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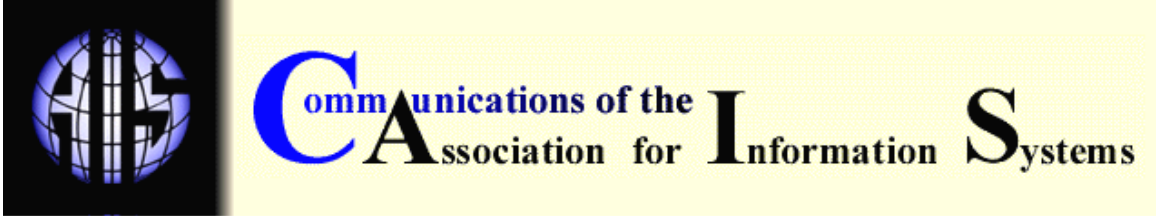
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UPGRADING IT101 WITH HANDHELD COMPUTERS

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ABSTRACT

This study examines the impact of handheld computers on students in a first year Information Technology course (IT101), measuring IT attitudes, skills, and performance. Students in standard sections used their laptop computers and traditional textbooks. Students in intensive sections used both handheld computers and laptop computers, that is, multiple platforms. Both standard and intensive sections covered the same topics. Although students in both standard and intensive sections became more skilled during the semester, students in the intensive sections improved more in programming and Microsoft Excel skills. Students in intensive sections also scored significantly better than students in the standard sections on the common portion of the final exam. Finally, according to anecdotal evidence, students in the intensive sections gained significantly more skill-based confidence in IT compared to students in the standard sections. Seven of our ten expectations were supported. While students benefited from the intensive version of IT101, several factors could account for the improvements: a self-selection factor, an active learning vs. textbook learning factor, and possibly an instructor factor. Future research should shed light on the relative weights of these factors.

Keywords. educational technology, mobile computing, handheld computer, multiple platforms, integrative learning, information technology, programming.

I. INTRODUCTION

The decrease in price and increase in functionality of handheld computers¹ makes it possible to use them in a variety of ways for integrating technology into the classroom experience. This study builds on earlier research that tested the use of personal digital assistants (PDAs) for pedagogical

¹ A handheld computer is often called a Pocket PC, but technically that term refers to a particular Microsoft specification for a handheld computer.

purposes. It takes place in the context of IT101, an introductory information technology course required of all first year students at Bentley College. IT101 is intended to teach students computer literacy.

The standard version of this course is taught in a linear fashion, with discrete units on basic topics such as the Windows XP operating system, hardware, software, networking, personal computer maintenance, Internet architecture, basic HTML, spreadsheets, current events, and ethics related to the use of IT. To explore the use of handheld computing technology in an introductory course, to create a new alternative for technologically advanced students, and to recruit students into the Computer Information Systems major, the department created a new, intensive version of IT101. The objective was to deliver the same conceptual content as the standard sections, but in a technology-intensive, multiple platform fashion expected to improve skills and performance. The intensive sections required students to purchase a handheld computer and use e-books instead of printed textbooks. Students in both the standard and intensive sections also leased the standard first year student laptop computer. The research question for this paper was: Does an intensive approach improve IT attitudes, skills or performance in first year students?

This paper is organized as follows. We first review prior research in educational mobile computing (Section II). We then explain our expectations of students' IT attitudes, skills, and performance (Section III). Sections IV and V describe our methods and results. Findings (Section VI), the study's limitations (Section VII), future research directions (Section VIII), and conclusions complete the paper.

II. PRIOR RESEARCH IN EDUCATIONAL MOBILE COMPUTING

Sharples et. al [2002] describe how elementary school students use specially designed PDAs as a tool for lifelong learning by capturing audio and visual data from daily experiences. They found that, as learning organizers, the PDAs are successful if integrated well with everyday informal learning activities. Luchini et. al [2004] present guidelines for creating specialized software for PDAs for teaching science topics at the high school level. Several studies investigate the impact and difficulty of using PDAs for reading course materials [Allert, 2003, Allert, 2004, Waycott and Kukulka-Hulme, 2003]. A common conclusion is that for reading and note taking, the disadvantages of the small screen and stylus input outweigh the advantages of the mobile form factor.

In Allert's research, he describes why he required his introductory Computer Science students to purchase Pocket PCs [Allert, 2003, Allert, 2004]. In addition to using these devices for note taking and reading electronic books, he creates several software visualization applications for animating common introductory computer science algorithms, such as loops, searching, and sorting. Allert found that the mobile form factor and easy access to the interactive visualizations make the Pocket PC an appropriate platform for learning how to program.

Other researchers investigate the use of Tablet PCs as mobile devices. Edwards and Barnett [2004] study the use of Tablet PCs in introductory Computer Science laboratory courses and report finding no significant differences between the performance of students using laptops and those using Tablet PCs. Edward and Barnett do, however, suggest that students benefit strongly from wireless access in both lecture and lab environments.

Miertschin and Willis [2003] describe a first year course in emerging information technologies focused on building students' technology skills so that they can become successful leaders in the workplace. Miertschin and Willis chose the Tablet PC for classroom use because these devices help the students gain experience from mobile and wireless technologies. They found Tablet PCs to be a useful tool for enhancing study skills, collaboration, and information management.

Campbell and Pargas [2003] investigate how the instructor can do a better job of teaching in situations when a laptop computer with a wireless Internet connection is available to each student. Campbell and Pargas outline several areas, including demonstrating concepts,

collaborative learning, instant communication, laptop etiquette, and discipline that an effective instructor must put into place in order to effectively use laptops in the classroom.

Thus far, the research results about the use of PDAs and other small form factor mobile computing devices are mixed, but trending positively. The form factor can be a help or hindrance. Similar to Edwards and Barnett [2004], this study compares the learning of students using handheld computers to those not using handheld computers. Similar to Miertschin and Willis [2003], this study examines the usefulness of handheld computers as a tool for helping students build their technology skills. Similar to Campbell and Pargas [2003], this study focuses on ways to integrate handheld computers in the curriculum by using the handheld computer outside the classroom. In contrast to most of these studies, the current study investigates the impact of handheld computers as mobile learning devices. They are significantly smaller than both laptop and tablet PCs, offering potentially more than an incremental advance in educational mobile computing.

Allert notes that the handheld computers must become the students' technology companions:

"This is the nature of a true companion device. Unlike a laptop, the added advantages of pocket size, minimal weight, and an instant-on, instant-off capability allow Handhelds to fit seamlessly into student lifestyles characterized by dynamic and intermittent study opportunities". [Allert, 2003]

We build upon the prior studies in three ways.

