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A Case for Ubiquitous, Integrated Computing in Teacher Education

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ABSTRACT The purpose of this study was to evaluate the effect of an integrated, laptop-based approach on pre-service teachers' computer attitudes, ability and use. Pre-post program analysis revealed significant differences in behavioural attitudes and perceived control (self-efficacy), but not in affective and cognitive attitudes. In addition, there was a significant improvement in all 10 computer ability areas (operating systems, communication, World Wide Web, word processing, spreadsheets, database, graphics, multimedia, web page design, and programming). Finally, pre-service teachers used laptop computers significantly more in a university setting than in their field placements.

Background

In the past 10 years, there has been considerable focus on the impact of technology on student learning. Some researchers have argued that computers have had a minor or negative impact on student learning (e.g. Cuban, 2001; Waxman et al, 2002; Robertson, 2003; Russell et al, 2003). On the other hand, several large-scale meta-analyses (Baker et al, 1994; Kulik, 1994; Scardamalia & Bereiter, 1996; Sivin-Kachala, 1998; Wenglinksy, 1998; Mann et al, 1999; Software and Information Industry Association, 2000; Kozma, 2003) have reported significant improvement in achievement scores, attitudes toward learning, and depth of understanding when computers were integrated with learning, however these gains were dependent on subject area (Kulik, 1994), type of software used (Sivin-Kachala, 1998), specific student population, software design, educator role, and level of student access (Sivin-Kachala, 1998). Success with respect to technology and education is clearly a complex issue, but one that current and future teachers will have to address.

Educational policy specialists and administrators have made a concerted effort to increase the presence of technology in classrooms, specifically focusing on student-to-computer ratio, high-speed Internet access, and pre-service teacher education. According to the US Department of Education, National Center for Education Statistics (2002), the average student-to-computer ratio in 2001 was 5.4 to 1, a significant increase from the 12:1 ratio reported in 1998. Furthermore, 99% of all public schools now have access to the Internet with 94% having high-speed broadband connections (US Department of Education, National Center for Education Statistics, 2002). Other countries have reported similar efforts to promote technology access in the classroom (McRobbie et al, 2000; Compton & Harwood, 2003; Plante & Beattie, 2004). Coupled with the rapid increase in hardware and Internet access is a push toward infusing technology into pre-service education programs. A multitude of nationally recognized organizations (e.g. Office of Technology Assessment for the US Congress, 1995; CEO Forum on Education and Technology, 2000; International Society for Technology in Education & National Council for Accreditation of Teacher Education, 2003; National Council for Accreditation of Teacher Education, 2003; – see Bennett, 2000/01, for a review) have influenced policy and set comprehensive standards with respect to technological use in teacher preparatory programs. It is reasonable to conclude, then, that the 'technological' environment has been firmly established for pre-service teachers to use technology in the classroom.

If we accept that thoughtful use of technology in certain contexts can have a significant and positive impact on student learning, teacher education is a reasonable place to start with respect to integrating technology into education, especially when there appears to be relatively strong infrastructure that supports computer use. However, there is some evidence to suggest that pre-service education programs are not preparing new teachers to use technology effectively (Office of Technology Assessment for the US Congress, 1995; Moursund & Bielefeldt, 1999; CEO Forum on Education and Technology, 2000; US Department of Education, 2000; Yildirim, 2000). In fact, there are a number of obstacles that prevent successful implementation of computers including a lack of time (Eifler et al, 2001; Wepner et al, 2003), teaching philosophy of mentors and school administration with respect to technology (e.g. Stuhlmann & Taylor, 1999; Dexter & Riedel, 2003; Doering et al, 2003), technological skill of faculty of education members (Eifler et al, 2001; Strudler et al, 2003; Thompson et al, 2003), fear of technological problems (Doering et al, 2003; Bullock, 2004), a clear lack of understanding about how to integrate technology into teaching (Cuban, 2001), and insufficient access to technology (e.g. Bartlett, 2002; Brush et al, 2003; Russell et al, 2003). Given the potential problems, it should come as no surprise that pre-service teachers are perceived as unprepared to use technology.

