clock to accomplish a wide range of academic tasks (Anglin, 1995; Green, 1998; Romiszowski & Mason, 1996; Scott, Cole, & Engel, 1992). Many prepare course assignments, make

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study notes, tutor themselves with specialized multimedia, and process data for research projects. Most exchange e-mail with faculty, peers, and remote experts. They keep up-to-date in their fields on the Internet, accessing newsgroups, bulletin boards, listservs and websites posted by professional organizations. Most access library catalogs, bibliographic databases, and other academic resources in text, graphics, and imagery on the World Wide Web.

The Corporation for Public Broadcasting's 1994 study of instructional technology use at 2000 U.S. institutions of higher education found that most students were already using word processing for academic purposes; many were also using spreadsheets and graphics applications. More recently, in the Campus Computing Project's survey of nearly 600 U.S. colleges and universities, institutional representatives estimated that half their students used the Internet daily for their studies and nearly half used e-mail regularly for academic purposes (Green, 1998). These figures were even higher according to a current survey of first year students, based on data collected from 275,811 students at 469 U.S. institutions; in response to questions about Internet use, posed for the first time in the survey's 33-year history, 83% of new freshmen reported network use and 66% reported e-mail use on a regular basis for course-related purposes (Sax et al., 1998). The Corporation for Public Broadcasting also found that 90% of students with experience accessing information electronically found it moderately to very useful to their school work. And according to our more recent study, the subject of this paper, students agreed that it would be difficult to accomplish their academic work without the use of computers, which, they believed, positively affected their academic work by increasing their motivation, efficiency, and organization.

This escalating interest in computer use appears to be motivated not only by this technology's academic advantages but also by students' awareness of the demand for computer skills in our knowledge and service economy; indeed, these demands have partly fueled increasing enrollments in higher education (Callan, 1998; Daniel, 1998). Contemporary students are keenly attuned to the scale and diversity of our

economy's dependence on information technology and, therefore, the importance of computer skills to their future in the job market. As a consequence, Green observed, "Students of all ages and across all fields come to campus expecting to learn about and also to learn with technology," creating "rising expectations and exploding demand" (1998, p. 4). Further, recent studies have identified near gender-equivalence in interest and demand, opportunity, use and skill levels (Kay, 1992; Kerr, 1996; Kirk, 1992; Reinen & Plomp, 1993). Contemporary male and female students alike are pragmatic; typically older, working and on a career path, often with families including children, and frequently with debt, many are returning to school part-time and with previous degrees for retraining (Fulkerth, 1998; Skinner, 1998; Syverson, 1996). Their sights are set less on intellectual development than professional advancement, and the utilitarian promise of higher education appeals to their desire to remain competitive and to increase personal income (Fulkerth, 1998; Sax et al., 1998).

Clearly, contemporary students appear to be justified in envisioning themselves as professional end users-in-training for wide-ranging workplaces. Over the last decade, studies of the landscape of "work" have confirmed the increasing and certain future demand for information technology skills, characterizing them as essential for success (e.g., Hull, 1997; Hull, Schultz, & Ziv 1994; Resnick & Wirt, 1996), across all professions and industries and up and down role hierarchies (Callan, 1998; Carnevale & Rose, 1998; Information Technology Association of America, 1998; Information Technology Association of America & Virginia Polytechnic Institute and State University, 1999; National Center for Educational Statistics, 1998a; Rush, 1998). Addressing the first workforce convocation sponsored in part by the U.S. Department of Commerce and Education, Miller stated, "America is rapidly moving to the point where economic realities make IT literacy as fundamental to the job skills of the well-rounded employee as the ability to read and write" (Information Technology Association of America, 1998, p. 1). Callan, discussing higher education policy, stated that, "In the new global, information-based economy, those without formal education or training beyond high school [in information

technology] are not even in the line ... to participate in a knowledge-based economy" (1998, p. 14). And in a study for the Educational Testing Service, Carnevale and Rose (1998) found that in "the office," the hub of work across professions and industries, the use and management of information technology have become central activities and are eroding long-established distinctions between high-tech and low-skilled office jobs.

Indeed, "IT literacy," broadly conceived, has become the new centerpiece of "professional literacy" and "workforce readiness," (Berryman & Baily, 1992; Christ & Blanchard, 1994; Ciofalo, 1992; Resnick & Wirt, 1996). In a study supported by the U.S. Department of Labor and the American Society for Training and Development (Carnevale & Gainer, 1989), employers identified the new "three Rs" as reading, writing and computation, equating them in importance to listening, oral communication, creative thinking, problem solving, decision making, team work, and "learning to learn." More recently, education and business leaders in the CEO Forum on Technology and Education (1997) defined workforce readiness as wide-ranging communication skills, competencies in emerging technologies, and critical thinking skills. In this context, given the certainty of technological change, far more desirable than competencies in a limited number of specific applications are broad and flexible skills (Rush, 1998), transferable skills and the related confidence to adapt easily to new applications and environments (Northover, 1999). Relatedly, Skinner (1998) found that employers value application- and system-specific training far less than what they expect from degree-granting institutions, "[an] emphasis on foundational theory and effective problem-solving needed for success in a rapidly changing business environment. Without these more enduring skills, [specific] technical skills themselves may be out of date quickly and careers become stalled" (p. 13).

Given the demand for computer skills among students and in the workplace, higher education administrators and officers are re-thinking their institutional mission. Romiszowki and Mason stated that higher education will expand academic computing resources not only for their pedagogical benefits but also "because it will be seen to be the

duty of education to use such systems in order to prepare its graduates for the realities of a workplace where they will be obliged to use them" (1996, p. 449). Doucette attributed trustees' interest in information technology to "the enormous increase in the training and retraining needs of the existing work force. For some of us, this could become the major share of our business. More than any other, this issue forces us to think and plan differently" (Association of Governing Boards of Universities and Colleges, 1998, p. 14).

Administrators and officers are also aware that students scrutinize their institutions' commitment to technology in the spirit of their consumer-oriented culture: What will I get, and how will my education translate into professional advancement and higher salaries? (CAUSE Current Issues Committee, 1997-98; Fulkerth, 1998). Regarding the expansion of computer technologies, Mingle stated that, for trustees, "The key external driver of change is student anxiety about jobs" (Association of Governing Boards of Universities and Colleges, 1998, p. 12). Due to this anxiety, Ferren contended, "Students today say, 'I pay high tuition and I expect...' - user services and support, individual attention, lab equipment, Internet access. This creates a 'technology lobby' among students" (Association of Governing Boards of Universities and Colleges, 1997, p. 13). Fulkerth (1998) concurred that students have come to expect not only "high tech" but also "high-touch," readily available and personalized human assistance with computer-related instruction and services.