1. We wanted to test prior conclusions regarding small screen reading at the college level, where purchasing textbooks is the norm.
2. We wanted to test whether handheld computers are powerful enough, yet user-friendly enough, for first year students to learn technology skills and concepts.
3. We wanted to test whether handheld computers would broaden the horizons of our students, making them better learners outside the classroom.

In sum, we believed that the handheld computer would provide an additional platform for learning IT, which could have synergistic benefits, including the encouragement to apply IT broadly.

III. EXPECTATIONS

Our variables of interest are organized into three categories:

- attitudes (Computer Anxiety, Computer Playfulness, and Web Enjoyment),
- skills (handheld computer use, programming, Microsoft Excel use, and personal organization), and
- performance (final exam score).

Our expectations regarding the differences between the standard and intensive section types varied among these three categories.

Attitudes: We expected a baseline difference between the standard and intensive sections in attitudes toward information technology, but we did not expect them to change over the semester.

Skills: We expected the skills to change at different rates in the standard and intensive sections because of the enabling technology (the handheld computer) and additional focus on skill development in the intensive sections.

We expected the intensive sections to perform better on the final exam.

Table 1 summarizes our seven expectations of IT attitudes, skills, and performance.

Table 1 Summary of Expectations

E1	No significant change in Computer Anxiety for students in either the intensive or the standard sections.
E2	No significant change in Computer Playfulness for students in either the intensive or the standard sections.
E3	No significant change in Web Enjoyment for students in either the intensive or the standard sections.
E4	Students in the intensive sections will report to have learned more about programming than students in the standard sections.
E5a-c	Students in the intensive sections will report to have learned more about Excel than students in the standard sections.
E6a-b	Students in the intensive sections will report to have become more organized than students in the standard sections.
E7	Students in the intensive sections will perform better on the common final exam than students in the standard sections.

IT ATTITUDES

Computer Anxiety

Computer Anxiety refers to the extent to which users feel anxious, apprehensive, and even fearful when they interact with computer systems [Igbaria and Chakrabarti, 1990]. Computer Anxiety can be either general and slow to change with experience [Venkatesh, 2000] or situation-specific and at different levels for specific technologies or applications. For our course, which includes a variety of computer technologies and applications, we use the general version of Computer Anxiety.

Computer Anxiety is characterized in the literature as a negative emotional reaction or effect [Torkzadeh and Angulo, 1992], which may develop over the course of many years. Young adults decide whether they like computers and are good at using them, starting from their preschool or elementary school years. Computer Anxiety is therefore a general attitude built over the course of 12 to 16 years, tantamount to a personality trait. One semester at college may have an effect, but it would be unlikely to strongly increase or decrease Computer Anxiety.

E1: There will be no significant change in Computer Anxiety for students in either the intensive or the standard sections.

Computer Playfulness.

Computer Playfulness refers to an individual's tendency to react spontaneously, creatively, interactively, and imaginatively with computers [Lin et al., 2004, Webster and Martocchio, 1992]. Playfulness was studied both as a state that varies with different technology and different environments [Webster et al., 1993] and as a stable and invariant personality trait [Webster and Martocchio, 1992, Yager et al., 1997]. Computer Playfulness was shown to correlate negatively with Computer Anxiety [Webster and Martocchio, 1992]. Similar to Computer Anxiety, we consider Computer Playfulness to be a long-standing attitude toward computers which is slow to change.

E2: There will be no significant change in Computer Playfulness for students in either the intensive or the standard sections.

Web Enjoyment.

Higher enjoyment is a significant predictor of IT use [Agarwal and Karahanna, 2000] and IT acceptance [Venkatesh, 2000]. Web Enjoyment is similar to Computer Playfulness, but it is

specific to the Web context. Since it is more specific, it is prone to specific beliefs about and experiences with the Web, such as searching, shopping, games, or news. Any highly enjoyable experiences, such as searching and finding information, shopping successfully, playing enjoyable games, or reading news of favorite athletic team winnings should increase user enjoyment. Any bad experiences, such as security or privacy breaches, viruses or spyware infections, are likely to tarnish Web Enjoyment. In one semester, students are likely to find new and enjoyable possibilities on the Web. They are also likely to find that their professors deploy the Web in new and challenging ways. Students are likely to enjoy creating their first web site and weblogs (blogs), but they are also going to use the Web to do mundane tasks such as checking for assignments and grades. Eighty-seven percent of U.S. teens aged 12-17 use the Internet for a variety of purposes, including web shopping, game playing, and news reading [Lenhart et al., 2005]. Thus, for most first year students in the U.S., the novelty of the Web is gone.

E3: There will be no significant change in Web Enjoyment for students in either the intensive or the standard sections.

SKILLS

Programming.

Students in the intensive sections write simple game programs on their laptop computers and deploy them on their handheld computers. They also write HTML web pages formatted for proper display on both devices, and include code to determine which version the page is to be displayed. The students in the standard sections do no programming, but they may think that web page creation with HTML qualifies as programming. Conceptually and technologically, the level of programming is deeper in the intensive sections.

E4: Students in the intensive sections will report to have learned more about programming than students in the standard sections.

Microsoft Excel. Students in standard and intensive sections have three similar Excel assignments. In addition, students in the intensive sections need to demonstrate Excel skills in five of the thirteen steps of the multiple platform project (see Appendix III).

E5: Students in the intensive sections will report to have learned more about Excel than students in the standard sections.

Personal Organization.

The handheld computers provide standard software functionality that helps their owners stay organized. They are most commonly used for managing contacts, appointments, and tasks. Although a laptop could be used to manage this information, the handheld computer offers a more mobile second platform for the same information. Information can easily be synchronized between the two platforms.

E6: Students in the intensive sections will report to have become more organized than students in the standard sections.

PERFORMANCE

Final Examination

In addition to IT attitudes and skills, it is important to evaluate differences between the two section types in their objectively measured performance in the course final exam. Although the students were to be tested on somewhat different material, the final exam across the different sections would have 80% common questions, thereby providing an objective basis for comparison.

E7: Students in the intensive sections will perform better on the common final exam than students in the standard sections.

In sum, we expect that the three general IT attitudes would not change significantly over the course of a semester. Despite the slowness of attitude change, specific skills would be expected to change for both types of sections, and more positively in the intensive sections. Finally, we expect students in the intensive sections to perform better on the final exam.

IV. METHODS

During summer orientation, students registered for the two intensive sections of IT101 after attending a presentation comparing the standard and intensive alternatives. Information about the intensive section also included a brief self-assessment exercise (Appendix I) that assisted students in making their decisions. In addition, all first year students met with their advisors, who helped determine whether an intensive section would be appropriate.