Models Used to Teach Technology

At least seven models have been used to teach technology to pre-service teachers including single course, integrated, modelling, field based, community based, multimedia, and combined. While a comprehensive review of these models is beyond the scope of this article, a brief description of each approach with advantages and disadvantages is presented below.

Single Course Model

Most faculties of education use the single-course model to teach technology (Stuhlmann & Taylor, 1999; Hargrave & Hsu, 2000). Typically, a standalone course is devoted to teaching a wide range of basic computer skills to all students, although various formats have been used including content based (e.g. Doering et al, 2003), project based (e.g. McRobbie et al, 2000), workshops (e.g. McRobbie et al, 2000), or process based (Francis-Pelton et al, 2000; Willis & Sujo de Montes, 2002). The principal advantages of this model are that it can improve self-efficacy (Albion, 2001; Gunter, 2001), provide a good overview of the use of technology in teaching (McRobbie et al, 2000) and develop a strong foundation of technology skills (Hargrave & Hsu, 2000; Strudler et al, 2003). Disadvantages observed in using this model include learning technology skills in isolation (Gunter, 2001; Whetstone & Carr-Chellman, 2001) and technology skills not being used in the field (Hargrave & Hsu, 2000; Pope et al, 2002; Willis & Sujo de Montes, 2002).

Integrated Model

An integrated model weaves the use of technology in all pre-service education courses. There is no single course that teaches basic computer skills. Several prominent organizations have strongly endorsed the integrated philosophy (see Moursund & Bielefeldt, 1999; International Society for Technology in Education & National Council for Accreditation of Teacher Education, 2003). While this approach has been successful in improving confidence (Pope et al, 2002) and technology skills (Vannatta & Beyerbach, 2000; Pope et al, 2002; Albee, 2003), its main advantage is a focus on meaningful, authentic problem solving where pre-service teachers are learning with computers, not about them (e.g. Halpin, 1999; Milbrath & Kinzie, 2000; Doering et al, 2003). Disadvantages to using this model include the lack of hardware (Vannatta & Beyerbach, 2000), limited faculty expertise and time (Vannatta & Beyerbach, 2000; Whetstone & Carr-Chellman, 2001; Eifler et al, 2001), and the difficulty of transferring what is learned at school to field experience in the classroom (Simpson et al, 1999; Eifler et al, 2001; Vrasidas & McIsaac, 2001; Brush et al, 2003).

Modelling

The modelling approach involves demonstrating how technology can be used in the classroom and is often used in conjunction with an integrated model. However, the emphasis with modelling is to provide pre-service candidates with concrete examples of how technology can be used in the classroom. The International Society for Technology in Education (ISTE) & National Council for Accreditation of Teacher Education (NCATE) (2003) support the use of modelling as an effective approach to teaching technology in pre-service education. The clear advantage to using modelling is that it transfers directly to the 'real-world' classroom, unlike the single course and integrated models (Howland & Wedman, 2004; Marra, 2004). Disadvantages to modelling include the inability of faculty to provide meaningful and effective technology examples (Vannatta & Beyerbach, 2000; Eifler et al, 2001) and pre-service teachers not being able to construct their own technology-based lessons in the classroom.

Field-based Model

The field-based model, while highly recommended by the ISTE/NCATE (2003), has been used sparingly by faculties of education (Balli et al, 1997; Beyerbach et al, 2001; Brush et al, 2003). The philosophy behind this model is to actively support the production and delivery of technology-based lessons by pre-service teachers. The main advantage of this approach is that students learn from hands-on experience and can focus on how technology affects learning in the classroom (Balli et al, 1997; Beyerbach et al, 2001; Brush et al, 2003). However, if this is the only model used to teach technology, pre-service teachers can feel unprepared due to a lack of skill (Brush et al, 2003).

