Digital Unity and Digital Divide: Surveying Alumni to Study Effects Of a Campus Laptop Initiative

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Abstract

This research study assessed the effects of an information technology initiative on undergraduates at a Western Pennsylvania college. A random sample of alumni from the classes of 1997, 1998, and 2000 were surveyed to gauge their attitudes about a technology program instituted in 1994, which provided laptop computers to all incoming freshman. The results indicated that not only was there a positive change in attitudes after the program was initiated, but digital divides based on sex and field of study were diminished during the students' time on campus. Interestingly, parts of the divide reappear after graduation, by field of study. (Keywords: alumni, cognitive style, computer attitudes, computer use, digital divide, gender, laptop computer, learning style.)

ASSESSING THE EFFECTS OF A CAMPUS LAPTOP INITIATIVE

According to a recent survey of college students published by the Pew Internet research project, 85 percent of college students between the ages of 18 and 24 own their own computer and 86 percent of them have gone online, while only 59 percent of the general population have done so (Jones, 2002). Much of this disparity between college students and the general population is attributed to college students' early exposure to computers at home or at school, but it is also explained as a naturally occurring diffusion of Internet access from college faculty to the college community as a whole. Even prior to the creation of the World Wide Web, however, college administrators wrestled with two primary options in the diffusion of computer technology on campus. One was to network the campus, making technology universally available in classrooms, laboratories, offices, and residence halls. However, a small number of campuses took an even more comprehensive approach. They began distributing laptop computers to every entering first-year student. As this practice gained momentum, some of its advocates adopted the name *ubiquitous computing* to characterize its primary objective of universal access.

We think, however, that the reasons for creating such an environment by implementing a laptop distribution program are better characterized by the term *digital unity*, because such preemptive academic initiatives have often been motivated by vague concerns that either the institution or its students might otherwise find themselves on the wrong side of a *digital divide*. In addition, we see a further benefit in addressing the effects of campus laptop initiatives as an issue of digital unity versus digital divide. By framing research questions within this larger context, observations about the implementation of a digital unity (comprehensive computing) plan within a college community may be generalizable not only to populations situated in other educational environments (Attewell, 2001) but also populations that are split by social (Light, 2001) and geographical (Hindman, 2000) differences.

To make this claim more coherent, the convergence of these terms—ubiquitous computing, digital divide, and digital unity—requires some historical explication. The term ubiquitous computing has been attributed to Marc Weiser, a researcher at Xerox PARC near Stanford University (MacDonald, 1997). Weiser (1998), in fact, has written about three waves of computing on campus, the first being mainframes, the second being networked PCs, and a third, yet to come, in which digital technology is so integrated into campus activities that it would be nearly invisible. Students would pull credit card interfaces out of their wallets to exploit the applications they needed. Brown, Burg, and Dominick (1998) apparently adopted the term to characterize the goal of the laptop initiative at Wake Forest University and to name a national movement that included other campus-wide efforts that can be traced back as far as a faculty decision at Drew University in 1983 (Candiotti & Clarke, 1998; Candiotti, 2003). The term digital divide, by contrast, arose in the domain of public policy. The term digital divide was popularized by the U.S. National Telecommunications and Information Administration in the mid-1990s to reflect the increasing concern of policy leaders and social scientists that socioeconomic differences could be exacerbated if the diffusion of digital technology was dependent on an individual's means to acquire it (Warschauer, 2003).

What we find analogous between the two movements is the insistence on universal access. Both movements, though operating in different spheres, chose as their catchwords terms that convey a sense that no community should be divided between *haves* and *have-nots*. Proponents of ubiquitous computing argue for universal access, among other reasons, (a) to prepare students to move into the workforce, (b) to make sure their institutions are competitive, and (c) to assure that all students within an institution have equal tools with which to learn (Brown, 2003). All these concerns constitute potential digital divides between learning and work, between one institution and another, and between one student and another. The problem with the term ubiquitous computing, however, as Brown and Petitto (2003) have noted, is that with "at least half of all colleges and universities 'practicing ubiquity'…the tight definition of *ubiquitous computing* no longer prevails because the concept itself has become ubiquitous" (p. 24).

For the purposes of this study, however, we have chosen to perpetuate that tight definition of ubiquitous computing with the term, *digital unity*. There are by current estimates from as few as 36 confirmed notebook universities (Confirmed, 2003) to as many as a hundred campuses with universal laptop programs and another fifty where individual schools or other campus units have adopted laptop initiatives (Brown & Petitto, 2003). In addition to the obvious portability advantages of a laptop computer, Brown (2003) lists multiple advantages for campus standardization of hardware and software, ranging from enhanced reliability because of system redundancy to facilitated problem solving, because using similar equipment makes every member of the campus community a potential volunteer helper. Metaphorically speaking, campus laptop initiatives impose the same digital unity among computer users that government regulated monopolies once imposed on telephone service. When telephone service was a regulated monopoly, every subscriber was issued the same black telephone manufactured by Western Electric. The telephone became an icon of universal service. We think it important to highlight this point, however, to illustrate that the metaphor may not be fully applicable. The current rate of innovation in digital technology precludes the degree of uniformity that was once achievable with phone systems. This disparity in the environment has always been a weakness in the digital unity concept and points up the importance of systematic research to determine if laptop programs remain justifiable now that college student ownership of computers has reached 85 percent (Jones, 2002).

ANECDOTAL AND SYSTEMATIC RESEARCH INTO UBIQUITOUS COMPUTING

The literature on campus-wide laptop initiatives can be divided into two branches. One branch is devoted to anecdotal reports designed to provide guidance and encouragement at every level of the process from campus-wide implementation (Brown, Burg, & Dominick, 1998; Brown & Petitto, 2003; Candiotti & Clarke, 1998; LeBlanc & Teal, 1998) to how curriculum and courses might be transformed (Brown, 2003; Kiaer, Mutchler, & Froyd, 1998). The other branch is composed of systematic studies documenting the effects of mandatory computing programs on student attitudes and learning as well as modes of teaching. Despite the dozens of campuses that have instituted laptop programs, the literature is limited to a handful of studies that focus on student experience (Mitra, 1998; Mitra & Steffensmeier, 2000; Platt & Bairnsfather, 2000), faculty experience (Mitra, Steffensmeier, Lenzmeier, & Massoni, 1999) or both (Schrum, Skeele, & Grant, 2002). We can only speculate that programmatic assessments made for institutional use have been too narrowly focused to merit scholarly publication, although summaries of survey data (Holleque, 2002) and verbal journals (McCarty & Robinson, 1999) can be accessed at university Web sites.