One instructor (Professor F) taught both intensive sections. Another instructor (Professor S) taught two standard sections. A third instructor (Professor K) taught one standard section. Students in all sections were asked to take an online survey at the start and end of the semester. The surveys were administered during class time during the third and fourteenth weeks of the course. The third week was chosen rather than the first week to let the add/drop date pass, thus minimizing subject mortality. Anonymity was assured to gain honest responses.

STANDARD VERSUS INTENSIVE SECTIONS

Because of the structure of conceptual textbooks, standard IT101 students typically focus on the memorization of terms and acronyms, sometimes at the expense of understanding how to apply the knowledge. In other words, the standard approach teaches discrete concepts in a traditional, didactic approach, with end-of-chapter exercises to reinforce the concepts. The intensive sections use the handheld computer to solve problems and develop comfort, familiarity, and fluency with information technology. The intensive sections cover largely the same content, but with a focus on solving applied problems on multiple platforms through the use of handheld computers and laptop computers.

The intensive sections integrated the use of Dell Axim X30 handheld computers into many assignments. Equipped with 312 MHz processors and available at an educational price of approximately \$250, these handheld computers were wireless-enabled (802.11b and Bluetooth) and included Pocket Word, Excel, and Internet Explorer, among other software applications. The cost of the traditional conceptual textbooks used in the standard IT101 sections was approximately \$160. Supporting this pilot program, the college purchased the handheld computers and subsidized the costs for students, making them available for \$200. No additional printed textbooks were required for the intensive sections. Instead, students used their laptops and handheld computers to access electronic books from the college library's e-books collection (Books24x7.com) and other web resources for reading assignments that supplemented the class lecture notes.

The intensive sections met in a laboratory-style computer classroom where each student could access a PC preloaded with Microsoft ActiveSync software and a Remote Display tool. Students were encouraged to bring their laptops to class so that they could exchange files directly with their laptops, on which they also installed ActiveSync and Remote Display. Each student was able to connect to an Ethernet port for Internet access. Students brought their handheld computers and USB cables to class, so that they could do in-class exercises and publish directly to web sites and blogs.

The standard and intensive sections were given similar assignments in hardware, software, web site design, Excel, PowerPoint, IT in the News, networking, multimedia, and operating systems. In addition, students in the intensive sections had the extra work of setting up their handheld

computers, installing specialized software applications, and configuring for wireless networking. They also were asked to use their handheld computers for daily life management and to write about their experiences. Beyond the handheld computer-specific work, the intensive students were given three additional, graded assignments:

- a multiple platform programming assignment using Microsoft Visual Basic.Net²
- an assignment to show that the handheld computer is being used for becoming more organized
- a multiple platform project integrating various software tools and technologies (Appendix III).

The handheld computer was expected to give students two benefits: 1) a small form factor to increase mobility and 2) an additional platform for learning Excel skills, programming, and web site development. The learning is more intensive because students could learn:

- the similarities and differences between Excel 2003 and Pocket Excel
- the differences between program development on the laptop and deployment on the handheld computer
- the importance of browser detection in properly displaying a Web page.

In essence, students needed to become platform-sensitive and platform-independent to grasp the functionality of the software independent of the underlying platform.

The intensive sections emphasized the appropriate use and capabilities of computer software. At the beginning of the semester, students worked in groups to identify, install, and evaluate third-party trial versions or free software packages on their handheld computers, as well as presenting their reviews in class. The following week, each student selected one of the other groups' projects to evaluate on his or her own handheld computer. Later in the course, students used Excel and Pocket Excel as a tool for solving problems and creating customized spreadsheets to perform common calculations on their handheld computers. A unit using Visual Basic.Net to create simple games for their handheld computers introduced students to programming and the process of deploying software onto a different platform. Thus, their experience with software included using generic applications, using specialized application software for solving problems, and creating original software applications.

SUBJECTS

All the students enrolled in this study's sections of IT101 completed a Web survey, assessing their abilities to perform various IT tasks. Seventy-seven percent of them were first year students. To maximize the validity of our findings, we analyzed the survey data only for those subjects who took the survey at both the start and end of the semester. In this paper, we call those who took both surveys the study cohort. Table 2 shows the gender breakdown and average SAT scores by cohort and section type.

² The course spends four sessions on programming SmartDevice applications that are easily deployed onto a handheld computer. After writing "Hello World!" in the first session, the second session makes the leap from Excel to programming applications by writing programs to perform numeric calculations based on user-entered values. Two additional sessions introduced tools necessary for creating simple games: timers for simple animation and counting down, tests for determining when two objects are overlapping, and using random numbers.

Table 2. Gender and SAT Scores in Cohorts

	Official Enrollment	Males in Cohort	Females in Cohort	Enrolled, but Outside Cohort	Verbal SAT Score in Cohort	Math SAT Score in Cohort
Intensive	59	33	5	21	602	633
Standard	104	48	17	39	581	635

Verbal SAT Scores were slightly higher in the intensive section than the standard section. Math SAT scores were comparable. It is important to note that male students were more likely to select the intensive section.

V. RESULTS

Table 3, which extends to the next page, presents a numeric summary of the descriptive statistics.

Table 3. Descriptive Statistics

Variable	Section	Cohort at Week 3 of Semester			Cohort at Week 14 of Semester		
		N	Mean	Stdev	N	Mean	Stdev
Computer Anxiety (min = 1, max = 7)	intensive	38	1.46	0.54	38	1.64	0.73
	standard	66	2.47	1.04	66	2.45	1.02
Computer Playfulness (min = 1, max = 7)	intensive	38	5.50	0.63	38	5.56	0.89
	standard	66	4.77	0.72	66	4.77	0.90
Web Enjoyment (min = 1, max = 7)	intensive	38	6.19	0.74	38	6.17	0.94
	standard	66	5.43	1.09	66	5.51	1.13
Compared to other students you know from your high school, what is your ability to use a handheld computer / PDA? (min = 1, max = 5)	intensive	38	2.82	1.47	38	4.03	0.85
	standard	65	2.17	1.10	66	2.08	1.07
Please evaluate your ability to accomplish this task using a computer: Write Computer Programs (min = 1, max = 5)	intensive	38	2.16	1.31	38	3.29	1.09
	standard	65	1.39	0.86	66	1.74	1.07
Please evaluate your ability to accomplish this task using a computer: Calculate Values on Spreadsheet (min = 1, max = 5)	intensive	38	3.50	0.98	38	4.47	0.69
	standard	65	3.22	1.04	65	3.63	0.76
Please evaluate your ability to accomplish this task using a computer: Graph Data on Spreadsheet (min = 1, max = 5)	intensive	38	3.63	0.97	38	4.61	0.50
	standard	65	3.35	1.17	66	3.79	0.81
Please evaluate your understanding of the following concept: How to write Spreadsheet Formulas (min = 1, max = 5)	intensive	38	3.21	0.94	37	4.24	0.64
	standard	65	2.65	0.99	65	3.57	0.79
Please evaluate your ability to accomplish this task using a computer: Keep an Electronic Calendar/ Appointment Book (min = 1, max = 5)	intensive	38	3.97	0.75	38	4.34	0.71
	standard	65	3.02	1.14	66	3.26	1.10
Please evaluate your ability to accomplish this task using a computer: Keep an Electronic Address Book (min = 1, max = 5)	intensive	38	4.03	0.85	38	4.26	0.80
	standard	65	3.08	1.14	66	3.38	1.09