Community-based Model

A community-based model involves establishing partnerships among universities, colleges, and public schools to create technology-rich learning experiences. This approach is a more elaborate and organized field-based model and, in its ideal state, involves developing communities of practice, knowledge repositories, expertise directories, peer and mentor assistance, and best practice examples (Carroll et al, 2003). Placing pre-service and in-service teachers in teams to collaboratively identify ways to integrate technology into the curriculum has a number of benefits including providing opportunities to explore and practise technological applications in a supportive environment, developing positive relationships between local public schools and the university, and increasing the comfort level of using technology (Dawson & Norris, 2000; Thompson et al, 2003). The key challenge of applying this approach is it takes considerable organization and time to develop effective learning communities and all parties must be motivated (Dawson & Norris, 2000; Carroll et al, 2003; Thompson et al, 2003). If one part of the community is resistant to the use of technology, the effectiveness of the model is compromised (Carroll et al, 2003).

Multimedia Model

This model is a grab bag of multimedia-based approaches used to incorporate technology into pre-service education. Examples include the use of technology case studies (Gillingham & Topper, 1999), online courses (Marra, 2004), and electronic portfolios (Doty & Hillman, 2000; Bartlett, 2002; Blocher et al, 2003). Case studies presenting examples of technology being used in the classroom offer similar advantages to modelling, although the mode of presentation is an online video. Online courses offer the advantage of accessibility, yet problem-based, constructive learning is difficult to achieve with this format (Marra, 2004). Electronic portfolios are essentially performance-based assessments that require pre-service teachers to demonstrate their mastery of technology in a variety of areas (Doty & Hillman, 2000). The multimedia model is relatively new, therefore clear advantages and disadvantages have yet to be systematically documented. This model could be combined with several other models discussed above.

Combined Model

The combined model involves two or more approaches to technology integration. For example, modelling/integration, single-course /integration and integration/community models are combinations regularly observed in faculties of education (e.g. Compton & Harwood, 2003; Smith & Robinson, 2003; Collier et al, 2004). Strudler & Wetzel (1999) reported that exemplary colleges of education use a combined model for introducing technology and include standalone technology courses, integration of technology in subject areas and assimilation of technology in student field experiences. The challenge of using this model is that it requires considerable organization, time, training, and design.

Summary

While numerous studies have been done on technology and pre-service education, the jury is still out with respect to identifying the most effective models for introducing technology to pre-service teachers. Part of the problem rests in a notable lack of methodological rigour. Design and analysis are often formative or descriptive (e.g. Albion, 2001; Compton &

Harwood, 2003; Wilkerson, 2003). A clear description of the program and sample is typically omitted (e.g. Hargrave & Hsu, 2000; Blocher et al, 2003; Robertson, 2003). Surveys used to evaluate programs rarely report estimates of reliability of validity (e.g. Stuhlmann & Taylor, 1999; Vrasidas & McIsaac, 2001; Bullock, 2004). Finally, the focus of evaluation is a bit of a checkerboard involving isolated measures of attitude (e.g. Milbrath & Kinzie, 2000; Wang, 2002; Ertmer et al, 2003), ability (Vannatta & Beyerbach, 2000; Bartlett, 2002; Bucci, 2003; Wilkerson, 2003), and use (Stuhlmann & Taylor, 1999; Smith & Robinson, 2003), but rarely all three.

In summary, to understand and compare models used to introduce technology to pre-service teachers, there is a need for more rigorous investigation which includes a clear description of the sample and program being evaluated, reliable and valid measures to collect data, and a more comprehensive focus assessing attitude, ability and use.