The most widely promoted comprehensive computing program has been the Wake Forest University initiative begun with freshman students matriculating in the fall of 1996 (Brown et al., 1998). In 1995, Wake Forest contracted with IBM to wire classrooms, residence halls, the library, and most offices in preparation for the fall semester of 1996, when all first-year students received IBM Thinkpad laptops. To establish a baseline for student attitudes and frequency of computer use, a detailed survey was undertaken in the fall of 1995 and subsequently readministered at the end of year one of the program in the spring semester of 1997, and again at the end of year two in the spring of 1998 (Mitra & Steffensmeier, 2000).

Summarizing these results both longitudinally and comparatively, Mitra and Steffensmeier (2000) found that the implementation of what they described as a "computer-enriched environment" generated a measurable change in student attitudes about computers. The students who received the laptops expressed more positive feelings about computers in general, their role in teaching and learning, and the opportunity they provided for better communication between faculty and students. The improved communication between faculty and students was strongly acknowledged by the legacy students who arrived at Wake Forest the year before the laptop program began, but who nevertheless benefited from the improved network infrastructure on campus. The improved infrastructure was seen as a plus, of course, but it also highlights one of the ironies of implementing a laptop distribution program. From a methodological perspective it should be noted that in the course of implementing a laptop program, administrators artificially foment a digital divide between legacy students and freshman, thereby, establishing criteria for a quasi-experimental study.

Prior to this longitudinal study, Mitra alone and with colleagues completed two other studies at Wake Forest that have a bearing on research into the efficacy of a laptop program. In acquiring first-year baseline data on the attitudes and computer use of students (Mitra, 1998) and first- and second-year data on faculty (Mitra, Steffensmeier, Lenzmeier, & Massoni, 1999), Mitra demonstrated that use and attitudes are multidimensional constructs. Accordingly, a standard was set to incorporate, when possible, questions that take into account varieties of computer use when constructing items for a general survey of users. Further, in evaluating changes in faculty attitudes and use, faculty skill levels differentially affected increased use of various types of computer software, which suggested that administrators must give careful attention to providing sufficient computer training and infrastructural support to maintain positive attitudes about the campus-wide initiative.

In a study involving two classes of medical students who were the first participants in a laptop initiative at Louisiana State University, Platt and Bairnsfather (2000) also employed questions that specified a variety of computer uses associated with instruction and learning in order to assess the impact of a mandatory purchase program. No comparison was made with medical students who were not participating in the program, but the freshman class of 2000 was subsequently interviewed as sophomores simultaneously with the freshman class of 2001. The researchers reported students were "very positive" concerning the program and "enthusiastic" about their ability to communicate with faculty, results that, despite the differences in circumstances, are similar to the attitudes measured at Wake Forest. The medical students, however, expressed dissatisfaction in responding to items about computer-based learning. Platt and Bairnsfather (2000) attribute these low ratings to difficulties experienced by faculty in finding appropriate software or developing suitable computer-assisted instruction materials locally.

Schrum, Skeele, and Grant (2002) have reported the results of a two-year study employing both survey and focus group methods to assess the effects of a grant designed to encourage college of education faculty at a laptop campus to further integrate computer technology into their curriculum and teaching. The analysis suggested that within-school technical support as well as incentives, especially released time, were successful in increasing faculty appreciation, knowledge, and skills for developing computer-assisted instructional materials. Interestingly, while a second year survey demonstrated impressive progress for faculty in mastering technological skills, students' responses remained the same from year one to year two, owing in part to high self-assessments in the first year of the study, which, although the researchers do not comment on this directly, could be attributed to the university's universal laptop program. From observation and focus group discussion, it was nevertheless apparent that students were motivated to model the faculty's efforts to incorporate technology into their preservice teaching activities. Further, Schrum et al. (2002) provide a salient example of the students' heightened consciousness about the consequences of an unequal diffusion of computing resources, observing that "during several focus groups the students initiated discussions about the Digital Divide and frequently mentioned the disparity between the suburban and urban schools" (p. 267).

GROVE CITY COLLEGE STUDY

From previous research, we recognized the advantage of designing a study that incorporated respondents who had entered as freshman both before and after the implementation of the universal laptop program, thereby enabling us to analyze the data as a quasi-experimental study. In our case, however, this strategy provided a second major advantage over previous studies. Grove City's Information Technology Initiative had been in operation long enough that we could survey alumni rather than students and benefit from their long-term perspective. The ITI had been implemented in conjunction with Compaq Computers (now merged with Hewlett-Packard) in 1994, with the distribution of laptops to all full-time faculty in the spring and to all full-time freshmen in the fall. Thus, three classes that had received laptop computers as entering first-year students had already graduated in 1998, 1999, and 2000 when this study was in its planning stage. College alumni had already entered the workforce or graduate school, and although they could not answer specific questions about the laptop program in its current configuration, they were uniquely qualified to comment on how they had fared in transcending the digital divide between college and the workplace, and to some extent indicate whether a digital divide existed between Grove City and other colleges with their ratings of the program's contribution to their professional achievements. Therefore, for this study, we surveyed alumni from the class of 1997, who were the last students required to bring their own computers to campus, along with the alumni from the classes of 1998 and 2000, who represented, respectively, the first class to receive laptops and the most recent class to receive them who could be expected to be settled at work or in graduate school at the time of the survey.

The survey was supported by the college, and thus had an immediate administrative objective. More than seven years after the Information Technology Initiative's implementation, administrators were eager to assess how well the stated goals of the college's plan had been met. Those goals included providing an acceptable level of convenience for students, integrating computer technology into courses, and preparing students for their professions. This third goal, focused on the long-term effects of the laptop program, led to a set of more expansive research questions. First, how did the level of computing activity during the students' four years on campus compare with their subsequent experience as working professionals as well as their previous experience as high school students? In this regard, we were cognizant of how various types of computer use should be included in the survey (Mitra, 1998) and that gender may be a critical variable because of differential experiences in school and at home (Chen, 1986, 1987). Recent data have suggested, in fact, that gender differences lie more often in type of use than frequency of use (Ono & Zavodny, 2003).