Table 4 provides the results of a 2x2 ANOVA analysis that tests two main effects (intensive vs. standard and start- vs. end-of-semester learning effect) and an interaction effect between the two main effects. The interaction effect, intensive*learning, was always tested in a model containing the two main effects: intensive and learning.

Table 4. Statistics for Main and Interaction Effects

Expectation	Dependent Variable	Intensive Effect		Learning Effect		Interaction Effect		Finding
		F-stat	p value	F-stat	p value	t-stat	p value	
E1	Computer Anxiety	48.9	0.00	0.1	0.71	0.7	0.46	Supported
E2	Computer Playfulness	43.9	0.00	0.0	0.87	0.3	0.78	Supported
E3	Web Enjoyment	23.5	0.00	0.1	0.81	-0.3	0.74	Supported
E4	Write Computer Programs	51.4	0.00	14.3	0.00	2.5	0.01	Supported
E5a	Calculate Values on Spreadsheet	17.0	0.00	22.8	0.00	2.2	0.03	Supported
E5b	Graph Data on Spreadsheet	14.8	0.00	22.0	0.00	2.0	0.04	Supported
E5c	How to write Spreadsheet Formulas	18.3	0.00	56.9	0.00	0.4	0.66	Not Supported
E6a	e-calendar/appt book	49.9	0.00	3.4	0.07	0.4	0.66	Not Supported
E6b	e-address book	38.5	0.00	3.2	0.08	-0.2	0.83	Not Supported

The discussion that follows covers the results of a Web survey and common final examination given to students in both intensive and standard sections of the course. The differences between the two groups are shown in the figures. The squares on the figures represent the standard sections; the diamonds the intensive sections. Note that in our discussions of the expectations, statistical values are shown where appropriate at the bottom of the figures.

Expectations 1-3. The differences were large between the intensive and standard sections in Computer Anxiety, Computer Playfulness and Web Enjoyment, but these attitudes did not change much over the course of one semester. The intensive vs. standard main effect combined with the lack of the interaction effect suggest that Expectations 1 through 3 are supported (Figures 1 through 3 and Table 4).

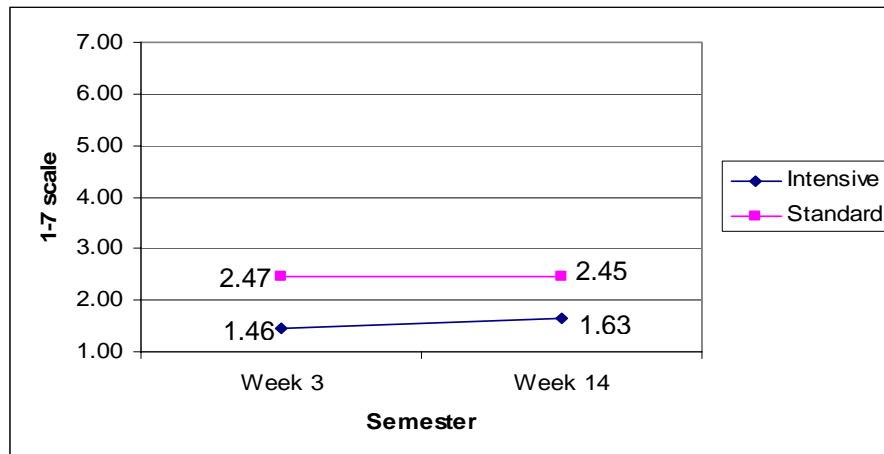


Figure 1. Computer Anxiety (n.s.)

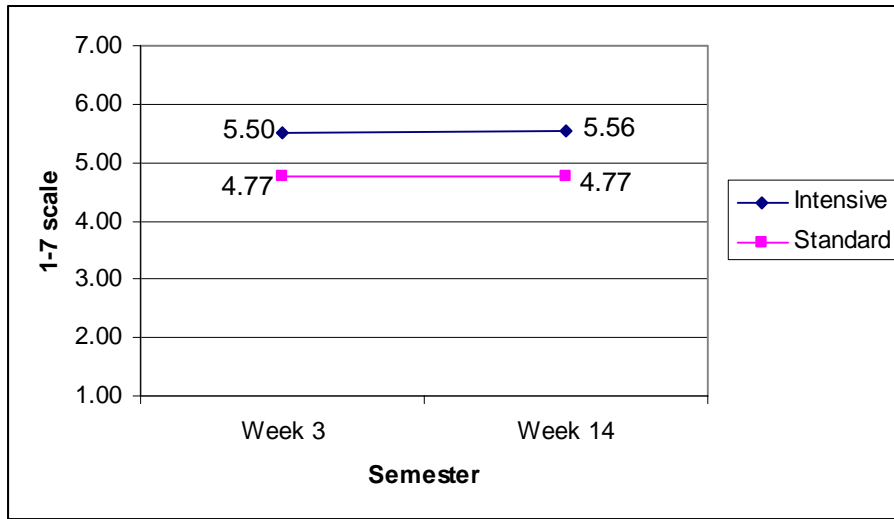


Figure 2. Computer Playfulness (n.s.)

