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ADDRESSING GENDER DIFFERENCES IN COMPUTER ABILITY, ATTITUDES AND USE: THE LAPTOP EFFECT

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ABSTRACT

The impact of gender on computer related attitudes, ability, and use has been actively documented, but little research has been done examining how to modify and reduce imbalances. The purpose of this study was to explore the effect of ubiquitous computing (24-hour access to a laptop and the Internet) on gender differences in pre-service teachers with respect to computer attitudes, ability, and use. Regarding computer attitudes, gender differences before the laptop program were observed in only one of the four constructs assessed: future intentions to use computers (behavioral attitude). There were no significant differences in attitude between males and females after the laptop program. With respect to computer ability, males reported having stronger skills in five of the ten ability constructs assessed before the laptop program (operating systems, database software, creating a web page, and programming). There were no significant gender differences in ability after the laptop program, with the exception of programming which continued to favor males. It is speculated that the gender equalization effect observed in this study could have a significant impact on the extent to which technology is used by future students, especially given recent trends in promoting the use of technology in the classroom.

OVERVIEW

In 1992, Kay reviewed 36 studies on gender and computer related behaviors. While there were clear measurement concerns regarding the assessment of gender differences in computer ability, attitude, and use (e.g., Kay, 1992, 1993, 1994), the overall picture indicated that males had more positive attitudes, higher ability, and used computers more. Five years later, a meta-analysis by Whitley (1997) revealed the imbalance between males and females continued to exist with respect to computer attitudes. Males had greater sex-role stereotyping of computers, higher computer self-efficacy, and more positive affect about computers than females. A current analysis of 42 studies (see Appendix A) indicates that differences between males and females may be lessening somewhat, although male dominance is still prevalent with respect to attitude, ability, and use.

In spite of this persistent pattern, little has been done with respect to evaluating intervention programs aimed at reducing or eliminating gender inequities (Sanders, in press). In addition, research on gender and technology in pre-service education is almost non-existent (Aust, Newberry, O'Brien, & Thomas, 2005; Sanders, 1997; Sanders & Campbell, 2001; Shapka & Ferrari, 2003; Yuen & Ma, 2002). Pre-service teachers, though, are a reasonable and potentially promising population to modify computer related behavior, particularly because of their influence on future students. The purpose of this article, then, was to examine the impact of an 8-month laptop program on pre-service teacher's computer attitudes, ability, and use.

LITERATURE REVIEW

Computer attitude is the most frequently examined construct with respect to gender differences, representing more than half of all studies (Kay, 1992; Whitley, 1997; Sanders, in press). Out of 98 instances of attitude measurement (two or more attitude measures may occur in a single study), males had more positive attitudes in 48 (49%) studies, females had more positive attitudes in 14 (14%) studies, and males and females had similar attitudes in 36 (38%) studies (Kay, 1992). This pattern was supported by Whitley's (1997) meta-analysis where U.S. and Canadian male participants exhibited greater sex-role stereotyping of computers, higher computer self-efficacy, and more positive affect about computers than females. A further review of 42 studies and 97 instances of attitude measures reviewed for this article, indicated that males had more positive computer attitudes in 40 (41%) cases, females were more positive in 16 cases (16%), and no difference between males and females in 41 (42%) cases. This attitude bias in favor of males, then, has been quite stable for over 20 years.

It is worthwhile to look at the specific attitude constructs assessed. The wide variety of measures used to examine gender differences can be organized into five categories: affective, cognitive, self-efficacy, sex-bias, and behavioral intentions. Regarding the 42 studies looked at in this article (Appendix A), male-female responses for affective attitude mirror the results observed over the past 20 years. However, male-female differences in cognitive attitude appear to be leveling off. Males had more positive cognitions in 4 (22%) cases, females had more positive cognitions in 4 (22%) cases, and there were no differences in 10 (56%) cases. On the other hand, self-efficacy appears to be more strongly biased than the other constructs with over 60% of all studies ($n = 16$) reporting higher self-efficacy in males. Finally, sexually biased attitudes were observed in males in five out of seven instances. Only 4 observations involving behavioral attitude were observed in the 42 studies evaluated, so no reliable pattern emerged.