Second, was there an indicator of cognitive style or intellectual disposition associated with the types and frequency of an individual's computer use? After nearly a decade of debate over the merits of universal access to the Internet, researchers have begun to focus on the fit between technology and "context into which that hardware would be put" (Warschauer, 2003). Although it is understandable that early assessments of laptop computing programs would focus on institutional objectives of encouraging usage and integration of technology, we thought it odd that such measures would be gathered with little consideration for the mechanisms of learning. As a first step, we decided to devote a substantial portion of the survey to assessing the respondent's learning style to provide a context for their use of computer technology.

In this domain, we made a comprehensive review of the learning style literature, ultimately incorporating the most widely cited instrument, Kolb's *Learning Style Inventory* (LSI), into our questionnaire. Kolb's (1984, 1993) instrument is based on a model of learning composed of four primary modes: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experience (AE). Kolb contends that learners have preferred modes of acquiring information that "result from individuals' preferred ways for adapting to the world" (Kolb, Boyatzis, & Mainemelis, 2001, p. 227). While Kolb's experiential learning model (ELM) is well established (Loo, 1997) and the LSI is recognized for its popularity and high face validity (Atkinson, 1991), we opted for this measure despite an intense debate about the stability of Kolb's measure and the limitations of his theory (Atkinson, 1991; Caño-Garcia & Hughes, 2000; Garner, 2000; Geiger, Boyle, & Pinto, 1992; Loo, 1997) because, unlike most other learning style measures, the extensive literature provided a basis for alternative methods of interpreting results.

METHODOLOGY

Data Collection

A total of 600 surveys, color coded by class—1997, 1998, and 2000—were mailed out anonymously to a random sample of Grove City College alumni on October 31, 2001. The 1997 and 1998 alumni were selected because their classes bridged the initiation of the comprehensive computing program at Grove City. The class of 1998 alumni were the first to receive laptop computers when they arrived on campus in the fall of 1994; the class of 1997 alumni were the last students who were expected to purchase their own machines. The class of 2000 alumni were included in the survey to provide additional validation of the effects of the program and reveal further trends. The sample of 600 represented just over 41% of the alumni for the three classes surveyed. Because the survey was completed anonymously, follow-up was limited to a postcard mailed to the entire sample on November 20, 2001, thanking those who had sent in their questionnaires for their participation and urging all others to submit them.

A total of 212 questionnaires were ultimately returned, representing an equal response rate of 37.5% for the classes of 1997 and 1998 and a lower rate of 31.0% for the class of 2000. Due to a response rate of less than 50%, a number of analyses were completed to determine the representativeness of the sample obtained. A comparison of responses to demographic items with known parameters for the three classes indicated that female students, representing 56.1% of the sample, were overrepresented by 7.0%. However, the general distribution of majors in the sample—liberal arts (27.4%), education (15.6%), business (27.4%), math and science (17.9%), and engineering (11.8%)—deviated only 0.5 to 3.5% from the population parameters for the three classes.

To evaluate the relative geographic distribution of respondents, the zip codes from the survey sample addresses were compared with the postmarked zip codes on the envelopes containing completed questionnaires. The analysis showed that 49.6% of the questionnaires had been mailed to Pennsylvania zip codes, while 42.9% of the returned questionnaires were postmarked in Pennsylvania, a deviation of less than 7%. Zip code comparisons for the next five states with substantial alumni sample addresses—Ohio (11.5% mailed vs. 12.3% returned), Maryland (5.1% vs. 6.1%), Virginia (4.7% vs. 3.3%), New York (4.7% vs. 3.8%), and New Jersey (2.5% vs. 2.8%)—revealed no deviation greater than 1.5%.

Finally, in order to check the internal representativeness of the returned surveys, they were grouped according to date of receipt. Reponses from the first 106 questionnaires received were compared item by item with the responses of the second 106 questionnaires. Only a handful of items revealed statistically significant differences, suggesting that there was no systematic difference between early and late respondents and by inference that non-respondents would not be expected to provide systematically different answers either. Accordingly, no further efforts, such as sending new copies of the questionnaire to the entire sample to increase the response rate, were made.

Variables

Opinion Measures. The three original stated goals of the Information Technology Initiative (ITI) at Grove City College were (a) to make computer technology convenient for students to use, (b) to integrate computer technology into courses, and (c) to prepare students better for their professions. Two components of the survey addressed these questions directly. A set of eight statements focused on practical matters of convenience and support afforded by the ITI, including how the initiative facilitated completing assignments, using computers in classrooms and dormitories, obtaining repairs, securing help with problems, and generating favorable attitudes towards the college. Using a five-point scale, ranging from (1) *strongly disagree* to (5) *strongly agree*, alumni were asked to circle an *SD*, *D*, *N*, *A*, or *SA*. The same format was used to rate a set of ten additional statements asking alumni to assess how well computer technology was integrated into courses, enhanced their learning, contributed to their professional development, and whether the laptop initiative was worth continuing.

Computer Use Measures. These two opinion sections of the questionnaire were separated by a section devoted to the type and frequency of computer technology used during high school, college, and the present day. The alumni were asked about six generic applications—word processing, spreadsheets, presentation software, Internet use, e-mail, and computer games-—indicating the frequency of use with a scale adapted from the Pew Internet Project (www.pewinternet.org). The ordinal scale included five levels with scores ascending from 1 to 5 as recalled frequency of use increased: (1) Never, (2) Once a week or less, (3) Once every few days, (4) About once a day, and (5) Several times per day.