Laptop Perspective

A number of universities have decided to provide students with a ubiquitous learning environment with respect to the use of technology. In this kind of setting, all students are issued a laptop computer and have full, high-speed access to the Internet. The computer is treated as an 'everyday' tool, like a pencil or pen, to be used regularly in the classroom. (Brown et al, 1998; Kontos, 2001; Poindexter et al, 2001; Efaw et al, 2004). The benefits of this kind of accessibility are flexibility (Efaw et al, 2004), effectiveness of building technology skills (Brown et al, 1998; Lim, 1999), increasing the range and scope of technology used (Brown et al, 1998), and improving the quality of teaching (Kontos, 2001). Barriers that have been reported include cost (Poindexter et al, 2001), time (Node Learning Technologies Network, 1999), and classroom management difficulties (Efaw et al, 2004).

Research on use of laptops in pre-service teacher education is limited to a small set of informal, qualitative descriptions (e.g. Thomas et al, 1996; Drazkowski, 2004; Resta et al, 2004). There is clearly a need for more systematic investigation in this area.

Purpose

The purpose of this study was to evaluate the effect of an integrated, laptop-based program on pre-service teachers' computer attitudes, ability and use.

Method

Sample

The sample consisted of 52 pre-service teachers (22 males, 30 females) from a variety of cultural backgrounds (38% reported that their first language was not English) ranging in age from 22 to 52 years (M = 35.6; SD = 8.7). Thirty-nine students had a BA, 10 had an MA, and two had a Ph.D. The average years of computer experience was 10.3 (SD = 6.2; ranging from 1 to 30).

Description of the Program

The Bachelor of Education degree at this university was an eight-month consecutive program, focusing on computer science, math, and science (physics, chemistry, biology, and general science) at the intermediate-secondary school level (grades 7 to 12, ages 12 to 17 years). All students were required to have a BA with five full university courses in their first teachable area and three full university courses in their second teachable area.

Every student in the pre-service teacher education program was given an IBM R40 ThinkPad at the beginning of the year loaded with a wide range of educational and application-based programs. All classrooms were wired with high-speed Internet access through cable and a wireless network. In addition, students had access to a wireless network throughout the university campus.

Model of Technology Use

An integrated model was used to incorporate technology into the pre-service education. In other words, students used their laptop computers in all courses offered, but did not take a standalone course in technology use. With the exception of a four-hour introductory workshop attended by all students at the beginning of the year and a two-hour workshop on designing web pages (optional attendance), there was no formalized instruction on how to use technology. Finally, there was one support person available eight hours per week to assist students with individual problems.

All faculty members created assignments and projects that required students to use the computer as a tool to solve meaningful, practical, and useful problems. Table I provides descriptions of the kind of activities that students engaged in with technology. A majority of the activities used were based on well-grounded learning theory including cooperative learning (e.g. Johnson & Johnson, 1994, 1998; Kagan, 1997; Sharon, 1999), constructivism (e.g. Vygotsky, 1978; Bruner, 1983, 1986), facilitation and coaching (e.g. Brown & Palinscar, 1989; Chi & Bassok, 1989; Collins et al, 1989), incorporating a variety of learning styles (e.g. Gardner, 1983), problem-based learning (e.g. Collins et al, 1989; Albanese & Mitchell, 1993), higher-level thinking skills (e.g. Resnick, 1989), connecting concepts to real-world knowledge (e.g. Lampert, 1986; Larkin, 1989; Stenberg, 1989), and actively applying knowledge (Carroll & Mack, 1984; Carroll, 1990).