These trends pose challenges to the traditional curricular and instructional practices and fiscal priorities of degree-granting institutions, especially those with pre-professional undergraduate programs and professional graduate programs. The Campus Computing Project's recent survey results not only reflect many of the trends but also hint at these challenges (Green, 1998): less than half of the nearly 600 participating American institutions had a strategic or financial plan for information technology; fewer yet had a curricular integration plan; nearly a third said their biggest hurdles were providing adequate user support and integrating technology into instruction. Other studies have documented such typical causes and consequences

of these scenarios as the over-investment in hardware and under-investment in user training and support (Northover, 1999).

Focus of the Paper

It is against this background that we became concerned with the special challenges facing faculty, especially faculty in graduate programs. Given this computer-dominated climate, faculty must increasingly assume new roles if they wish to plan curriculum and instruction that will enhance the skills students need and desire and, ultimately, empower students as end users of computer technology as they pursue their graduate studies and prepare for wide-ranging positions across professions and industries.

What is important for faculty to know? Faculty must, of course, be guided by programmatic goals, workplace trends and learning theory. However, faculty must also be guided by the needs and preferences of the end users themselves. "Most needs arise from users ... they are the key category of participants who must be involved in defining needs ... though they might not have a full grasp of technology, they are the experts in what they need every day" (National Center for Educational Statistics, 1998b, p. 3). Few sound implications about the education of graduate students can or should be drawn without an understanding of their own perspectives.

Most studies of academic computing in higher education to date, however, including those intended to support needs assessments, have collected data largely from institutional representatives *about* students, not *from* students (Corporation for Public Broadcasting, 1994; Green, 1998; Sax, et al., 1998). This has left faculty and other institutional providers without the benefit of the voices of end users, essential to the evaluation and improvement of computer support, curricular integration and instruction. Further, most studies have concerned undergraduates, leaving a gap in our understanding of *graduate* students whose needs and preferences may be considerably different. Many fit the profile of contemporary students described earlier and, as mature adults, have not benefited from elementary, secondary or, perhaps, adequate undergraduate exposure to

personal computers. And this profile may endure for some time, given both the increasing return of older students to graduate programs for professional development and the continuing uneven diffusion and integration of information technology in U.S. schools (CEO Forum of Technology and Education, 1997; McCandless, 1998; National Center for Educational Statistics, 1998a; National Center for Educational Statistics, 1998b).

In this paper, we present selected findings from a large-scale survey of over 300 graduate students in a Department of Administration and Technology Studies (ATS) (a pseudonym), housed in a school of education in the northeastern U.S. This department has four field-based programs representing sub-specialties in the field of education: Business Education, Educational Administration, Educational Technology, and Higher Education. We believe that the graduate students in these programs are similar to and share goals with their counterparts in other schools of education throughout the U.S. While they are already part of the computer revolution as students and advancing professionals—in K-12 and higher education administration, teaching, or educational technology—information technologies will become even more central in their future leadership roles and in the education and professional preparation of the next generation of learners they will serve.

The major questions we addressed about the ATS graduate students as end users were: What were their attitudes toward the value of computers in graduate school? What were their major uses of computers in graduate school? What computer skills did they have, in what skills had they had formal instruction, and what skills did they want to acquire? What learning strategies and instructional formats had they used to acquire computer skills, and what strategies and formats did they prefer? Did important educational or background characteristics account for any differences that were uncovered among these end users?

Methods

We employed a survey research design for this study, the goals of which were to investigate ATS students' attitudes, uses, needs and preferences

with regard to academic computing in graduate school.

Development and field testing of the questionnaire. From late fall of 1996 to early winter of 1998, a research team of four ATS faculty members and four ATS graduate students developed an extensive questionnaire. The team generated early drafts based on its goals and reviewed similar surveys on computer uses developed for other populations. We also examined small-scale surveys on student uses of and attitudes toward academic computing that were developed by graduate students as part of an assignment in a Fall 1996 survey research course taught by one of the authors. In booklet form, the questionnaire was field tested and revised several times in accordance with design guidelines articulated by Dillman (1978) and Salant and Dillman (1994).

The first complete version of the questionnaire was field tested with two groups of students taking ATS courses in spring 1997, one group in a computer-related course and another in a survey research course taught by one of the authors. Both groups, totaling 40 students, were asked for their evaluations of the booklet's overall appeal, the clarity of its instructions, and the quality and clarity of all questionnaire items in relation to the team's goals. Based on the evaluations of these students, the research team revised the questionnaire. The second complete version was field tested with still a third group of students in a Fall 1997 survey research course. Their reactions and those of the research team were very consistent and positive. Cover letters to accompany each of the questionnaire's several mailings underwent the same field testing.

The questionnaire. The final 12-page booklet had five sections. The first section determined whether students were using computers for their graduate studies and, if so, for what specific purposes. The second section assessed where and when students used and preferred to use computers for their graduate studies, the kinds of hardware and software they used most frequently, the kinds of computer instruction they had completed and desired in the future, the computer learning strategies and instructional formats they had used in the past and preferred in the future, and their

evaluation of university computer facilities and services. The third section tapped the kinds of computer hardware and software students had at home and the extent of their computer-related services and reading. The fourth section explored students' attitudes towards the value of computers in graduate school. The final section asked students about key educational and background characteristics. Completed questionnaires contained nearly 230 pieces of information that required coding.

The sampling frame. Names, totaling 462, were obtained from computerized student rosters maintained by each of four ATS programs. Lists were reviewed by faculty representatives of respective programs in order to remove names of students who had graduated or were currently inactive, leading to the removal of 50 names. The actual sample to be surveyed, therefore, was comprised of 412 students.

The questionnaire mailings. We followed data collection procedures articulated by Dillman (1978) and Salant and Dillman (1994). To obtain the highest return rate, we took several steps. We assured students' anonymity by placing no identification numbers on the questionnaires themselves; instead, we enclosed in each set of mailings a postage-paid postcard with an identification number on it, asking that students return it separately from, but at the same time as returning, the questionnaire. Each mailing package included a cover letter, the questionnaire and a postage-paid envelope in which to return it, and the identification postcard. The first mailing was sent to the sample at the beginning of January 1998. One week later, all 412 students received a reminder postcard, encouraging them to complete and return the questionnaire if they had not already done so. Three weeks after the first mailing, a replacement package, with a second cover letter, was sent to all students from whom we had not received the identification postcard. Four weeks later, a second replacement package, with a final cover letter imploring them to set aside time to complete and return the survey, was sent to all those from whom we had still not received identification postcards.

The questionnaire returns. The vast majority of questionnaires were returned between February 6, 1998 and March 10, 1998. As a result of our

active Dillman follow-up strategy, we received a final count of 314 usable questionnaires, a 76% return rate.