Learning Styles. Permission was obtained from the publisher, McBer & Company, to include the *Learning Style Inventory* (Kolb, 1993) to generate primary learning style scores for each participant. The inventory includes 12 introductory statements, all indicating the same theme—"I learn best when…." that are followed by four choices describing different modes of learning. The participants are asked to rank these four choices according to how well they think each one fits the way they would go about learning something. The first item in the *LSI*, for example, asks the respondent, in response to the statement "When I learn," to rank the following four possibilities—(a) "I like to deal with my feelings," (b) "I like to think about ideas," (c) "I like to be doing things," or (d) "I like to watch and listen." Each item must be uniquely ranked, giving four points to the item "*most* like you," three points to the item "*second most* like you," two points to the *"third most"* item, and one point to the "*least* like you" item.

These four "like" items reflect the four dimensions—feeling, thinking, doing and watching—of Kolb's theory of experiential learning. The set of choices for each statement about learning always reflects these four dimensions, although the item order is staggered for each of the 12 questions. It is Kolb's practice to assign each respondent to one of four categories of learning styles by combining the scores from two adjacent learning dimensions. The validity of this categorization process is strongly disputed by critics (Cornwell & Manfredo, 1994; DeCiantis & Kirton, 1996). Accordingly, after classifying the students according to Kolb's procedures, we retained the total scores for each of the four dimensions—feeling, thinking, doing and watching—and used each participant's highest score as the measure of his or her primary learning style (Cornwell & Manfredo, 1994).

Analysis

The analysis naturally evolved from the quasi-experimental design of the survey. Alumni who graduated in 1998 and 2000 were considered a treatment group because they had received laptops when they arrived on campus as freshmen. By contrast, alumni who graduated in 1997, who comprised the last freshman class whose members were expected to bring personal computers to campus, were the control group. Analysis of variance (ANOVA) procedures were used to determine whether the mean scores of the 1998 and 2000 alumni's responses differed significantly from the mean scores of the 1997 alumni, thereby indicating that implementation of the laptop initiative had had an effect. In addition, because the laptop program itself was continually evolving in this period (e.g., specifications for the laptops improved each year), there was a possibility that there would be differences in the responses between the classes of 1998 and 2000 as well, although certainly not as dramatic.

Once this initial analysis, which focused solely on survey items that reflected ITI goals, was completed, a second exploratory analysis was undertaken, which focused on the alumni's computer usage, not only as college students, but currently as professionals, and retrospectively as high school students. This analysis also evaluated differences in mean scores, but the dependent measure was frequency of use of various computer applications, while the independent variables included—in addition to graduation year—gender, time period, and field of study. The use of multiple independent variables required the use of multivariate analysis of variance (MANOVA) procedures in which frequency of use means between various subgroups were compared.

RESULTS AND DISCUSSION

The three primary goals of the Information Technology Initiative were (a) to make computer technology convenient for students to use, (b) to integrate computer technology into courses, and (c) to prepare students better for their professions. Two components of the survey, composed of 8 and 10 items each, addressed these questions directly.

Technological Convenience and Support

The responses of the alumni to the convenience and support items (see Table 1) demonstrate that the 1998 and 2000 alumni who received laptops were for the most part more positive about the state of technology on campus than the 1997 alumni who had had to bring their own computers to campus or depend solely on public computer labs. In particular, the 1998 and 2000 alumni had statistically significant higher mean scores when it came to agreeing that the technology made it convenient to do assignments ($F(2,207)=40.02$, $p<.001$), and they had statistically significant lower mean scores than the 1997 alumni showing that they would have found it inconvenient to bring their own computers ($F(2,205)=40.58$, $p<.001$) to campus. In addition, after their four year experience their mean scores showed them to be more satisfied with the college's computer repair service than their 1997 classmates ($F(2,199)=24.82$, $p<.001$). In fact, based on the difference in means scores, they were even more likely than the 1997 alumni to express the opinion that the technology available to them was better than at other colleges ($F(2,205)=14.57$, $p<.001$). For these four items the statistically significant differences in mean scores between the 1997 alumni control group and the 1998 and 2000 alumni experimental group were confirmed using a post hoc Scheffé's test.

The evaluations, despite their generally positive character, were nevertheless surprisingly discriminating. In response to an item about dormitory rooms being well-equipped for technology, a post-hoc Scheffé analysis demonstrated that, when warranted, the 1998 alumni held opinions more in line with the laptop-deprived 1997 alumni. College dormitories had not been fully wired when the laptop initiative had begun. Accordingly, only the members of the class of 2000, who arrived on campus two years later, agreed that dormitories were technologically well equipped

Table 1. One-Way ANOVA: Technology Convenience and Support by Graduation Year

Convenience Items	Means			One-Way ANOVA		
	1997[a]	1998[b]	2000[c]	*F*-Ratio	*df*	*signif.*
1. Computer technology provided by Grove City College made it convenient for me to complete assignments	3.12[b,c]	4.12[a]	4.40[a]	40.02	2,207	$p<.001$
2. The College's classrooms were well equipped to support the use of computer technology during class time.	1.95[c]	2.27	2.34[a]	4.28	2,207	$p<.02$
3. The College's dormitory rooms were well equipped to support the use of computer technology.	2.40[c]	2.78[c]	3.95[a,b]	34.54	2,203	$p<.001$
4. While I was a student, I believed the computer technology available on campus was better than what was available at other similar colleges.	2.62[b,c]	3.38[a]	3.57[a]	14.57	2,205	$p<.001$
5. I found it more convenient to bring my own personal computer than to use the College's equipment.	3.77[b,c]	2.26[a]	2.27[a]	40.58	2,205	$p<.001$
6. I was satisfied with the service provided by the College's computer repair shop.	2.83[b,c]	3.77[a]	3.60[a]	24.82	2,199	$p<.001$
7. I was satisfied with the service provided by the College's computer help desk.	3.13	3.47	3.31	2.42	2,205	$p<.10$
8. When I had problems using computer technology, friends and classmates most often provided the help I needed.	4.09	3.97	4.02	0.47	2,207	*n.s.*

Note: Superscripts a, b, and c are used to designate the three graduation years 1997, 1998, and 2000, respectively. Scheffé's test, a post hoc multiple comparison statistic, was used to determine whether differences between mean scores were statistically different for any particular item. When a mean score is superscripted with a letter, then that score is statistically different than the mean score for the graduation year denoted by the letter.