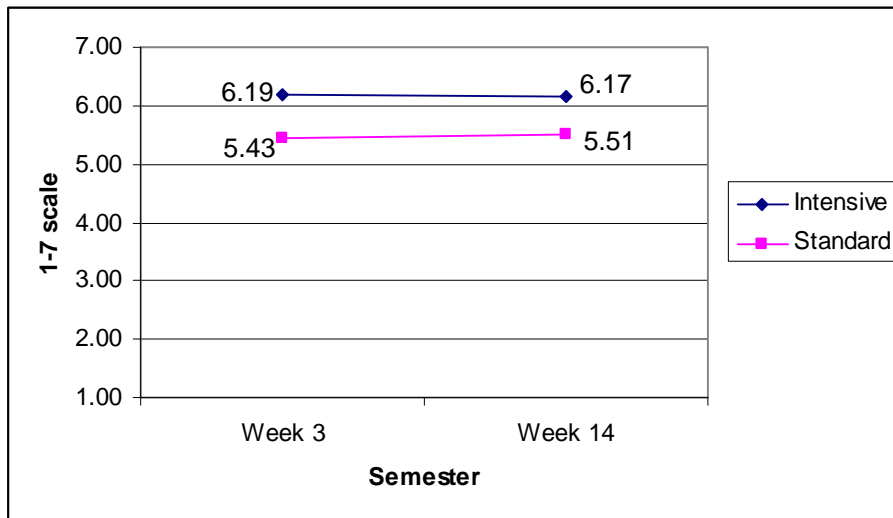


Figure 3. Web Enjoyment (n.s.)

Expectation 4. The data show that the ability to write computer programs was higher in the intensive sections than the standard sections. The results confirm that even the simple programs written in the intensive sections were enough to give those students an appreciation of what is involved in creating custom software. The increase in the students' ability to program was significantly greater in the intensive sections than in the standard sections, and thus, Expectation 4 is supported (Figure 4 and Table 4).

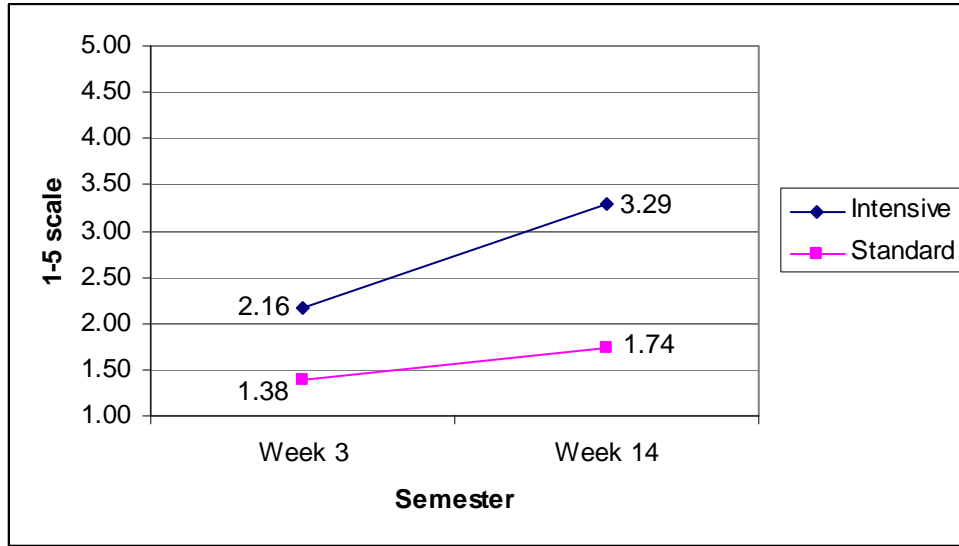


Figure 4. Write Computer Programs ($t = 2.53$, $p = 0.012$)

Expectations 5a-5c Students in intensive sections were significantly better at calculating values and graphing data in MS Excel than students in the standard sections. Expectations 5a and 5b are supported (Figures 5 and 6 and Table 4).

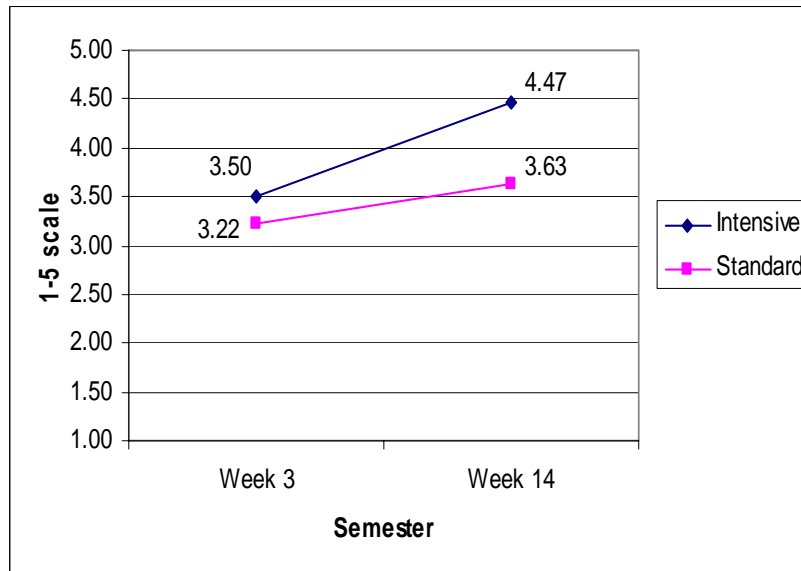


Figure 6. Ability to Graph Data on Spreadsheet ($t = 2.02$, $p = 0.044$)

The situation was, however, different for the third aspect of Excel use: writing Excel formulas. Here, both intensive and standard sections learned approximately the same amount, as can be seen from the parallel lines in Figure 7, and no significant interaction effect (Table 4). Two uncontrolled possibilities may be responsible for this result:

1. In the multiple platform project, students may have calculated values in Excel without using formulas (e.g., =A1+A2 rather than =sum(a1:a2)).
2. The phrasing of the survey question for formula writing was somewhat different in the questions for E5a and E5c. The formula writing question asked for “understanding of the concept,” whereas the phrasing for the questions in E5a and E5b asked for “ability to accomplish the task”. Expectation E5c is not supported (Table 4).

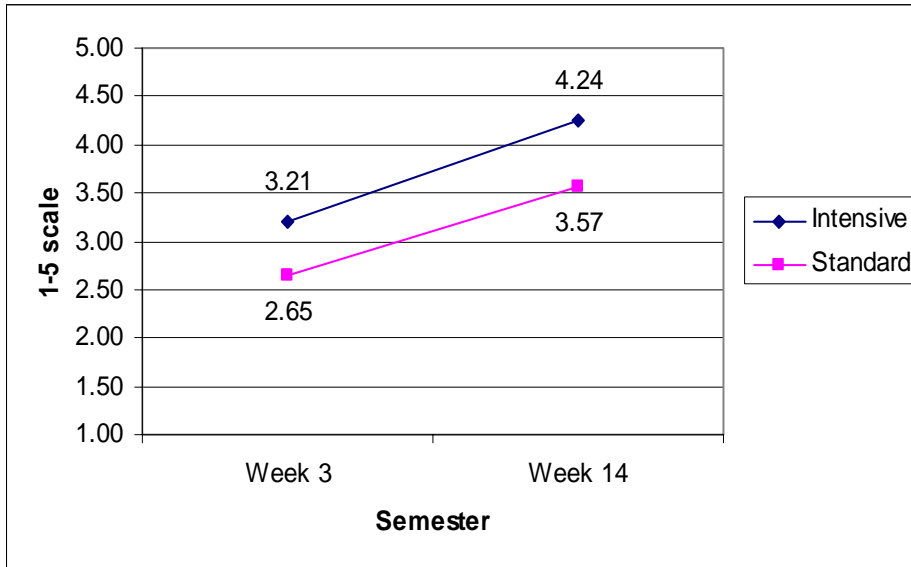


Figure 7. Understand Concept of Writing Spreadsheet Formulas (n.s.)