Typical activities	Description
Assessment	Students post the first draft of an assignment in a discussion board and feedback is posted by other students or the teacher.
Case Studies	Students are presented with a case study and have to work in teams to develop and post a solution on a discussion board. Teams can then evaluate each other's answers and post further suggestions online.
Discussion Boards	Online discussions can be very effective or disastrous, depending on the kind of questions you ask, the size of your class, and the rules you establish for posting messages. If you ask focused questions, limit the number of people who can participate in a specific discussion (8-10), promote clear, short subject lines and concise 3-5 sentence postings, you can have very meaningful and lively discussions.
Electronic Portfolios	Creating electronic portfolios, journals, or research logs can be an effective tool for students to showcase their work, as well as bring together a number of topics and skills in a culminating task.
Fast Feedback	At the end of each class, students use an online evaluation tool (e.g. www.getfast.ca/) to respond to a brief evaluation asking them what they learned and any key questions they might have. The responses of this evaluation can be used as a lead in to the following class.
Java Applets	The use of this activity depends on the specific discipline, but there are numerous *Java* applets that can be used for practice, exploration, and demonstration. Using online exercises with immediate feedback can help solidify a number of key concepts, particularly in mathematics and science.
Labs	A subject-specific piece of software (e.g. *Starry Night*, *Geometers Sketchpad*) is used in lab setting that models the use of the software and allows students to learn how to use it.
Online Debates	Students within a large lecture are divided into learning teams. A debate topic based on a current issue in education is presented and students have to research and post their arguments (as a team) on the discussion board.

Online Questionnaires	Depending on the discipline, there may be interactive online questionnaires, tests, or exercises that students can complete leading them into a specific topic. Students are interested in learning about and evaluating themselves and this exercise helps them focus on the material presented after.
Research Tasks	Students must first select a topic of interest, possibly within a given set of topics offered by the teacher, and then they must research the topic using the Web OR ideally, an electronic library of formal journal articles and books.
Resource Collections	Students collect, analyze, and annotate various web pages and then post online. This allows for the collection of immediate and valuable resources for the class and the students. Through the creation of a digital resource website, students then take the listed web pages and collect, organize and synthesize them into meaningful topic areas.
Streamed Videos	Streamed videos can be used inside or outside of class, but students should bring headphones. There are many videos that help bring a real-world context to a variety of disciplines. We have concentrated on the Annenberg collections where there are hundreds of exceptionally well-done videos in education, science, and mathematics.
Video Projects	Creating mini video clips or digital pictures can be a powerful tool for engaging students in a variety of topics. It can also be an effective evaluation tool for presentations. Many students benefit considerably from watching themselves present information. The range of application is virtually endless – microteaching, mini-lessons on specific core topics, creating virtual research conferences, and teaching core concepts.
Web Page Design	Learning teams (2-4) design web pages for a specific high school course. This promotes planning, understanding content, and organization. When the project is finished, a CD of web pages for all high school courses is created and distributed to all students.
WebQuests	Students can follow a well-organized WebQuest (e.g. investigation using the Web as a resource) that must include a specific set of tasks and a good set of starting resources.

Table I. Description of technology-related activities used in program.

Data Sources

Survey

The survey consisted of 16 sections (215 items) focusing on three principal constructs: attitude, ability, and use (see Table II).

Scale Construct Measure	No. items	Range	Type of question	Internal reliability
Attitude				
Affective	10	10-70	7 pt, SDS*	r = .94
Cognitive	15	15-105	7 pt Likert Scale	r = .77
Behavioural	10	10-70	7 pt Likert Scale	r = .87
Perceived Control	7	7-49	7 pt Likert Scale	r = .86
Ability				
Operating System	17	17-85	5 pt Likert Scale	r = .96
Communication	12	12-60	5 pt Likert Scale	r = .93
WWW Skills	14	14-70	5 pt Likert Scale	r = .95
Word Processing	15	15-75	5 pt Likert Scale	r = .94
Spreadsheets	6	6-30	5 pt Likert Scale	r = .94
Database	6	6-30	5 pt Likert Scale	r = .98
Graphics	6	6-30	5 pt Likert Scale	r = .96
Multimedia	6	6-30	5 pt Likert Scale	r = .91
Create Web Page	15	15-75	5 pt Likert Scale	r = .98
Programming	12	12-60	5 pt Likert Scale	r = .99
Use				
Communication	6	6-30	5 pt Likert Scale	r = .85
Cooperative Work	2	2-10	5 pt Likert Scale	r = .71
Planning	4	4-20	5 pt Likert Scale	r = .68
Entertainment	2	2-10	5 pt Likert Scale	r = .72
Tool	10	10-50	5 pt Likert Scale	r = .84
Multimedia	6	6-30	5 pt Likert Scale	r = .90

* SDS – Semantic Differential Scale

Table II. Description of survey.