Table 2. One-Way ANOVA: Career Preparation Ratings by Graduation Year

Career Preparation Items	Mean			One-Way ANOVA		
	1997[a]	1998[b]	2000[c]	*F*-Ratio	*df*	*signif.*
1. Computer technology was an essential tool that I used during my career at Grove City College.	3.58[b,c]	3.99[a]	4.02[a]	4.65	2,207	$p<.01$
2. Student use of computer technology to complete assignments enhanced student learning.	3.53	3.88	3.79	3.33	2,207	$p<.05$
3. Use of computer technology in college frequently increased my understanding of course content.	2.81	3.01	3.03	1.28	2,207	*n.s.*
4. My professors frequently provided assignments that required the use of computer technology.	3.27	3.27	3.66	2.34	2,206	$p<.10$
5. The College's administration supported and encouraged faculty to develop technology-integrated courses.	3.04	3.08	3.29	1.33	2,206	*n.s.*
6. It was beneficial to have a portable laptop computer during my College career. (Answer if applicable.)	3.80[b,c]	4.49[a]	4.53[a]	6.81	2,152	$p<.001$
7. As a student, a desktop computer would have been more beneficial to own and use than a portable laptop computer.	2.69[b,c]	2.19[a]	2.24[a]	5.52	2,198	$p<.005$
8. The computer technology I used at Grove City College helped to prepare me for my chosen profession.	3.16[b]	3.73[a]	3.53	7.28	2,207	$p<.001$
9. Using computer technology in college was essential for my later professional success.	3.63	3.76	3.71	0.28	2,207	*n.s.*
10. I believe the Grove City College laptop computer program is important to continue for future students.	4.19[c]	4.45	4.56[a]	4.70	2,207	$p < .01$

Note: Superscripts a, b, and c are used to designate the three graduation years 1997, 1998, and 2000, respectively. Scheffé's test, a post hoc multiple comparison statistic, was used to determine whether differences between mean scores were statistically different for any particular item. When a mean score is superscripted with a letter, then that score is statistically different than the mean score for the graduation year denoted by the letter.

($F(2,203)=34.54$, $p<.001$). A similar disparity occurred in regard to classroom facilities. Essentially, all three alumni groups registered means below 3.0, which means they disagreed with the proposition that classrooms were well equipped to support computer technology. However the mean response for the 2000 alumni was sufficiently higher than that of the 1997 alumni to infer that the later laptop class, who arrived on campus as freshman the year the 1997 class graduated, found classroom conditions significantly better but not satisfactory. The 1998 alumni, though their mean score on this item is closer to the 2000 alumni, cannot be statistically differentiated from either group, which means there was considerable variation in the responses provided by the class, resulting in a statistically significant but lower *F*-ratio ($F(2,207)=4.28$, $p<.02$).

Finally, the survey results provided a dose of reality about the contribution made by computer help desks. Whether they were part of the laptop program or not, alumni in all three classes exhibited remarkable agreement about the role of friends and classmates in providing computer help ($F(2,207)=0.47$, *n.s.*), which may not be a programmatic failure to the extent that digital unity enables every user to become a potential helper (Brown, 2003). In that regard, it is interesting to note how the mean rating of the help desk is highest for the 1998 alumni, who were the first to get laptops, but falls for the 2000 alumni, who by the time of their arrival may have had less interaction with the help desk because after their freshman year everyone on campus had a laptop, thereby establishing digital unity ($F(2,205)=2.42$, $p<.10$).

Effects on Courses and Preparing for a Career

The Information Technology Initiative was not limited, of course, to just technical improvements in infrastructure. The new information technology was expected to have a substantial effect on how courses were taught, thereby creating an environment that was also substantially more attuned to the work environment that students would face after graduation. Alumni assessments of these dimensions of the technology initiative are, on the whole, positive, but their opinions also reveal gaps in the laptop program (see Table 2). In their responses, the 1998 and 2000 alumni clearly registered higher mean scores than the 1997 alumni, demonstrating more enthusiasm for computer technology as an essential tool at college ($F(2,207)=4.65$, $p<.01$) and the benefits of having a laptop computer at college ($F(2,152)=6.81$, $p<.001$), specifically preferring it to a desktop computer ($F(2,198)=5.52$, $p<.005$).

However, only the 1998 alumni members were demonstrably more positive than the 1997 alumni in agreeing with the statement that technology helped prepare them for their profession ($F(2,207)=7.28$, $p<.001$). The members of the class of 2000, perhaps because they are not as far along in their professional development, were not as sure. Further, the mean scores for the three alumni classes were virtually indistinguishable in response to the idea that using technology in college is essential for later success ($F(2,207)=0.28$, *n.s.*).

Responses to the remaining items in this section of the questionnaire suggest, in fact, that the anticipated curricular revolution was lagging behind the technological innovations that occurred while these alumni were on campus. There is no evidence in the data to support the notion that the technology initiative automatically led to better learning. Mean scores were neutral (2.81 *M* 3.03) when it came to technology increasing the understanding of course content ($F(2,207)=1.28$, *n.s.*) and barely higher (3.04 *M* 3.29) in r egard to perceptions about faculty being encouraged to integrate technology in courses ($F(2,206)=1.33$, *n.s.*) with no significant differences between classes. Nevertheless, the 2000 alumni ranged from *agreement* to *strong agreement* ($M=4.56$) when asked if it were important for the laptop program to continue. Their attitude was significantly more favorable than the 1997 alumni ($F(2,207)=4.70$, $p<.01$), who despite having missed the laptop program by a year, nevertheless agreed ($M=4.19$) that the program should be continued for incoming undergraduates.

In sum, then, the responses to this section of the questionnaire may be interpreted as a vote of confidence in the Grove City Information Technology Initiative, although the responses also have hallmarks of other student surveys at laptop institutions that reveal skepticism or impatience with the pace of integrating technology into the curriculum (Platt & Bairnsfather, 1999; Mitra & Steffensmeier, 2000). As far as encouragement to faculty is concerned, Schrum et al.'s (2002) analysis of the effects of a faculty development grant awarded at a laptop university indicated that incentives are useful for motivating faculty participation. Their study also demonstrated the efficacy of using qualitative methods—rather than surveys—to understand faculty attitudes and behavior.