Expectations 6a and 6b. No interaction effect was found for either of the skills that measure personal organization: e-calendar/e-appointment and e-address book. Handheld computer users indicated a higher level of skills with personal organization tools both at the start and at the end of the semester, but only a modest level of learning occurred for both groups. As discussed in Section IV, Students in the intensive sections received an assignment to show that they were using their handheld computers to help them become more organized. However, they were required only to show three screenshots of their calendar, contacts, and tasks once during the semester. Some students may have done the minimum required to fulfill the assignment. Anecdotal evidence from students' weekly blog entries suggests that a fair number of students in intensive sections did become more organized; however, the blogs were written for the instructor, which might bias the data. Students in the standard sections perhaps became more organized by using calendar, appointment, and address applications on their laptop computers. In addition, some students in the standard sections mentioned that they used “e-PostIt” sticky notes software on their screens to post reminders to themselves, thereby using their laptops to keep organized. Table 4 shows that students in both the intensive and standard sections became more organized, although not quite at a statistically significant level. Expectations 6a and 6b were not supported.

Even though not statistically significant, a substantial amount of anecdotal evidence supports improved organizational skills in the student blogs. For example:

"I think the most useful part of my handheld computer is keeping my life in order. I have everything I need to do listed in tasks - ranging from homework assignments to laundry and cleaning. Then, the appointments work great for classes, work, meetings, sports events, and other commitments. At any given time I can look at my handheld computer and see what I need to do for the next few days. I haven't missed an assignment or meeting (that I didn't want to) since using the handheld computer. For that purpose alone it is a great investment."

Expectation 7. A common final examination was administered to all students of Professors F and S to assess their knowledge objectively. Professors F and S each developed half of the questions on predetermined content areas. They then reviewed each other's questions, together rewording or replacing those that either thought potentially inappropriate for one class or the other. Most questions were posed in either multiple choice or short answer format. For the few questions for which partial credit would be awarded (on Excel formulas or HTML), the two instructors together graded ten student exams selected at random to determine uniform policies prior to grading the remainder of the exams.

Out of the common portion of the final exam, worth 80 points, the standard sections (N=70) scored an average of 53.3, standard deviation 9.7, and the intensive sections (N=57) scored an average of 68.9, standard deviation 6.8. The difference is statistically significant ($F = 105.58$, $p < 0.0001$). Thus, Expectation E7 is supported.

LIFE TECHNOLOGY AND EMOTIONAL RESPONSE

Students in the intensive sections kept blogs throughout the course to document their use of IT. Their blog entries indicate that they accomplished a number of course tasks, including the gathering of survey data and uploading it to their laptops for further analysis. They kept their schedules, tasks, and address books, and they felt organized and empowered. Students also used their handheld computers creatively to solve technology problems other than those posed in class, for example:

"Since the IBM [laptops] don't have floppy drives, clearly we should use USB Flash devices [to transfer files] instead. However, when I recently tried to transfer a file from my [old] Dell [laptop] running Windows 98, the operating system was so old that it didn't even recognize the USB device. Instead of taking the time to install new drivers, I decided to ... send the file by infrared from my Dell to the handheld computer. With that done, I could then simply run an ActiveSync and the file was then on my IBM."

Another student acquired more detailed and complete knowledge:

"We all know the internet is massive and complex, but I had no knowledge of the different layers. All of this little stuff contributes to a greater knowledge, and I feel like a lot of the gaps were filled in with information I didn't previously know. Sweet."

Students also discovered graphing calculators for use in Calculus classes, spell checkers for use in English, and mapping software to help them acclimate to new surroundings. They checked email and surfed the web using free wireless Internet access available both on and off campus, at coffee shops, bookstores, and other locations. They tracked their remaining meal plan points using Pocket Excel. They installed and evaluated software to allow them to listen to MP3s and watch DVDs using their handheld computers. Student blogs show that they thought about their learning and how they intended to continue using their handheld computers after the semester:

"Throughout the semester we have incorporated our handheld computers into nearly every project that was assigned. Using my handheld computer quickly became a daily routine, and the more we used it in class, the more I began to

use it out of class. Every morning I keep my handheld computer next to the bed, when I get up I am able to access that day's news in sports, or around the world. I can also take on the infamous "chess genius" anywhere I take the handheld computer. I know I will continue to use it long after IT intensive is over; its ability to schedule and plan is unmatched."

Appendix IV presents additional quotes from students.

In sum, although attitudes toward computers (Computer Anxiety, Computer Playfulness, and Web Enjoyment) did not change much, students in the intensive sections improved in skills and knowledge, as well as increased their skill-based confidence.

VI. DISCUSSION

Although students in both cohorts exhibit improvements (upwardly sloping lines in Figures 4 through 7), the students in the intensive sections reported increased skills, performed better on the final exam, and increased their skill-based confidence. On several of the self-reported levels of skills, the average scores for students in the intensive sections came close to the maximum possible score. That ceiling effect may account for Expectations 5c, 6a and 6b not being supported. The intensive sections incurred additional overhead to get up to speed on the handheld computer, learning platform differences, and completing three additional assignments, including the multiple platform project. Despite all of this additional work and the class proceeding at a faster pace, they succeeded.

STANDARD VS. INTENSIVE: WHAT WERE THE KEY DIFFERENCES?

The handheld computer may have attracted the students to the intensive section in the first place, but we speculate that it was the active learning approach using multiple platforms, not the handheld computer or the instructor, that was the essence of the course. The handheld computer was an enabler of the multiple platform aspect of this approach. We believe that the use of multiple platforms encourages critical thinking to isolate commonalities and differences between software applications and operating systems.