The programs varied in their return rates, with Educational Technology having the highest rate (87%) and Educational Administration having the lowest, though still respectable, rate (59%). Return rates for Business Education and Higher Education were, respectively, 83% and 74%. As a result of the differences in return rates among programs, Educational Technology was somewhat overrepresented while Educational Administration was somewhat underrepresented in the final sample. On the whole, however, the sample returning questionnaires looked very similar to the original sample when using program as the defining factor.

The sample studied. ATS students as a group were predominately women (68%). The majority (78%) were between 26 and 51 years of age. Half identified themselves as European American (54%), and half included substantial pluralities who identified themselves as African American, Asian, or Latino(a). Half were in doctoral programs (51%, with Ph.D. and Ed.D. combined), and half were in master's (43%) and post-master's Certificate of Advanced Study programs (6%) (the latter two will be combined for the purposes of this paper). However, there were significant differences in this regard across programs. There were nearly twice as many doctoral students as master's students reporting in both Business Education and Educational Administration, while the reverse was the case in Educational Technology. The degree groups reporting in Higher Education were nearly equivalent in size.

A substantial majority had been enrolled in their programs two years or less (58%). One-third of the whole sample reported full-time status, taking three or more courses in a typical semester, and a quarter characterized their occupations as "students." Two-thirds were part-time matriculants (66%), taking one or two courses per semester or "active" as a function of working on advanced components of their doctoral research. As would be expected, those who were not enrolled full-time varied in occupations, from K-12 and higher education administration and teaching to

educational technology. A large majority lived in the local metropolitan area (62%).

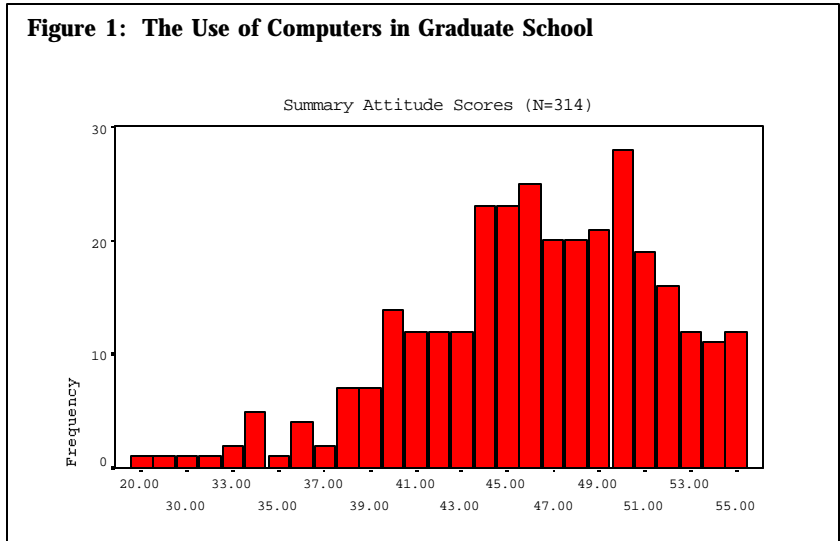
Findings

The findings reported in this section relate directly to the major questions, posed earlier, about ATS graduate students as end users of computer technology.

Students' Attitudes Toward the Value of Computers in Graduate School

The questionnaire contained a series of Likert-formatted items that had been assessed during the field testing as having face validity in the measurement of graduate students' attitudes toward the value of computers in graduate school. A factor analysis of the sample's responses to these items revealed that 11 of the 15 were strongly inter-correlated. These 11 items included: "Using a computer makes me more organized in my graduate work"; "Using a computer makes me more motivated to do my graduate work"; "Sharpening my computer skills in graduate school is essential in my professional work"; and (the negatively worded) "I prefer to do my academic work without much use of computers." Responses to each item could vary from "strongly agree" (5) to "strongly disagree" (1), with negatively worded items reversed in their scoring. A multiple item attitude scale was constructed from these 11 items, which had a .78 Cronbach alpha coefficient of reliability.

The summary scores of students on the multiple-item attitude scale ranged from a low of 20 to a high of 55. The scale, however, had a mean of 46.2 and a standard deviation of only 5.45. Thus, the histogram in Figure 1 shows graphically that the distribution of scores was strongly skewed in the negative direction. In short, this sample of graduate students as end users was very positive about the use of computers in their graduate work and in preparation for positions across the sub-specialties in the field education represented by ATS.



Students' Use of Computers in Graduate School

Did graduate students' receptivity to and enthusiasm for the use of computers in their graduate work translate into actual use? Virtually all ATS students (97%) reported using computers in their graduate studies. Regarding the purposes for which they *regularly* used computers in their studies, most selected "writing" (91%) and "research" (83%); nearly that proportion (79%) also chose "doing regular course assignments"; and roughly two thirds indicated "corresponding with professors" (68%) and "corresponding with classmates" (61%). When asked how many hours each week *on average* they used computers in their graduate work, a third (34%) reported 6 to 10 hours, and another nearly 20% said they used computers 16 hours or more each week.

Students' answers to a more specific question about their academic computer use are summarized in Table 1. We asked them to indicate those application types they used *frequently* in their studies (from a list of 20). The results corroborated the purposes for which they reported regularly using computers in their studies. Most reported frequent use of word processing (96%), e-mail (82%) and the Internet/World Wide Web (81%), and nearly half (47%) also reported use of on-line library catalogs. The table also reveals that the frequency of the students' use of any other type of application fell off sharply after that.

As additional aspects of academic computer use, we inquired into the extent to which graduate students in ATS were required to use computers (other than for word processing) in their courses, taken largely but not exclusively in ATS programs; where they most frequently used and preferred to use computers for their graduate work; what computer platforms they used; and what kinds of computer applications they owned. In analyses of these data, not presented here in tabular form, we found that 32% reported required computer use in "all" of their courses in a typical semester.

Another 59% reported this requirement in between half and all of their courses. Smaller numbers reported that less than half (23%) or none (18%) of their courses required computer use in a typical semester. When presented with the statement, "In

Table 1: Computer Applications Frequently Used for Graduate Work Reported by Students in the Department of Administrative and Technology Studies

(N = 305)

Computer application	Percentage reporting use
Word processing	96.1
E-mail	81.6
Internet/WWW	80.9
On-line library catalogs	46.6
Listservs	36.1
Electronic journals	34.1
Presentation/graphics	25.9
Bibliographic databases	23.3
Databases	20.7
Spreadsheets	20.3
Multimedia authoring	20.3
Newsgroups	19.7
Quantitative research	19.0
Desktop publishing	18.0
Web authoring	18.0
Qualitative research	15.4
Imaging	14.1
Digital video editing	9.2
Chat or IRC	7.5
Programming	1.6

all graduate courses, faculty should require some kind of computer use," 62% of the students agreed, and 79% agreed with the statement, "Professors should encourage e-mail communications among students."