Assessing the Effects of Digital Unity on Frequency of Computer Use

To answer the research question about how the laptop initiative may have affected computer use, it may be useful to hypothesize first what would constitute a positive result. A major section of the questionnaire included questions to gauge how frequently the participants used (1) word processing, (2) spreadsheet, and (3) presentation software or accessed the (4) Internet, (5) e-mail, and (6) computer games, measured on a five-point scale from (1) *never* to (5) *several times a day*. Further, participants provided estimates for each activity during three different periods in their lives—high school, college, and current work—that were interpreted as repeated measures over time.

The question reduces to how these data would be arrayed if the laptop initiative were having an optimal effect. In our analysis, we have used both alumni graduation year (which alumni class) and sex as surrogates for pre-existing digital divides. Many studies have demonstrated that males in high school use computers more than females, so we can expect a digital divide in our data during the high school time period (Young, 2000). At the same time, however, if digital unity is an antidote to pre-existing digital divides, then the discrepancy between males' and females' frequency of computer use should have diminished while the 1998 and 2000 alumni were on campus, and, in an ideal case, not reappear when the same men and women enter the workforce or continue in graduate school. On the other hand, the implementation of the laptop initiative artificially created a digital divide between 1997 alumni who were sophomores, when 1998 alumni arrived as freshmen and received the first set of laptops, and seniors, when the class of 2000 alumni arrived as freshmen and received even better laptops. Their technology ratings were generally lower than those of the 1998 and 2000 alumni. Their frequency of use might be expected to be lower as well.

Table 3 presents mean frequency of use scores for six generic applications, sorted according to life period, sex, and graduation year. The frequency of use responses for three time periods in the respondents' lives (high school, college, and current work) were submitted as repeated measures using the General Linear Model function on SPSS 10.0. At the most inclusive level, the gender divide can be evaluated by looking at the most

Table 3. Mean Frequency of Use Scores by Time Period, Sex, and Graduation Year

		High School		Undergraduate		Current Work			
Frequency of Computer Use	Grad Year	Male *n*=90	Female *n*=116	Male *n*=90	Female *n*=116	Male *n*=90	Female *n*=116	Between Subjects Effects	*p*-values
Word Processing	1997	2.30	2.49	3.43	3.51	4.30	3.88	Sex	*n.s.*
	1998	2.45	2.37	3.81	3.29	4.23	3.80	Grad Year	*n.s.*
	2000	2.66	2.62	3.72	3.81	3.83	3.84	S x Y	*n.s.*
	Average	2.47	2.48	3.66	3.52	4.12	3.84		
Spread Sheet	1997	1.30	1.42	2.40	2.09	3.70	3.12	Sex	*p*=.004
	1998	1.56	1.44	2.66	2.22	3.47	2.98	Grad Year	*n.s.*
	2000	1.66	1.47	2.72	2.28	3.21	2.81	S x Y	*n.s.*
	Average	1.51	1.44	2.59	2.19	3.46	2.98		
Presentation Software	1997	1.03	1.05	1.79	1.60	2.41	1.95	Sex	*p*=.041
	1998	1.09	1.07	1.63	1.76	2.44	2.15	Grad Year	*n.s.*
	2000	1.31	1.18	2.03	1.79	1.97	1.76	S x Y	*n.s.*
	Average	1.14	1.09	1.81	1.71	2.28	1.97		
Internet	1997^{0}	1.17	1.21	2.87	2.64	4.70	4.43	Sex	*p*=.001
	1998^{0}	1.47	1.17	3.31	3.34	4.72	4.41	Grad Year	*p*=.000
	2000^{7,8}	2.21	1.76	4.48	3.85	4.52	4.03	S x Y	*n.s.*
	Average	1.60	1.35	3.54	3.23	4.65	4.31		
E-mail	1997^{8,0}	1.07	1.19	2.83	3.42	4.77	4.56	Sex	*n.s.*
	1998^{7,0}	1.52	1.12	3.61	4.02	4.77	4.54	Grad Year	*p*=.000
	2000^{7,8}	1.97	1.52	4.59	4.27	4.55	4.24	S x Y	*p*=.031
	Average	1.51	1.26	3.67	3.87	4.70	4.46		
Computer Games	1997	2.30	1.69	2.70	1.74	2.17	1.64	Sex	*p*=.000
	1998	**2.65**	**1.76**	2.77	2.49	2.16	1.59	Grad Year	*n.s.*
	2000	**2.76**	**1.79**	2.83	1.88	1.79	1.52	S x Y	*n.s.*
	Average	2.57	1.74	2.77	2.04	2.04	1.59		

Note: Numeral superscripts in Grad Year column indicate statistically significant differences in means between the 1997, 1998, and 2000 alumni with superscript numerals corresponding to last numeral of differentiated grad years; statistically significant differences in mean scores in a time period between males and females who are alumni in the same grad year class are indicated with ***bold*** *(p<.001) or underlined (p<.05) figures; Between Subjects Effects p-values designate differences in means for Sex regardless of Time Period or Grad Year and for Grad Year regardless of Sex or Time Period as well as interactions between Sex and Grad Year without regard for Time Period.*

right-hand column of Table 3, which lists the statistical probabilities of the between-subjects effects of sex, grad year, and their joint interaction on each type of computer use. Gender differences are apparent in the frequencies reported of using spreadsheets (males use them more often, especially as undergraduates), presentation software (males use them more at their current work), the Internet (males access it more often during all life periods), and computer games (males are overwhelmingly more active, especially in high school). Within these four domains, at least, the digital divide appears to be unabated by the existence of Grove City's technology initiative.

However, there are notable exceptions. Within the word-processing domain, the difference in only one pair of means is noted as statistically significant. Thus, the realm of word-processing appears gender-neutral. The other exception is e-mail, where the 1998 and 2000 alumni remember accessing it more frequently than the alumnae do during high school, but once at Grove City the difference in mean frequency diminishes to the point that it is no longer statistically significant. Interestingly, there is a statistically significant difference between the sexes for the 1997 alumni, but in this case the frequency of use is higher among the alumnae. This mixed result is ultimately reflected in the weak "sex by graduation year" interaction effect for e-mail. What is equally noteworthy about both e-mail and Internet use is the real differences in means between the three classes (confirmed using a post-hoc multiple comparison test and noted with superscripts on Table 3). Although some of the between-group difference may be attributed to the technology initiative, the parallel increases in the frequency of Internet and e-mail use in high school suggest that simple diffusion of the technologies also contributes to the annual increases. This is especially apparent in the jump in the frequency of Internet use, which statistically differentiates the 2000 alumni from 1998 alumni even though they are both participants in the laptop program.