Apart from the handheld computer, the other main differentiator between the intensive and standard sections was that students were required to decide to enroll in the intensive sections at registration time. They self-selected to opt-in, whereas the students in the standard sections self-selected not to opt-in. Why? Was it simply the presence of the handheld computer? The intensive students were not aware that their version of the course would require additional assignments. Therefore, the handheld computer was likely a big part of what drove their decision. Support for Expectations E1-E3 suggests another, more fundamental reason. Students attracted to the intensive sections were significantly more positive and unchanging attitude toward Information Technology, as can be seen from the statistically insignificant change in Computer Anxiety, Computer Playfulness and Web Enjoyment (Table 4).

STANDARD VS. INTENSIVE: WHEN IS INTENSIVE BETTER?

The findings in this study suggest that an intensive approach using handheld computers instead of traditional textbooks works quite well for self-selected students interested in technology. Almost all of the students in the intensive sections were familiar to some extent with IT concepts prior to the course. Furthermore, from anecdotal blog data, most students were able to use the multiple platform, active learning approach to solve applied technology problems.

Using the handheld computer enabled students to integrate several concepts taught at different times throughout the course. Students needed to interact with multiple IT tools and environments and share data among them. Unlike the standard sections, where a single HTML or Excel project was given during the semester and no additional similar work was required, the intensive sections

focused on applying earlier skills to later assignments using multiple platforms. Thus, the intensive approach tried to reinforce earlier learning in a cumulative, integrative fashion.

The mobile form factor of the handheld enabled the students to create uses for technology outside of the classroom, because they could take the device with them. They sensed that their learning was relevant and practical. The handheld computer also enabled new illustrations of essential computing concepts. For example, most students used a single computer and often used it to connect to other computers via the Internet, but rarely connected it to other computers directly. The handheld computer provided an instant lesson in network computing because the process of synchronizing a handheld computer with a laptop requires students to build a very simple client-server network.

COURSE EVALUATIONS

How did students in Professor F's intensive sections assess the course, compared to students in Professor F's prior semesters of standard sections? From course evaluations, students reported (Table 5) that they understood the course material, benefited from it, and recommended it at significantly higher levels than prior students assessed.

Table 5. Course Evaluations for Professor F

	Course Understanding	Course Benefits	Course Recommended	Course Difficulty	Expected Grade
(min, max)	(1, 5)	(1, 5)	(1, 5)	(1, 5)	(1, 4)
standard, prior semester	3.7	3.7	3.2	3.0	3.2
intensive, current semester	4.4	4.3	4.3	3.1	3.3

No significant difference was observed in either the assessment of course difficulty or the students' expected course grade. The students in the intensive sections were self-selected, thereby suggesting that they were a better fit for the intensive version of IT101. Whether randomly selected students would be a similar fit is the question for the next paper in this stream of research.

VII. LIMITATIONS

As with any pedagogical study involving actual students, this study involved limitations.

1. Except for one or two students who enrolled in an intensive section accidentally because it best fit their schedules, all of the students in the intensive sections were in the class by choice. This self-selection may impact the levels of knowledge and motivation of subjects. Nevertheless, although the intensive effect was stronger than the learning effect, an interaction effect was observed for several variables.

2. The sections in the study were taught by three different instructors, only one of them teaching the intensive sections. Although Professor F taught standard sections in prior semesters, he taught only intensive sections in this study's semester. Neither Professor S nor Professor K taught an intensive section. Even though the IT101 curriculum is common across all sections, the differences in instructor styles and specific areas of emphasis may have affected the results.

3. We tested attitudes and skills at the start and the end of the semester. For an objective verification, we examined final exam scores for the standard and intensive sections. We did not collect objective baseline knowledge at the beginning of the course through a diagnostic exam or other similar tool. Although a diagnostic exam would provide valuable information, it would, of necessity, have been ungraded, which might have decreased student motivation to perform well.

Although ungraded, such a diagnostic exam could have been used to calibrate the course to the students, including the formation of teams that include both less advanced and more advanced students.

4. Our survey instruments (Appendix II) may have introduced a self-report bias [Nisbett and Wilson, 1977]. Subjects may respond to questions in ways they thought would please the researchers or in ways that corresponded to what they wished was true, their ideal self on an ideal day. As such, we acknowledge that because all responses to the survey questions were self reports, they may deviate somewhat from reality. The survey instruments were validated in other studies and they were minimally adapted for the purposes of this study.

VIII. FUTURE DIRECTIONS

This study shows that students in intensive sections can handle the additional workload and succeed. That is an encouraging first step. To extend and refine the findings, we are adding a few extensions to this study.

1. To control for the self-selection bias, we plan to select a standard IT101 section at random to follow the intensive curriculum, including handheld computers and e-books, but without informing the students prior to registration. The cost to the student will be made equivalent to that of students in the standard sections, so that no financial disparity exists. One might posit that taking the intensive approach with a random section could be a mismatch, that the handheld computer could intimidate someone with high Computer Anxiety, low Computer Playfulness or low Web Enjoyment. The assumption of such reasoning, however, is that the handheld computer is the essence of the active learning approach, which is the core of this course.

We believe that the handheld computer is an enabler and that the multiple platform, active learning approach would make the course beneficial to everyone, not only to gadget enthusiasts. Comparing this new section to the opt-in sections will show us whether student opt-in is important. To proceed cautiously, however, remedial support should be available for students in the randomly selected section. We will also need to check whether student evaluations of the difficulty of the intensive approach are significantly higher than those of students who have opted-in to such a course.

2. Given that student laptops are wireless enabled, we will be investigating the active learning approach of the intensive sections with e-books rather than printed textbooks, but without using handheld computers at all. Using only the standard platform with digital content will help determine the viability of learning from electronic resources without the additional platform. In addition, to counter the learning benefits of additional assignments, the non-intensive sections should be given additional, reinforcement assignments which introduce no new content.

3. To control for any instructor effect, each professor should teach a standard section, an intensive section, and an intensive, single platform section, as introduced above.

4. Since most of our variables were self-reported by students, quizzes should be used to capture additional performance data. Quizzes would provide multiple snapshots or a process view of student learning prior to the final examination.

IX. CONCLUSION

This study shows that the use of handheld computers and a multiple-platform, active learning approach is effective in teaching IT skills and concepts. Students in the intensive sections performed significantly better on the common final exam than did students in the standard sections. By interacting with technology both inside and outside the classroom, students were able to apply their learning to solve practical business and technology problems.

Statistical and anecdotal evidence suggests that the intensive approach to learning information technology was successful. The handheld computer enabled new opportunities for learning about and using technology on multiple platforms, for both educational and extracurricular purposes. The students not only succeeded in the intensive sections of IT101, but they succeeded in applying the technologies they learned in IT101 more broadly, to the contexts of their own lives.