Over 60% of the students used computers for graduate work primarily at home. When asked whether they would like to change their location of primary use, nearly three-quarters (72%) said "no." Of those who did their academic computing primarily at the university, 68% said they would prefer working at home; and of those who did so at their workplaces, 46% said that they would prefer working at home. These differences were statistically significant beyond the .0001 level.

When asked what operating system they used for their graduate work, over half of the students reported using PCs and another 27% reported using PCs and MACs. The press toward PC use was also seen in another way. Although only one-quarter of all users, regardless of platform, expected to purchase a new computer soon for home use, 9% of the MAC users among them reported their intention to buy PCs, compared with 16% who said they intended to buy MACs. No PC user reported the intention to buy a MAC. And of those in the market who reported using both platforms, 17% intended to buy PCs, while 8% planned to buy MACs. These differences were also statistically significant beyond the .0001 level.

We found that students' ownership of computer applications (and related hardware and services) correlated with the types they most frequently used and the purposes for which the majority used computers in their graduate work; 97% owned word processing software, 78% had Internet providers, 90% owned modems, and 54% owned communication software. However, students also reported high levels of ownership of application types they did not frequently use. For example, while 78% owned spreadsheet applications, only 20% reported frequent use of them; while 67% owned database software, only 20% reported frequent use of it; 57% owned graphics packages, but only 26% reported frequent use of them; and 40% owned desktop publishing applications, while only 18% reported frequent use of them.

Students' Computer Skills: Satisfaction, Skills Acquired, Future Preferences

In the attitude section of the questionnaire, students were asked to agree or disagree with the statement, "I am satisfied with my current computing skills." Despite their highly positive responses to other items in the attitude section, their range of skills and frequent and varied use of computers, less than half (47%) of the students in our sample reported strong agreement or agreement with this statement. An equally large proportion (42%) indicated strong disagreement or disagreement with it. Another 11% were unsure. In short, there was considerable variation in the students' satisfaction with their current computer skills.

Attempting to develop a more detailed picture of the students' skill levels and needs, we asked whether they had completed and/or desired formal instruction in the use of various application types. Table 2 contains a summary of the responses to these two questions. Over half (59%) of the students reported completing formal instruction in word processing, nearly half (49%) in e-mail, and a large plurality (43%) in the Internet/World Wide Web, corresponding, again, with the majority's primary academic purposes for computer use and most frequently used applications. However, formal instruction by itself is not an accurate indicator of skill levels. Since frequency of use reported for these applications was significantly higher, the percentages completing formal instruction likely under-represented skill levels for the group as a whole. Not surprisingly, few currently felt the need for instruction in these application types.

However, while percentages of students who reported completing formal instruction in the remaining applications in the list fell off, many indicated the desire for formal instruction in a number of other software tools. As shown in Table 2, the top seven in rank order were: quantitative research (44%), qualitative research (42%), presentation graphics (38%), web authoring (38%), digital video editing (36%), desktop publishing (35%), and bibliographic databases (35%).

It is worth noting the relatively low percentages of students who reported completing or desiring formal instruction in selected basic productivity applications and research-related tools, matching

Table 2: Formal Instruction in Computer Applications Completed and Wanted by Students in the Department of Administrative and Technology Studies

(N = 302)

Computer application	Percentage completing formal instruction		Percentage wanting formal instruction	
Word processing	59.1	(1)	9.3	(18)
E-mail	48.7	(2)	7.3	(19)
Internet/WWW	43.3	(3)	20.9	(17)
Spreadsheets	38.4	(4)	26.5	(13)
Databases	37.7	(5)	29.8	(10)
On-line library catalogs	30.8	(6)	26.8	(12)
Presentation/graphics	24.2	(7)	38.4	(3)
Desktop publishing	22.8	(8)	35.4	(6)
Multimedia authoring	22.8	(9)	33.1	(8)
Quantitative research tools	22.5	(10)	43.7	(1)
Web authoring	20.9	(11)	38.4	(4)
Listservs	20.9	(12)	21.5	(15)
Newsgroups	19.9	(13)	22.2	(14)
Electronic journals	17.5	(14)	31.8	(9)
Qualitative research tools	15.2	(15)	42.1	(2)
Digital video editing	13.9	(16)	35.8	(5)
Imaging	13.2	(17)	28.8	(11)
Bibliographic databases	13.2	(18)	34.9	(7)
Programming	8.3	(19)	21.5	(16)

applications they did not frequently use. For example, with regard to spreadsheets, 38% completed formal instruction and 27% desired formal instruction; for databases, 38% completed formal instruction and 30% desired formal instruction. In relation to electronic journals, 18% completed formal instruction and 32% desired formal instruction; for on-line library catalogs, 31% completed formal instruction and 27% desired formal instruction.

Students' Computer Learning Strategies: Past Approaches and Future Preferences

In Table 3 we summarize student reports of the computer-related learning strategies and instructional formats they have used in the past and preferred in the future. Students reported using a wide array of strategies and formats. Most often used were trial and error (61%), learning from others on the job (53%), manuals and texts (53%), and, somewhat less often, friends and relatives (49%) and university

courses (49%). Clearly, however, students did not prefer these strategies in the future. Instead, they indicated a much narrower set of preferences, both in the category of "formal" instruction: university workshops (46%) or university demonstrations (35%).

Summary Index Analyses

To give another perspective to our descriptive findings and to simplify correlational analyses, we created four summary indexes. By adding students' choices together in four different areas, these indexes indicate the average number of (1) computer applications (types) students frequently used in graduate school, (2) computer applications (types) in which students had completed formal instruction, (3) computer applications (types) in which students desired formal instruction and (4) computer-related learning strategies or instructional formats students

preferred. These summary indexes are shown in Table 4.

Although one student did not frequently use the computer for any type of application, another reported frequently using 20 different types. The mean scale score of 6.09, however, shows that students, on average, frequently used six different

Table 3: Computer-Related Learning Strategies and Instructional Formats Used and Preferred by Students in the Department of Administrative and Technology Studies

(N = 302)

Method of learning	Percentage reporting use		Percentage reporting preference	
Trial and error	60.9	(1)	7.9	(9)
From others "on the job"	53.3	(2)	16.6	(4)
Manuals and texts	53.0	(3)	12.3	(7)
University courses	49.3	(4)	15.7	(6)
Friends and relatives	48.7	(5)	11.8	(8)
Self-instruction software	42.1	(6)	18.2	(3)
University demonstrations	26.2	(7)	35.4	(2)
University workshops	23.2	(8)	46.4	(1)
Commercial training	23.2	(9)	16.2	(5)
K - 12 course work	20.1	(10)	--	

Table 4: Four Summary Indexes: Means, Standard Deviations, and Ranges

	Mean	Standard deviation	Range	N
1. Number of computer applications (types) students frequently used in graduate school	6.09	3.45	0 - 20	304
2. Number of computer applications (types) in which students completed formal instruction	4.95	4.40	0 - 19	300
3. Number of computer applications (types) in which students desired formal instruction	5.47	4.42	0 - 17	300
4. Number of computer learning strategies or instructional formats students preferred	1.79	1.85	0 - 9	286

application types. The percentages reported in Table 1 suggest that, again, those most often included word processing, e-mail, and the Internet/World Wide Web.