Computer attitude. Four theoretically distinct constructs (cognitive, affective, behavioural, and perceived control), based on over 45 years of general attitude scale development (Kay, 1989a, 1993a), were used to assess attitudes of pre-service teachers toward computers. The internal reliability estimates for all constructs were moderate to high ranging from .77 to .94 (Table II).

Computer ability. Several researchers (e.g. Kay, 1989a, b, 1992, 1993b; Fulton, 1997) have noted that computer proficiency is an evolving concept based, to a certain extent, on who is learning and what technology is available. Perhaps the best one can do is to examine what skills are important in a given context. Recall that the context of this study includes the following key elements: pre-service teachers (grades 7 to 12), a focus of mathematics and science, ubiquitous access to a computer and the Internet, and a model that focuses on integration. It is reasonable, then, to develop a comprehensive assessment of computer ability based on the kind of tools that would be used in an educational setting. Therefore, a composite measure of 10 computer skills was developed from a content analysis of instruments designed to assess computer ability of beginning teachers (Fulton, 1997; Gunter, 2001; Bartlett, 2002; Albee, 2003; Bucci, 2003; Seels et al, 2003; Thompson et al, 2003; Wepner et al, 2003; Wilkerson, 2003; Collier et al, 2004). The specific skills identified in previous research included operating systems, communication, World Wide Web, word processing, spreadsheets, database, graphics, multimedia, web page design, and programming. A new measure of computer ability was created because the majority of previous instruments did not report reliability or validity statistics (Fulton, 1997; Gunter, 2001; Bartlett, 2002; Albee, 2003; Bucci, 2003; Seels et al, 2003; Thompson et al, 2003; Wepner et al, 2003). The reliability estimates for the computer ability skills assessed in this study were high ranging from .91 to .99 (Table II).

Computer use. A composite measure of computer use was developed based on a comprehensive review of research designed to assess computer use in pre-service teachers (Wang & Holthaus, 1999; Garland, 1999; Halpin, 1999; Maeers et al, 2000; Milbrath & Kinzie, 2000; Vannatta & Beyerbach, 2000; Baylor & Ritchie, 2002; Pope et al, 2002; Compton & Harwood, 2003; Russell et al, 2003; Thompson et al, 2003). A decision was made to develop a new measure because previous measures were either limited in focus (Halpin, 1999; Maeers et al, 2000; Milbrath & Kinzie, 2000) or were not statistically reliable (Wang & Holthaus, 1999; Baylor & Ritchie, 2002; Pope et al, 2002; Russell et al, 2003; Thompson et al, 2003). Six categories of use were assessed: communication, cooperative work, planning, entertainment, tool use, and multimedia. Use was looked at in two environments – the university and the field placement.

Procedure and Data Analysis

Subjects were told the purpose of the study and asked to give written consent if they wished to volunteer to participate. The survey was administered at the beginning of the year (September) and at the end of the year (April). It took 25-35 minutes to complete.

A series of paired *t*-tests were used to compare computer attitude and ability at the beginning and end of the program. Computer use was examined using independent *t*-tests to compare university and field placement environments. A probability level of $p < .005$ was used to compensate for the number of *t*-tests done (see Kirk, 1982, p. 102).

Results

Attitude

Overview. All items were assessed on a seven-point Likert scale (1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree) with the exception of Affective Attitude, which was assessed on a seven-point semantic differential scale. Overall, students appeared to have moderately positive attitudes in all areas with mean scores ranging from 4.6 to 5.4 out of 7 (affective $M = 5.2$, cognitive $M = 5.4$, behavioural $M = 5.4$, and perceived control $M = 4.6$).