We suggest that any college or university with a course similar to IT101 consider offering a section that employs handheld computers, at least as an experiment. If successful, the multiple platform, active learning approach could be considered for additional sections or in more advanced courses. We are considering doing so at Bentley.

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APPENDIX I. SELF-ASSESSMENT SURVEY**IT 101 TECHNOLOGY DRILL**

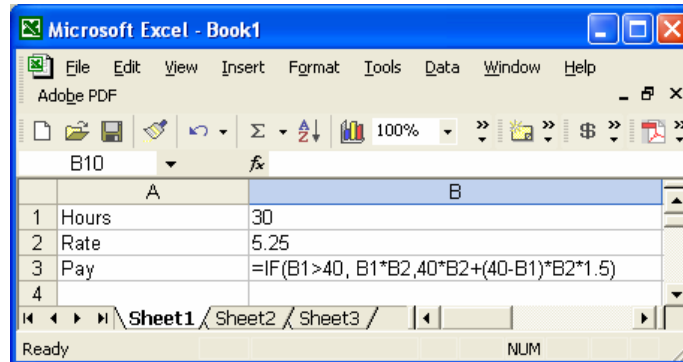
IS THE intensive IT 101 THE RIGHT COURSE FOR YOU?

TAKE THIS SIMPLE SELF-EVALUATION TO FIND OUT.

What program would you most likely use to view the information below? What would it look like?

```
<HTML><HEAD><TITLE>IT101</TITLE></HEAD><BODY>
<H1>I           like           Computers!</H1><HR>
<FONT           COLOR=BLUE>Welcome           to
Bentley!</FONT></BODY></HTML>
```

What rule does cell B3 use in this Excel worksheet in order to calculate a worker's pay?



What is each of these storage devices? Order them in capacity, from least to most.



What do these terms mean?



Which of these icons do you recognize? What do they tell you?



If you know the answers to most of these questions, or you like using computers and want to play around with more, consider taking the intensive IT 101.

APPENDIX II. SURVEY INSTRUMENTS

For our survey instrument, we used or adapted established scales from prior literature.

Computer Anxiety [Venkatesh, 2000]
1. Computers do not scare me at all.
2. Working with a computer makes me nervous.
3. I do not feel threatened when others talk about computers.
4. It would not bother me to take computer courses.
5. Computers make me feel uncomfortable.
6. I feel at ease in a computer class.
7. I get a sinking feeling when I think of trying to use a computer.
8. I feel comfortable working with a computer.
9. Computers make me feel uneasy.

Computer Playfulness [Webster and Martocchio, 1992]
The following questions ask you how you would characterize yourself when you use computers. For each adjective listed below, please indicate the number that best matches a description of yourself when you interact with computers. 1 = Strongly Disagree – 7 = Strongly Agree
1. Spontaneous
2. Unimaginative (<i>reversed</i>)
3. Flexible
4. Creative
5. Playful
6. Unoriginal (<i>reversed</i>)
7. Uninventive (<i>reversed</i>)

Web Enjoyment, adapted from Perceived Enjoyment [Venkatesh, 2000]
1. I find browsing the Web to be enjoyable.
2. The actual process of browsing the Web is pleasant.
3. I have fun browsing the Web.

APPENDIX III. MULTIPLE PLATFORM PROJECT

A final multiple platform project requires students to work in teams of three to use Perseus technology (<http://www.perseus.com>) to create a five-question survey. The project is personally meaningful, as students choose topics related to their campus jobs, student organizations, or other relevant problems. Intensive section students design their surveys in such a way that the answers are amenable to data entry on the handheld computer and analysis in Excel. Executing this multiple-step multiple platform project requires the students to use several of the technologies presented in the course to pass data among devices and platforms in different formats. The project requires the following steps:

1. Download and install Perseus and Perseus Mobile from the college's software download site.
2. Create a survey on the laptop of one student in each group.
3. Transfer the survey to each group member's handheld computer.
4. Interview at least ten people, using the handheld computer to collect survey responses.
5. Transfer the responses back to Perseus running on each student's laptop.
6. Export the responses from Perseus into an Excel spreadsheet.
7. Merge each student's spreadsheet into a single spreadsheet containing the results for the entire group.
8. Use Excel to analyze the responses, transforming the data format as necessary in order to prepare pie or bar charts.
9. Use Excel to save the original data as HTML and charts as image files.
10. Save the Perseus survey as HTML.
11. Use the Remote Display tool to take screenshots of the survey questions on the handheld computer.
12. Design web pages with prose describing the survey and add links to additional pages containing the original survey, merged spreadsheet file, original data as HTML and images of the Excel graphs and screenshots.
13. Use FTP to post the pages to the student's web site.

APPENDIX IV. BLOG DATA INDICATING STUDENTS' EMOTIONAL RESPONSE TO INTENSIVE IT101

The following quotes from student blogs show an emotional response to the intensive version of IT101. The quotes are from four different students.

"I have really enjoyed this course. This is my one class I went to most of the time...missed it only when I was sick. Also I tried to get all of the work in on time because to me it wasn't really work. It was something that was fun for me. Or something that made me think...I hope this advanced technology class will be offered in the future because I hear some of the stuff they do in the regular IT class, and I know I would have missed or slept through every class. This was much better for me. It actually made me think."

"It is a sad day now that the course is over. We have learned everything from Excel, to Perseus, to HTML. I plan on using basically everything we learned in this class throughout my years of existence. I know I'll be using Excel every year here, so I am very thankful that I will be able to use my advanced knowledge on Excel to my benefit...When I went into the course, I really had no clue what to

expect from it. I had no clue that I would be learning a lot of information about maximizing my experience with XP, the Internet, and other programs. I can use everything I learned everyday, and I now know a lot more about my computer than my other friends whom were in regular IT classes. We went into more depth about how to use programs and XP...I now understand much more about my computer and how to maximize the use of it to my benefit thanks to the course."

"Leaving IT101, I feel more comfortable in almost every area of computers we covered. Not only do I feel much more comfortable with my computer, I have a new appendage to my daily life. Who would've thought that a computer course would train you to organize and set a foundation to your day? With my handheld computer, I do just that. The handheld computer was not just a device I used in class. I am not going to just store it away now that the class is over, I am going to continue using it daily until it is out of date and a new one is necessary. This was my favorite class this semester and definitely the class I cared about the most."

"In the future I know that I will further my curiosity towards technological innovations and how they blend with our daily lives. I know that whatever my profession will be in the business world, technology will be at the forefront. I feel that I will continue to learn and be ready for whatever challenges lie ahead of me."

If these are to be believed, intensive IT101 was an educational experience that had an impact.

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