While quite a few students ($N=61$) completed no formal instruction in any type of application, one reported completing formal instruction in 19 types. The mean scale score of 4.95, however, reveals that students, on average, reported completing instruction in roughly five different application types. The percentages shown in Table 2 suggest that those most often included word processing, e-mail, and the Internet/World Wide Web.

Although quite a few students ($N=45$) desired no formal instruction in any type of application, others ($N=2$) wanted instruction in as many as 17 types. The mean scale score of 5.47 shows that, on average, students expressed the desire for instruction in five to six different application types. The percentages reported in Table 2 suggest that students most often wanted instruction in quantitative analysis, qualitative analysis, presentation graphics, and web authoring applications.

While many students ($N=93$) reported no preference with regard to computer-related learning strategies or instructional formats, others ($N=2$) reported preferences for all nine alternatives listed. The mean score of 1.79 demonstrates, however, that students, on average, reported a rather narrow preference for one or two approaches. The

percentages reported in Table 3 suggest that the most prevalent preference was for university workshops and/or university demonstrations.

Selected Correlational Analyses

To what extent did selected key educational and background characteristics of our sample relate to the summary measures presented above? Put another way, did differences in program affiliation, graduate degree status, gender or age account for differences among students on the

four summary indexes—the average number of (1) computer applications (types) students frequently used in graduate school, (2) computer applications (types) in which students had completed formal instruction, (3) computer applications (types) in which students desired formal instruction and (4) computer-related learning strategies or instructional formats students preferred? We also questioned whether any of these characteristics or summary measures related to several other variables, including average weekly hours of computer use for graduate work, level of satisfaction with current computer skills, attitude toward the value of computers for graduate study, and amount of course-driven computer use. To examine these effects and relationships, Tables 5 and 6 were generated, and they will be discussed in this section. Because program affiliation is best treated as a nominal variable, we employed analysis of variance for it (Table 5). For all the other variables we used Pearsonian correlational analysis (Table 6).

Effects of program affiliation. Table 5 reveals the influence of program affiliation on summary measures of applications frequently used for graduate work, formal instruction in computer applications completed, formal instruction in computer applications desired, and computer-related learning strategies or instructional formats preferred. A comparison of program means on each of these variables, based on analyses of

Table 5: A Comparison of Means on Various Key Variables According to Program Affiliation

	Bus Educ	Educ Admin	Educ Tech	Higher Educ	P
1. Number of computer applications (types) students frequently used for graduate work	5.84	4.48	7.31	5.93	.000
2. Number of computer applications (types) in which students completed formal instruction	3.81	3.84	6.36	4.70	.001
3. Number of computer applications (types) in which students desired formal instruction	5.09	4.75	5.05	6.37	.097
4. Number of computer learning strategies or instructional formats students preferred	1.40	1.47	2.23	1.81	.032
5. Average weekly hours of computer use	2.53	2.92	3.68	3.10	.000
6. Level of satisfaction with computer skills	2.84	3.06	2.80	2.81	.508
7. Attitude toward value of computers in graduate school	45.07	45.41	47.46	46.67	.018

Note: The mean scores presented for each program on each of the first five variables represent average numbers. For example, Business Education students, on average, reported frequently using nearly six (5.84) applications for graduate work and reported desiring instruction in five (5.09) more applications. Level of satisfaction with computer skills ranged from a possible low of 1 to a high of 5. Attitudes toward the value of computers in graduate school ranged from a possible low of 11 (strongly negative) to a high of 55 (strongly positive). P values are based on one-way analyses of variance.

variance, shows that three of the four reached various levels of statistical significance. Educational Technology students as a group reported frequently using more applications types (7.31) than did students in the other programs, with Educational Administration students reporting the least (4.48). Educational Technology students as a group also reported completing instruction in more application types (6.36) than did students in the other three programs, with Business Education students reporting the least by almost half (3.81). And still again, Educational Technology students reported preferences for somewhat more learning strategies or instructional formats (2.23) than did students in the other programs, with Business Education students reporting the least (1.40). Program mean differences on the extent of formal instruction desired did not reach statistical significance.

In other analyses, program affiliation was found to be related to differences in computer platforms used and where students used and preferred to use computers for their studies. While large majorities

reported using PCs in Business Education (89%), Educational Administration (67%), and Higher Education (63%), Educational Technology students more frequently reported using MACs (36%) than PCs (17%). These differences were statistically significant beyond the .0001 level. With regard to locations of use, Educational Administration students more frequently used computers at home (73%) compared to students in Business Education (65%), Higher Education (58%), and Educational Technology (52%). Not surprisingly this trend was reversed when asked whether they wished to change their locations of use; those who said “yes”

to a change to home use included 19% in Educational Technology, 16% in Higher Education, 11% in Business Education, and 6% in Educational Administration. These differences were statistically significant beyond the .01 level.

Effects of degree status. The influence of degree status (master’s/certificate or doctoral) on a range of characteristics and variables is shown in Table 6. An examination of Pearson correlations reveals that most coefficients are close to zero. Moreover, the few that are statistically significant are small: master’s/certificate students frequently used a greater range of applications for their graduate work than did doctoral students, $r = -.18$, had completed slightly more formal instruction than had doctoral students, $r = -.11$, and took more courses that required computer use than did doctoral students, $r = -.22$. Table 6 also shows that degree status was found to be unrelated to the amount of formal instruction desired, learning strategies and instructional formats preferred, the average weekly hours of computer use for graduate work, level of

Table 6: Correlations of Summary Indexes with Key Educational and Background Characteristics

	1	2	3	4	5	6	7	8	9	10	11
1. Number of computer applications (types) students frequently used for graduate work	---										
2. Number of computer applications (types) in which students completed instruction	.42***	---									
3. Number of computer applications (types) in which students desired instruction	-.04	-.03	---								
4. Number of computer learning strategies or instructional formats students preferred	.03	.03	.35***	---							
5. Average weekly hours of computer use	.38***	.11	.01	.06	---						
6. Level of satisfaction with computer skills	.13 *	.23***	-.29***	-.09	-.02	---					
7. Attitude toward value of computers in graduate school	.29***	.15 *	.06	.06	.24**	.21***	---				
8. Course-driven use	.30***	-.18 **	.05	.08	.21**	.04	.24*	---			
9. Degree status	-.18 **	-.11 *	-.02	-.04	-.01	-.03	-.07	-.22***	---		
10. Gender	.03	.09	-.03	-.02	-.02	.08	.01	-.02	.17 *	---	
11. Age	-.13 *	-.13 *	-.03	-.06	-.16 *	-.24***	-.16	-.16 **	-.4**	.10	---
* p <= .05											
** p <= .01											
*** p <= .001											

satisfaction with current skills, and attitude toward the value of computers for graduate study.