Use

Computer use is the second most examined construct in research on gender and computers. Kay (1992) reported that males overwhelmingly used computers more often than females (23 out of 38 instances). An examination of the 42 studies (Appendix A) in this article revealed 72 evaluations of use, 37 (51%) of which showed higher use for males, seven (10%) of which showed higher use for females, and 28 (39%) of which showed no significant differences. While computer use was defined in a variety of ways including access to computers (Atan, Sulaiman, Rahman, & Idrus, 2002; Ching Kafai, & Marshall, 2000; Colley, 2003; Solvberg, 2002; Young, 2000), general use at home and school (Atan et al., 2002; Papastergiou & Solomonidou, 2005; Solvberg, 2002, Volman, Eck, Heemskerk, & Kuiper, 2005), playing games (Colley, 2003; Colley & Comber, 2003; Miller, Schweingruber, & Brandenburg, 2001; Papastergiou & Solomonidou, 2005; Schumacher & Morahan-Martin, 2001; Volman et al., 2005), using the Internet and e-mail (Durndell & Haag, 2002; Jackson, Ervin, Gardner, & Schmitt, 2001; Lupart & Cannon, 2002; Miller et al., 2001; Ono & Zavodny, 2003; Papastergiou & Solomonidou, 2005; Schumacher & Morahan-Martin, 2001) and using a variety of application software (Comber, Colley, Hargreaves & Dorn, 1997; Lowe, Krahn, & Sosteric, 2003; Shapka & Ferrari, 2003; Volman et al., 2005), not one study used a comprehensive measure of use.

Ability

Ability is the least studied construct in gender-technology research. Ability was examined on 33 occasions (20%) in Kay's (1992) review and only 16 times (8%; total $n = 209$) in the current review (Appendix A). In the 1992 review, researchers observed that males reported higher computer ability in 15 out of 33 instances, although no difference was observed 13 times. On only five occasions did females surpass males in computer ability. In the current review, males reported higher ability 8 times, females 1 time, and there was no difference in ability in 7 cases. Note that a wide range of measures was used to assess computer ability including basic skills (Aust et al., 2005), typing skill (Schumacher & Morahan-Martin, 2001), online activities (Aust et al., 2005; Karavidas, Lim, & Katsikas, 2005; Schumacher & Morahan-Martin, 2001; Volman et al., 2005), and application software (Karavidas et al., 2005; Volman et al., 2005). A systematic, thorough measure of computer ability was rarely used (Aust et al., 2005; Volman et al., 2005).

Behavior

In 1992, Kay noted that evaluation of gender differences was limited to paper-and-pencil measures of computer-related behaviors. While a majority of recent studies still use survey techniques, several researchers have observed and analyzed actual computer behavior including solving problems using computer mediated communication (Adrianson, 2001), learning a new education software task or game (Light, Littleton, Bale, Joiner, & Messer, 2000; Passig & Levin, 1999; Shapka & Ferrari, 2003), and Lego/Robo Lab construction (Voyles & Williams, 2004). This research has revealed interesting results with respect to working in same vs. mixed sex groups, help-seeking behavior opinion change, and preferences for particular software interfaces, although consistent patterns have not emerged.

Models of Computer Use

In order to develop a comprehensive model explaining the relationship among attitude, ability, and actual use, all three constructs need to be studied simultaneously. However, only three of the 42 studies examined in Appendix A looked at attitude, ability, and use, while 10 studies explored two constructs. The vast majority of the studies ($n = 25$, 66%), looked at only one concept and more often than not, that construct was attitude. Clearly, more multi-construct studies are needed.

Pre-Service Education

Over the past five years there has been a strong push toward infusing technology into pre-service education programs. A multitude of nationally recognized organizations (e.g., CEO Forum on Education and Technology, 2000; ISTE/NCATE, 2003; National Council for Accreditation of Teacher Education, 2003; OTA, 1995; see Bennett, 2000/2001 for a review) have influenced policy and set comprehensive standards with respect to technological use in teacher preparatory programs. The tremendous cost of technology in time and money over the past ten years (SIIA, 2000) places substantial pressure on pre-service teachers to use technology in the classroom. If gender differences in computer attitude, ability, and use continue to persist in this pro-technology climate, students of new female teacher graduates may be at a disadvantage with respect to using computers in the classroom.

Gender differences in computer attitude, ability, and use need to be actively addressed for pre-service teachers because they have considerable influence on future students. However, limited research has been done looking at gender differences in computer-related behavior in pre-service candidates (Aust et al., 2005; Shapka & Ferrari, 2003; Yuen & Ma, 2002).

Aust et al. (2005) observed higher male ability in basic skills and presentation software, but no gender differences in online skills, word processing spreadsheet and database software. This study used a reliable measure of computer ability, but did not examine attitude or use.

Shapka and Ferrari (2003) reported no gender differences in computer attitudes, computer use, and completion of a computer task, however males preferred not to use help while learning a new task. The research was comprehensive in that three constructs were measured simultaneously, but a dated measure of attitude with limited reliability was used (Gressard & Loyd, 1987). Furthermore, reliability and validity estimates were not reported for the computer use scale.

Finally, Yuen and Ma (2002) found no significant differences in perceived usefulness of computers, ease of use, or intention to use computers. While a post-hoc principle components analysis of attitude subscales was done, no theory guided this analysis and reliability estimates were not presented. In addition, ability and use were not examined.

More research on pre-service teacher gender differences in all three key constructs is needed using reliable, theoretically sound measures.