Changes in computer attitudes. Significant differences in behavioural attitude and perceived control occurred after the integrated laptop program, but not in affective and cognitive attitudes (Table III). In other words, after the laptop program, pre-service teachers changed with respect to their perceived control over the computer (self-efficacy) and their intentions to use computers in the future, but not in their affect or cognitions with respect to computers.

Attitude measure	Before program		After program			
	M	*(SD)*	*M*	*(SD)*	*df*	*t*
Affective	52.1	(8.7)	54.1	(10.2)	50	– 1.71
Cognitive	80.3	(10.3)	82.2	(11.0)	51	– 1.35
Behavioural	54.2	(14.4)	59.7	(8.8)	50	– 3.45*
Perceived control	32.1	(10.1)	38.6	(7.5)	51	– 6.72*

* $p < .001$.

Table III. Computer attitude scores before and after integrated laptop program.

Ability

Overview. All items were assessed using a five-point Likert scale (1 = No Skill, 2 = Some Skill Level, 3 = Moderate Skill Level, 4 = High Skill, 5 = Expert Skill Level). Based on this scale, most students came to the program with moderate skills in operating systems ($M = 3.5$), word processing ($M = 3.5$), communication and spreadsheet software ($M = 3.4$), and using the World Wide Web ($M = 3.2$). Students were weaker in database ($M = 2.4$), graphics ($M = 2.3$), multimedia ($M = 2.3$), programming ($M = 2.0$), and web page creation ($M = 1.7$).

Changes in computer ability. Pre-service teachers improved significantly in all 10 measures of computer ability after being exposed to the integrated, laptop program (Table IV). They reported high skill in all areas with the exception of database and programming skills. Students showed the biggest gains in their weakest areas: graphics, multimedia, and web page creation.

Ability measure	Before program		After program			
	M	(SD)	M	(SD)	df	*t*
Operating Systems	60.1	(19.2)	73.5	(11.9)	51	– 7.71*
Communication	41.5	(12.9)	51.7	(8.0)	50	– 8.24*
WWW Skills	44.6	(15.1)	59.7	(9.7)	51	– 8.89*
Word Processing	52.3	(14.6)	66.1	(9.1)	51	– 8.05*
Spreadsheets	20.4	(7.0)	26.0	(4.8)	50	– 6.62*
Database	14.2	(8.5)	18.4	(7.8)	50	– 5.13*
Graphics	13.8	(7.3)	21.9	(7.0)	49	– 8.24*
Multimedia	13.8	(6.6)	24.0	(5.4)	49	– 13.92*
Create Web Page	25.6	(15.2)	57.2	(15.7)	50	– 14.43*
Programming	23.8	(15.5)	29.8	(18.2)	49	– 4.16*

* $p < .001$

Table IV. Computer ability scores before and after integrated laptop program.

Use

Overview. All items were assessed on a five-point Likert scale (1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Very Often, 5 = Always). Overall, students used their laptops more in the university than they did in their field placements. With respect to laptop use in the university, students used the laptop most for groupwork (M = 3.9), planning (M = 3.9) and tool use (M = 3.2), and least for communication (M = 2.7), multimedia (M = 2.4) and personal entertainment (M = 2.1). When students moved to their field placement, their priorities for laptop use were similar, but frequency of use dropped. Laptops were used for planning (M = 3.4), tool use (M = 2.7) and groupwork (M = 2.6) sometimes, whereas tasks related to communication (M = 2.1), entertainment (M = 1.8) and multimedia (M = 1.6) were rarely done.

Differences between university and field use of computers. Pre-service students used computers significantly less in all areas of computer use when they were on field placements as opposed to when they were working at the university (Table V).