Furthermore, it is worth noting that degree status was found to be largely unrelated to the application types in which students reported the desire for formal instruction. Master's/certificate students were just as likely as doctoral students to want formal instruction in research-related tools, including applications for quantitative research (45% and 44%, respectively) and qualitative research (43% and 42%, respectively), bibliographic databases (37% and 33%, respectively), electronic journals (32% and 31%, respectively), and on-line library catalogs (26% and 29%, respectively). Differences found in this regard were minimal: the desire for formal instruction in word processing and the Internet/World Wide Web was slightly stronger

among doctoral students than among master's/certificate students.

Effects of gender and age. The effects of gender and age are also presented in Table 6. An examination of Pearson correlations reveals that gender had no effect on the four key variables or several others, including the average weekly hours of computer use for graduate work, level of satisfaction with current computer skills, and attitude toward the value of computers for graduate study.

Age, on the other hand, did have a small effect on the average weekly hours of computer use for graduate work (the older the student, the fewer the hours used, $r = -.16$) and on attitude (the older the student, the less positive, $r = -.16$). Age had only a small effect on formal instruction completed (the older the student, the less instruction completed,

$r = -.13$) and frequently used applications for graduate work (the older the student, the smaller the range of frequently used applications, $r = -.13$). Age had somewhat more of an effect on level of satisfaction with current computer skills (the older the student, the less satisfied, $r = -.24$).

Other correlations. The Table 6 matrix also reveals a number of other interesting relationships. Not surprisingly, rather large correlations existed between formal instruction completed and frequently used applications (the more instruction completed, the more application types frequently used, $r = .42$); between the average weekly hours of computer use for graduate work and frequently used applications (the more weekly hours of use, the more application types frequently used, $r = .38$); between formal instruction desired and learning strategies or instructional formats preferred (the more instruction desired, the more strategies or formats preferred, $r = .35$); between the amount of course-driven computer use and frequently used applications (the more required use, the more application types frequently used, $r = .30$); and between the amount of course-driven computer use and the average weekly hours of computer use for graduate work (the more required use, the more weekly hours of use, $r = .21$).

In addition, level of satisfaction with current computer skills was moderately related to formal instruction desired (the greater the dissatisfaction with current skills, the more instruction desired, $r = -.29$) and formal instruction completed (the greater the satisfaction with current skills, the more formal instruction completed, $r = .23$). It had a small effect on frequently used applications (the greater the satisfaction with current skills, the greater the number of application types frequently used, $r = .13$).

Finally, attitude toward the value of computers for graduate study was moderately related to frequently used applications (the more positive, the more application types frequently used, $r = .29$), to the average weekly hours of computer use for graduate work (the more positive, the more weekly hours of use, $r = .24$), to the amount of course-driven computer use (the more required use, the more positive, $r = .24$), and to level of satisfaction with current computer skills (the more positive, the greater the satisfaction with current skills, $r = .21$).

Attitude had a smaller effect on formal instruction completed (the more positive, the more instruction completed, $r = .15$).

Discussion

In this section we present five major points, based on our findings, to respond to the question posed earlier: What is important for higher education faculty to know in order to plan curriculum and instruction that will enhance the skills students need and desire and, ultimately, empower students as end users of computer technology as they pursue their graduate studies and prepare for wide-ranging positions across professions and industries?

Old Chestnuts

Our findings strongly suggest that two frequently-held beliefs—first, that older adult students express more resistance than do younger students toward computing for academic and professional purposes, and, second, that males are more involved with, interested and skilled in the use of computers than are females—are no longer accurate.

The effect of age, which appeared to loom large until recently as a factor affecting computer attitudes, use and skills, seems to have weakened considerably. Our study suggests that the pervasive use and importance of computers among undergraduates (Corporation for Public Broadcasting, 1994; Green, 1998; Sax et al., 1998) are mirrored in graduate students. The current generation of adult graduate students appears to be highly receptive to the use of computers in their graduate work and frequent users of a range of applications for a variety of purposes. Despite small negative effects of age (and related degree level) on formal instruction completed, frequent use of a range of applications, weekly hours of use, attitude toward the value of computers in graduate school, and level of satisfaction with current computer skills—effect sizes so small as to be almost unimportant—this largely positive picture holds up. More significant is that older students preferred to use computers for their academic work and believed it would be difficult to accomplish their graduate work without the use of computers. They found that computer

use enhanced their efficiency, motivation, and organization in their graduate work, and they wanted as much formal instruction in the future as did younger students.

Perhaps more important, our study refutes the long-perceived male bias in the computer environment (Kerr, 1996) and, instead, supports recent studies that have identified greater gender-equivalence in interest, opportunity, use and skill levels (Kay, 1992; Kirk, 1992; Reinen & Plomp, 1993). Gender, at least among the graduate students in our sample, did not account for differences in frequently used applications, formal instruction completed, formal instruction desired, learning strategies or instructional formats preferred, average weekly hours of computer use for graduate work, level of satisfaction with current computer skills, or attitude toward the value of computers for graduate study. Female as well as male graduate students now seem to be equal in their receptivity to computer use, the extent of their computer use, and the purposes for which they use computers.

More Similar Than Different

On the majority of measures included in our survey, ATS graduate students were more similar to than different from one another, not only across ages and genders but also despite a range of other background and educational differences. The sample as a whole demonstrated consistently positive attitudes toward the value of computers in their graduate work and for professional preparation, a similar range of purposes for academic computer use and frequently used application types, considerable prior instruction, formal and informal, and a strong desire for formal instruction to acquire additional skills in the future. While doctoral students desired more formal instruction than did master's/certificate students in word processing and the Internet/World Wide Web, all students shared considerably more interest in formal instruction in the future in, for example, applications for quantitative and qualitative research, bibliographic databases, electronic journals, and on-line library catalogs.

The factor that did have somewhat stronger effects in our sample was program affiliation.

Educational Technology students reported using computers more frequently, for a wider array of purposes and for greater numbers of hours each week in than did students in the other three programs. They also reported completing more formal instruction and more positive attitudes toward the value of computers in graduate school. While one would expect students choosing a technology-based program like Educational Technology to reflect such differences, the fact that these differences were small was unexpected.