Assessing the Effects of Cognitive Style on Computer Use

The final research question—searching for a measure of cognitive style that is associated with computer use—turned out to be the most vexing problem. When developing the questionnaire, we devoted a major portion (one and a half pages) to the inclusion of Kolb's (1993) *Learning Style Inventory*. In a quandary about its validity (Cornwell & Manfredo, 1994; De Ciantis & Kirton, 1996), we used it because no other instrument had been so widely cited or discussed in the educational research literature. In the end, we found, however, that Kolb's idiosyncratic scoring system was not as coherent as the four basic scales—concrete experience, reflective observation, active experimentation, and concrete experience—that comprise his measurement tool. Assigning respondents to one of those four dimensions, based on their highest score, was one reasonable alternative to using Kolb's own scoring system (Cornwell & Manfredo, 1994). Cohen's (2001) finding that exposure to a technology-rich environment can change learning style added yet another dimension to our quandary.

A reasonable solution to this dilemma became apparent when we found that the four primary learning styles were significantly associated with the alumni's major field of study—liberal arts, education, math and science, business, and engineering (X^2=23.72, *df*=12, *p*=.02). By contrast, Kolb's scoring procedure resulted in categories that failed to exhibit any connection with the alumni's major fields of study, or for that matter, virtually any other measure of technology use or attitudes gathered during the course of the survey. Justification for using field of study as a surrogate for learning style is provided by Jones, Reichard, and Mokhtari (2003), who have demonstrated that primary learning styles of community college students were discipline-specific with regard to English, mathematics, science and social studies, and by Loo (2002), who has found that primary learning styles distinguish the orientation of undergraduate business students towards choosing hard (accounting, finance, and MIS) or soft (marketing and general management) majors. We finally reasoned that because an improvised measure based on Kolb's instrument would surely complicate the explication of results, it was better to use field of study as an indicator of cognitive style, because its meaning was empirically derived.

The results are presented in Table 4, whose format is essentially the same as Table 3 except that the respondents' fields of study, rather than sex, comprise the independent variable. Because there are five fields of study, the table includes 360 mean scores. Thus, it can be best comprehended by looking at the patterns generated by bold and underlined results. For each class, for each type of computer use, in each life period, we have compared the means to determine if there is a statistically significant difference between them. When the one-way ANOVA was significant at the .001 level, we listed the set of five means in bold print. When the statistic was significant at the .05 level or less, we underlined the five means. Thus, the most efficient way to look at Table 4 is to think of it as a two-way table with 6 rows, depicting computer use, and 3 columns, depicting life periods (high school, college, and current work). The points of interest are wherever the numerals are in bold or underlined.

Given these criteria, the most important section of the table is the second row, which depicts the means for the frequency of spreadsheet use. Only 1 set of mean scores out of 12 is not statistically significant. In fact, 10 of 12 are statistically significant at the .001 level. Quite simply, the frequency of the use of spreadsheets during college and currently at work, and even more remarkably during the high school years, appears to differentiate business and engineering majors from education majors.

Using this criterion, two other cells are of particular interest. During their college years, the frequency of use of presentation software consistently distinguishes the business and engineering students once again from education majors, although the degree of difference is not as great for the 1998 or 2000 alumni as it is for the 1997 alumni—perhaps an outcome of the technology initiative leveling the cognitive playing field. Another interesting point is that for the 1998 and 2000 alumni, the frequency of word processing use reported at work distinguishes business and engineering students from math and science majors.

Table 4. Mean Scores of Six Types of Computer Use by Life Period, Field of Study, and Graduation Year