Use measure	University		Field placement			
	M	(SD)	M	(SD)	df	*t*
Communication	16.4	(4.4)	12.8	(5.7)	45	7.05*
Group work	7.8	(1.7)	5.1	(2.6)	46	8.08*
Planning	15.6	(2.8)	13.7	(3.7)	45	4.06*
Entertainment	4.1	(2.0)	3.5	(2.3)	46	2.96**
Tool to Complete Work	32.1	(5.8)	27.2	(8.1)	46	7.18*
Multimedia	16.9	(6.1)	11.2	(6.0)	43	8.62*

* $p < .001$; ** $p < .005$.

Table V. Difference in computer use between university and field placement settings.

Discussion

Attitudes

It is interesting and worthwhile to note that attitude changes associated with the integrated, laptop model evaluated in this study, were dependent on the type of attitude assessed. Perceived control and intentions to use computers in the future improved significantly, whereas cognitive and affective attitudes did not change. This mixed result underlies the need for theoretically based, reliable attitude surveys. It is difficult to assimilate the results of this study with previous research on attitude change toward technology, because many studies examining pre-service teachers did not elaborate on the theory or reliability of attitude measure used (Balli et al, 1997; Simpson et al, 1999; Albion & Gibson, 2000; McRobbie et al, 2000; Milbrath & Kinzie , 2000; Yildirim, 2000; Pope et al, 2002; Wang, 2002; Albee, 2003; Ertmer et al, 2003; Snider, 2003).

Ability

It is reasonable to conclude that an integrated approach to using technology in pre-service education, based on well-grounded learning theory, was effective in improving the computer skills of pre-service teachers. Significant increases were observed in all 10 areas of the computer ability measure. It is equally reasonable to speculate that the use of laptop computers facilitated the overall process of learning with computers. The same result, though, might have been achieved using computer labs. However, the range and variety of technology-based learning activities used by faculty (see Table II) appears to lend itself to a more ubiquitous, laptop learning environment. Determining the relative contribution of the integration model and use of laptop computer is not possible given the design of this study.

It is also important to recognize that students who chose to be part of this program may have been more open to learning with technology than students in a non-laptop environment. Without a control group, it is difficult to conclude that access to laptop computers was a key factor in improving computer ability.

Use

Previous research noted that it was challenging to transfer and apply skills learned in a university classroom to the field placement classroom (Stuhlmann, 1998; Hargrave & Hsu, 2000; Pope et al, 2002; Willis & Sujo de Montes, 2002; Strudler et al, 2003) and this study supports this conclusion. Computer use was more frequent at the university than in the field, although students engaged in similar activities in both settings. It is important to note that students did use their laptops consistently in lesson planning and groupwork while on their field placements. However, integration of technology into classroom activities and lessons was minimal.

An integrated, laptop model for introducing technology to pre-service teachers may be effective in improving computer ability and attitudes, but an additional approach, perhaps field or community based, may be needed to stimulate effective computer use in the field placement.

Conclusions and Educational Implications

Four main conclusions can be drawn from this study. First, an integrated model, based on pedagogically sound learning strategies, coupled with ubiquitous access to computing, can help students develop into very capable users of technology. Another way of looking at this result is that there is one less barrier between new teachers using computers in their classrooms.

Second, cognitive and affective attitudes toward computers do not change as a result of being part of the integrated, laptop model, however, perceived control and intentions to use computers in the future increase significantly.

Third, pre-service teachers taught with the model examined in this study used computers significantly more in their formal studies than in the field. Incorporating a field-based or community-based model might improve the application of technology in a 'real-world' classroom.

Finally, and perhaps most importantly, future research on comparing and evaluating models of introducing technology to pre-service teachers should provide clear sample and program descriptions, use reliable, theoretically driven measures, and attempt to assess a wide range of constructs including attitude, ability, and use. Without consistent, reliable, and comprehensive documentation, meaningful comparisons of these models will be challenging, if not impossible.

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