This "more similar than different" pattern would seem to support the profile of contemporary students in the literature (Fulkerth, 1998; Green, 1998; Sax et al., 1998; Skinner, 1998; Syverson, 1996) and their mindfulness of the role of computer-based technologies across professions and industries (Callan, 1998; Hull, 1997; Hull et al., 1994; International Technology Association of America, 1998; Resnick & Wirt, 1996; Rush, 1998). The latter point, our findings suggest, extends to the field of education and a sample of its sub-specialities. Therefore, what seems of practical importance is how similar the graduate students in our sample were regardless of degree status, program affiliation, age and gender.

At Home In a Windows World

The majority of ATS graduate students preferred to do their academic computing at home, rather than at the university or their workplaces. Evidence of this preference in responses to questionnaire items about location of use was corroborated by the large numbers of students who responded "not applicable" to items about their satisfaction with on-campus computer labs, bringing the number of students recommending improvements in these labs down considerably. Open-ended responses elsewhere in the questionnaire included, "Would love a home computer, but it is expensive, so I use the computer at my office. I often have to come in to the office early in the morning or on weekends to get coursework done." While the majority of ATS students resided within city limits, a typical response from a commuter was, "Since I live and work outside the city, I have limited access to on-campus resources."

This preference was not surprising, given the resemblance of our sample to the profile of contemporary students in the literature (Green, 1998; Fulkerth, 1998; Sax et al., 1998; Skinner, 1998; Syverson, 1996). These students may be expected to be juggling academic, family and professional responsibilities, curtailing the amount of time they can or wish to spend on campus to do their academic work. Fitting academic work into the mix would appear to be more convenient when these students are not dependent on facilities away from home base.

At home, the majority of ATS graduate students have made and continue to make computer platform decisions that are congruent with those made across the majority of professions and industries. By and large, they were and planned to remain Windows users. Even a large percentage of those who were MAC users planned to make their next purchases in the Windows world.

High Tech and High Touch

Despite ATS graduate students' preference for working at home, they did report strong expectations from the university with regard to academic computing. The majority wanted "high tech" (Fulkreth, 1998), that is, to acquire more skills in a wider variety of application types, and they wanted to do so through formal workshops and demonstrations provided by the university and more fully integrated computer use in their courses, with adequately skilled faculty. They also wanted "high touch" (Fulkreth, 1998), more personalized and individualized computer-related instruction and services. Despite their array of skills and frequently used applications and their extent of prior instruction, the students' expectations may relate to their significant level of dissatisfaction with both their current computer skills and the majority of ways in which they had acquired them in the past.

More skills in a wider variety of application types. As noted earlier, most students had completed formal instruction in and/or frequently used such applications as word processing, e-mail, and the Internet/World Wide Web. However well under half reported formal instruction in or frequent use of a wide range of other application

types. When asked about their preferences, they expressed, on average, the desire for instruction in five to six application types. The top seven in rank order were: quantitative research, qualitative research, presentation graphics, web authoring, digital video editing, desktop publishing, and bibliographic databases. Open-ended responses emphasized these types, including such specific applications as SPSS, HTML and Java, bibliographic software and, most frequently, electronic search and retrieval skills. Altogether, these preferences appear to relate to students' current graduate work, expectations of professional needs, or both.

However, despite what employers appear to be looking for, at least in part (Northover, 1999; Rush, 1998; Skinner, 1998), and despite high rates of ownership, low percentages of students reported frequently using or completing or desiring formal instruction in such basic productivity software as spreadsheets and databases; in related open-ended responses, students seldom mentioned these types of applications. The high rates of ownership reported may be less a function of expectation or desire to use such applications in the future than the popularity of productivity "suites" on the market, purchased mainly for their support of word processing, or the result of a vendor's frequent practice of bundling productivity software with computer purchases. However, in view of the widespread academic and professional uses of such applications, perhaps students have failed to grasp or experience their utility.

More formal instruction through university workshops and demonstrations and use of skills in courses with faculty experienced in computer use. As shown earlier, the graduate students in our sample favored short-format university workshops and demonstrations, both being "formal" group instruction, over full-length courses and such informal or independent approaches as trial and error, learning "on the job," or manuals and texts. The strength of this preference and the general importance of further instruction were reflected in the students' open-ended responses as well, which, throughout the questionnaires returned, concerned this topic more than any other. Many requested "short workshops," "brief seminars," and "workshop seminars." One student requested

“short (1 day or 2 day) courses to help students upgrade their skills or become more facile with the computers. It is too expensive to do a full course for computers.” Another student wrote, “More step by step instructions and demonstrations of the programs students are expected to learn. There is too much ‘figure it out yourself’ learning of very complex programs.”

As another avenue of learning and practice, ATS students believed that computer use should be integrated into their courses. Recall that only a third reported required computer use (apart from word processing) in all of their courses in a typical semester; half reported this requirement in between half and all of their courses; and a smaller, but not insignificant, number reported that less than half or none of their courses required computer use in a typical semester. Large majorities agreed with the statements, “In all graduate courses, faculty should require some kind of computer use in relation to courses” and “Professors should encourage e-mail communications among students.” Further, open-ended responses revealed a strong call for more faculty capable of such integration, for example: “We need professors who know how to use [computers]”; “In my opinion, all faculty in ATS should participate in learning and utilizing computer technology!”

High touch. “High touch” (Fulkreth, 1998) refers to the students’ desire for more readily available assistance with computer-related instruction and services, and of a more personalized nature. We believe this desire is one implication of students’ strong preference for more formal instruction in general and for more integration of computer use in their courses by skilled faculty.

However, students’ desire for “high touch” was more explicitly evidenced in their responses to questionnaire items that invited recommendations to improve university computer facilities and services. With regard to all university computer labs, second and third items chosen related to increased assistance to students, including: “Better train staff to be more approachable”; “Improve instructions for using electronic databases”; “Better train librarians to assist students with electronic resources”; and “Better train staff to solve software problems.” Relevant open-ended responses were

more direct and emphatic: “Provide help at the lab!”; “No one is available to help”; “Weekend staff supports at labs were low in number and unskilled or uninterested when I sought help. I stopped trying”; “No one helps you in the library. I can read directions; I wouldn’t ask for help if I wasn’t having a problem”; “There are always several people behind the counter. All seemed too bothered to help students at the computer. When you got them to the computer, they were quick to run away. If they stayed and helped you, you wouldn’t need to call them again!”

With regard to the university’s telephone help services, the three strongest recommendations for improvement included these questionnaire options: “Train the help center staff to be more helpful”; “Increase available service from the help center”; and “Provide better written instructions for setting up on-line, dial-in services from home.” In this context, open-ended responses called for increased, more patient and technical “human” help. Finally, with regard to improved services at the university computer store, “Personnel with more computer expertise” took second place in importance, in an array of five options.