Frequency of Computer Use	Grad Year	Frequency of Use in High School					Frequency of Use as Undergraduate					Frequency of Use at Current Work				
		Lib Art	Educ	M/Sci	Busi	Engn	Lib Art	Educ	M/Sci	Busi	Engn	Lib Art	Educ	M/Sci	Busi	Engn
		n=50	*n*=32	*n*=47	*n*=54	*n*=24	*n*=50	*n*=33	*n*=47	*n*=55	*n*=24	*n*=50	*n*=33	*n*=47	*n*=55	*n*=24
Word Processing	1997	2.23	2.36	2.44	2.47	2.55	3.38	3.50	3.56	3.42	3.55	4.46	3.43	3.69	4.58	3.92
	1998	2.33	2.00	2.38	2.62	2.50	3.57	3.78	3.31	3.64	3.17	4.05	3.89	3.25	4.41	4.33
	2000	2.81	2.70	2.53	2.64	2.43	3.88	4.10	3.50	3.57	4.00	3.38	4.10	3.36	4.43	4.29
	Average	2.46	2.38	2.45	2.57	2.50	3.62	3.76	3.46	3.55	3.58	**3.94**	**3.76**	**3.43**	**4.47**	**4.12**
Spread Sheet	1997	1.23	1.07	1.38	1.58	1.55	**1.38**	**1.71**	**2.13**	**2.53**	**3.45**	**3.00**	**2.43**	**2.94**	**4.32**	**3.83**
	1998	1.43	1.00	1.38	1.68	2.00	**1.16**	**2.22**	**2.63**	**2.73**	**3.17**	**2.62**	**3.00**	**2.13**	**4.27**	**4.17**
	2000	**1.25**	**1.20**	**1.53**	**1.93**	**2.14**	**1.81**	**2.10**	**2.79**	**2.86**	**3.29**	**2.44**	**2.60**	**2.71**	**3.93**	**3.57**
	Average	**1.32**	**1.09**	**1.43**	**1.71**	**1.83**	**1.68**	**1.97**	**2.50**	**2.69**	**3.33**	**2.66**	**2.64**	**2.59**	**4.20**	**3.84**
Presentation Software	1997	1.00	1.00	1.06	1.05	1.09	**1.46**	**1.14**	**1.50**	**2.11**	**2.27**	2.15	1.50	2.38	2.53	2.00
	1998	1.00	1.00	1.06	1.18	1.00	1.48	1.53	1.56	2.05	1.83	2.00	2.22	1.88	2.73	2.83
	2000	1.19	1.00	1.27	1.50	1.14	1.69	1.40	1.87	2.36	2.29	1.25	2.10	1.67	2.14	2.71
	Average	1.08	1.00	1.13	1.22	1.08	**1.54**	**1.33**	**1.64**	**2.15**	**2.17**	1.80	1.88	1.98	2.51	2.42
Internet	1997	1.31	1.07	1.19	1.22	1.18	2.62	2.86	2.63	2.58	3.18	4.69	4.00	4.44	4.89	4.58
	1998	1.19	1.00	1.25	1.55	1.33	3.24	3.78	3.25	3.45	3.00	4.67	4.11	4.31	4.68	4.83
	2000	1.88	1.20	1.93	2.50	2.29	4.19	3.40	4.40	4.29	4.29	4.06	4.20	4.27	4.50	4.29
	Average	1.44	1.09	1.45	1.69	1.54	3.38	3.27	3.4	3.36	3.46	4.48	4.09	4.34	4.71	4.56
E-mail	1997	1.31	1.00	1.06	1.21	1.09	3.38	3.43	3.00	3.21	2.82	**4.69**	**4.14**	**4.56**	**4.89**	**4.97**
	1998	1.19	1.00	1.16	1.64	1.17	3.76	4.33	3.69	4.00	3.40	4.67	4.22	4.50	4.82	4.80
	2000	1.75	1.00	1.80	2.07	1.86	4.44	4.40	4.53	4.29	4.43	4.06	4.70	4.27	4.57	4.57
	Average	1.40	1.00	1.32	1.60	1.33	3.88	3.97	3.72	3.8	3.43	4.48	4.33	4.45	4.78	4.79
Computer Games	1997	1.69	1.69	2.13	1.95	2.36	1.92	1.93	2.00	2.32	2.55	1.54	1.62	1.69	2.16	2.17
	1998	1.95	1.75	2.40	2.36	1.83	2.48	2.89	2.75	2.68	2.33	1.71	1.89	1.88	1.91	1.83
	2000	1.88	2.40	2.60	2.21	2.14	1.94	2.00	2.87	2.43	2.29	1.44	1.70	1.80	1.71	1.57
	Average	1.86	1.91	2.37	2.18	2.17	2.16	2.21	2.53	2.49	2.42	1.58	1.72	1.79	1.95	1.92

Note: ***Bold*** *figures indicate statistically significant F-ratios at $p<.001$ per field of study and time period; underlined figures indicate $p<.05$*

More speculative, but certainly interesting, are the remaining boldfaced or underlined items in Table 4, which appear to repeat the pattern of differentiating former business and engineering students from former education majors. The fact that education majors reported extremely low frequencies of software and e-mail use (often no experience at all) in all areas except word processing and computer games could be cause for alarm. Their considerably higher scores for Internet and e-mail use while at Grove City, however, may be an indication that the Informataion Technology Initiative played a role in stemming the digital divide that currently afflicts elementary and secondary schools (Levin & Arafeh, 2002). This result is consistent with the outcomes reported by Schrum et al. (2002) in their study of education majors at a laptop university. Some consolation might also be taken by the fact that the digital divide that separates males and females when it comes to computer games is nowhere evident in regard to fields of study, suggesting that it is a matter of personal taste and not individual prowess.

CONCLUSIONS

For the administrators and academics at Grove City College, the results of this survey should reassure them that their quest for digital unity on campus had at least one of its desired effects. It generated positive attitudes about the state of technological readiness at Grove City among affected alumni in the classes of 1998 and 2000. There is less consensus, however, about whether the modes of teaching and learning were revolutionized by the distribution of laptops to the full-time faculty and each incoming full-time student.

Beyond such institutional objectives, however, assessing the effects of the Information Technology Initiative has provided a valuable opportunity to investigate what role such programs may play in ameliorating two types of digital divides. Perhaps the most telling aspect about the gender-based usage differences is that they appear to be non-existent when it comes to conventional office applications. There were no differences in usage for males and females for either word processing or presentation software, and even spreadsheet use in high school and after graduation is roughly equal. Ironically, though, because no difference was exhibited by the 1997 alumni, the implementation of the laptop initiative for the classes of 1998 and 2000 may have effected a four-year digital divide between males and females in the use of spreadsheet programs. Similarly, for the frequency of Internet and e-mail use, only a few statistically significant differences are exhibited, with no discernible pattern. Thus, the most compelling gender divide captured in these data is also the least surprising. Alumni reported more frequently use of computer games than alumnae, a divide between males and females that is universal in high school and seems to continue, somewhat abated, at college and beyond.

The digital divide between male and female alumni in regard to spreadsheet programs takes on even broader implications when we look at differences based on fields of study. In fact, some of the gender differences may only be a result of disproportionately high numbers of males taking business and engineering courses. Nevertheless, one reading of the frequency of usage results for spreadsheet programs is that high school usage may be a precursor of a cognitive divide that is ultimately heightened at college and further during a person's professional career. To some extent, presentation software use shows the same affinity with business and engineering, although the pattern is not discernible in high school. Otherwise, the argument may be made that the laptop initiative may have played a role in diminishing the digital divide. Once college ends, differences occur between alumni based on their fields of study for all applications except computer games, but interestingly, for Internet and e-mail use these differences are not statistically significant for the classes of 1998 and 2000. How much of that modest closing of the digital divide resulted directly from the laptop initiative is difficult to estimate in an era of rapid diffusion of PC technology.

One finding, however, is indisputable. The classes of 1998 and 2000, who fully participated in the laptop computer program, exhibited their highest levels of agreement with two statements in support of digital unity on campus: portable computers were beneficial during their college careers ($4.49<M<4.53$) and the laptop program is important to continue for future students ($4.45<M<4.56$). This suggests that Weiser's (1998) vision of a third wave of ubiquitous computing—when computer use is fully and seamlessly integrated into student life—would be readily welcomed by these alumni.

Contributors

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