More Is Better

We wish to call attention to the “more is better” pattern that emerged in our earlier discussion of selected correlations shown in Table 6. For example, the more instruction completed and the more hours of weekly use, the more application types frequently used; and the more required use, the more application types frequently used and the more weekly hours of use. Nearly as strong was the role of satisfaction: the greater the dissatisfaction with current skills, the more instruction desired; and the greater the satisfaction with current skills, the more formal instruction completed and the greater the number of application types frequently used. And attitude was a strong factor in the same direction: the more positive the attitude toward the value of computer use, the more application types frequently used, the more weekly hours of use, the greater the satisfaction with current skills, and the more instruction completed; and the more required use, the more positive the attitude.

This pattern clearly squares with learning theory in general (Farnham-Diggory, 1992; Shuell, 1986) and in the computer environment in particular (Anderson, 1990; Scott et al., 1992). Learning in the computer environment requires the special challenge of developing a mix of declarative, procedural, conceptual and logical knowledge (Cuban, 1986; Johnson & Johnson, 1996; Scott et al., 1992). While successful learning is always a function of the interaction of many factors, those known to be essential for cultivating computer skills include extensive practice (Anderson, 1990), experimentation with many “instances” or “examples” of applications and application types (Brown, Collins, & Duguid, 1989; CTGV, 1990), a positive attitude, motivation, and the sense of satisfaction that attends accomplishment (Brown, Collins, & Duguid, 1989; Cuban, 1986; Farnham-Diggory, 1992). These factors clearly interact in a circular fashion; for example, the more one has or takes the opportunity for instruction and practice, the more time one will devote; this supports motivation and satisfaction which, in turn, extend one’s use and thirst for more. Further, it appears from our data that the greater one’s dissatisfaction with one’s current skills, the greater the desire to pursue more instruction which, in turn, strengthens satisfaction.

Concluding Comments

Graduate students are increasingly and enthusiastically engaging in computing. They are benefiting from the pedagogical advantages of information technology and preparing for the professional world of work, appropriately anticipating that skills in the use and management of information technology will be essential for advancement along their chosen career paths. We believe that faculty must assume new roles, using a variety of concrete curricular and instructional avenues, if they are to support and empower graduate students as end users—in school and in the workplace—while under their watch.

Historically, higher education institutions have experienced internal conflict and external criticism over the issue of whether “workplace readiness” and basic literacy skills (including remediation) ought to be part of their mission, and, ultimately,

the curriculum of traditional degree-granting pre-professional and professional programs. We suggest that information technology skills and literacy comprise the new battle on this front. Skinner (1998) noted that, with information technology taking center stage across professions and industries, there appears to be a mismatch between skills needed by the private sector and those valued by higher education institutions: “Corporate leaders are convinced that university employees—administrators and faculty members—do not understand the requirements of the private sector and the need for students to be better prepared for the demands of a changing global economy” (p. 6). And indeed, he continued, many institutions face at least two major obstacles. The first is a philosophical disdain for addressing practical issues. Four-year and, especially, graduate programs, he asserted, are commonly criticized for being biased towards theory, making curriculum and resource decisions without regard for real job opportunities, and turning out graduates in the traditional disciplines who are unprepared for the reality of the job market. The second obstacle, according to Skinner, is logistical. Many higher education institutions are unable to create new programs and refresh old ones rapidly enough to keep pace with developments in information technologies and the resulting changes in their professional applications, hampered by months of red tape, problems of funding, and inadequate staffing.

Miller, applauding President Clinton’s recent push for increased educational emphasis on high-tech skills, commented that, “[T]his is an economy marked by a growing disconnect between the skill sets employers demand and the education, training and experience of many American workers” (International Technology Association of America, 1999, p. 1). Callan, questioning what American society needs from higher education, noted growing disagreement about the public purposes of colleges and universities. He pointed specifically to the issue of technology: “Institutions that neglect technology will run the risk in the future of being marginalized in favor of educational systems that more effectively serve a generation of learners accustomed to the benefits of ubiquitous computing and communications” (1998, p. 3).

Remedies Skinner (1998) offered include an attitude shift, an acknowledgement that real world problems are worthy of intellectual effort. Increased communication and resource sharing between higher education and professions and industries would give university departments a better sense of the skills graduates must have in today's workforce. More speed and flexibility in curriculum revision and development, taking seriously the needs in wide-ranging workplaces and roles, would allow institutions to be more responsive.

In this paper, we have presented an array and analysis of graduate students' attitudes, uses, needs and preferences with regard to academic computing in graduate school. We believe these can and should be considered in the mix of factors that guide curricular and instructional priorities and decisions. Our findings suggest that graduate faculty should seek approaches to the explicit integration of information technology skills into programmatic goals and related curricula, in ways that enrich rather than compromise them. They suggest that graduate students, largely regardless of age, gender, degree status and program affiliation, already possess a range of computer skills and engage in various frequent computer uses, but that they are highly motivated to expand these skills; accordingly, it would seem from our findings, faculty may integrate basic computer-assisted instructional practices in their courses without prior instruction or anticipation of resistance, and they may be assured that their students will be eager to learn to use applications that are new to them when their utility is clear.

Our findings further suggest that graduate faculty should, in addition to integrating computer use in their courses, make regularly available a wide range of short-format, hands-on workshops and demonstrations in which students can be given individual attention. These should address application types of most interest and relevance to students and the professional fields to which their programs relate, and they should include a variety of "instances" or "examples" of each type. Since skill development depends on an interaction of instruction and frequent use, the subjects of workshops or demonstrations offered by graduate programs might parallel applications being

integrated into course activities, in order to enhance exposure and high levels of practice.

In view of graduate students' preference for academic computing at home and the strength of their expectations from the university, our findings support the criticism of institutions for allocating far more fiscal resources to on-campus hardware and infrastructure than to upgrading users' skills and user support (Green, 1998; Northover, 1999). At least for graduate students, faculty and institutions may be well-advised to apply fewer resources to on-campus computer labs and more to instruction, easily accessible support services, highly skilled and personable staff, opportunities for students to purchase affordable hardware and software for use at home, and remote connectivity to the campus network for all students. Indeed, the majority of our sample agreed with the statement, "The university should increase financial aid for students to buy computer equipment." In these contexts, the Windows world ought to be given more attention than the MAC world.

Finally, our study is somewhat of a wake-up call for graduate faculty and those in positions to expand professional development opportunities for them. Our findings suggest that faculty may need to strengthen their understanding of what their students—and their professions—need and prefer in the realm of computer technologies during their graduate studies and in preparation for the world of work. Further, faculty will need to expand their own skills in relevant computer applications, the integration of computer use into curricula, and the creation of computer-rich learning environments.

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