Intervention Programs

Research on intervention programs that address gender differences in computer-related behaviors is lacking. Only one published gender-intervention study (Volk & Holsey, 1997) could be found. The study reported that high school girls were more likely to say they would be involved with technology in the future, after they participated in a summer institute program. To date, no research has been done examining strategies to achieve gender-balance in computer-related behaviors for pre-service teachers. Given the relative stability of gender differences in attitude, ability, and use in the past 20 years, a systematic investigation of intervention strategies is needed.

Purpose

The purpose of this study was to explore the impact of an eight-month, integrated, laptop program for pre-service teachers on gender differences in computer attitudes, abilities, 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; *S.D.* = 8.7). Forty students had a B.A. or B.Sc., ten had an M.A., and two had a Ph.D. The average years of computer experience was 10.3 (*S.D.* = 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). All students were required to have a B.A. 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—Integration

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 stand-alone 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 1 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., Bruner, 1983, 1986; Scardamalia & Bereiter, 1996; Vygotsky, 1978), facilitation and coaching (e.g., Brown & Palinscar, 1989; Chi & Bassok, 1989; Collins, Brown, & Newman, 1989), incorporating a variety of learning styles (e.g., Gardner, 1983), problem-based learning (e.g., Albanese & Mitchell, 1993; Collins et al., 1989), higher-level thinking skills (e.g., Resnick, 1989), connecting concepts to real world knowledge (e.g., Lampert, 1986; Larkin, 1989; Sternberg, 1989), and actively applying knowledge (Carroll, 1990; Carroll & Mack, 1984).

Data Sources

Survey

The survey consisted of 16 sections (215 items) focusing on three principle constructs: attitude, ability, and use (see Table 2).

Computer Attitude

Four theoretically distinct constructs (cognitive, affective, behavioral, and perceived control), based on over 45 years of general attitude scale development (Kay, 1993), 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 2).

Computer Ability

Several researchers (e.g., Fulton, 1997; Kay, 1992, 1993) 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 ten computer skills was developed from a content analysis of instruments designed to assess computer ability of beginning teachers (Albee, 2003; Bartlett, 2002; Bucci, 2003; Collier, Weinburgh, & Rivera, 2004; Fulton, 1997; Gunter, 2001; Seels, Campbell, & Talsma, 2003; Thompson, Schmidt, & Davis, 2003; Wepner, Ziomek, & Tao, 2003; Wilkerson, 2003). The specific skills identified in previous research included operating systems, communication, World Wide Web, word processing, spreadsheet, database, graphics, multimedia, Web page creation, and programming. A new measure of computer ability was created because the majority of previous instruments did not report reliability or validity statistics (Albee, 2003; Bartlett, 2002; Bucci, 2003; Fulton, 1997; Gunter, 2001; 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 2).

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

Table 1. Description of Technology Related Activities Used in Program

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., http://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 into 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.

Table 1. (Cont'd.)

Typical activities	Description
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 helped 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 Web site, 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 all high school courses are 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 2. Description of Survey

Scale construct measure	No. items	Range	Type of question	Internal reliability
Attitude				
Affective	10	10-70	7 pt, SDS[a]	r = .94
Cognitive	15	15-105	7 pt Likert Scale	r = .77
Behavioral	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
Spreadsheet	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

[a]SDS – Semantic Differential Scale

(Baylor & Ritchie, 2002; Compton & Harwood, 2003; Garland, 1999; Halpin, 1999; Maeers, Browne, & Cooper, 2000; Milbrath & Kinzie, 2000; Pope, Hare, & Howard, 2002; Russell, Bebell, O'Dwyer, & O'Connor, 2003; Thompson et al., 2003; Vannatta & Beyerbach, 2000; Wang & Holthaus, 1998-99). 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 (Baylor & Ritchie, 2002; Pope et al., 2002; Russell et al., 2003; Thompson et al., 2003; Wang & Holthaus, 1998-99). 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. Fifty-two out of 65 candidates chose 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

Changes for Males

With respect to computer attitude, there was a significant improvement in perceived control (self-efficacy), but not in affective, cognitive, and behavioral attitudes (Table 3). With respect to computer ability, males improved significantly in all of the ten computer ability constructs measured (Table 3). The average effect size (based on Cohen's *d*) for significant attitude and ability differences for males was 0.79 (*S.D.* = 0.46, range .32 to 1.74). According to Thalheimer and Cook (2020), this is a large effect (Table 3).

Changes for Females

Females showed significant attitude gains in perceived control (self-efficacy) and behavioral attitude or intentions to use computers in the future. Furthermore, females improved significantly in all ten computer ability constructs assessed (Table 4). The average effect size, (based on Cohen's *d*) for significant attitude and ability differences for females was 1.25 (*S.D.* = 0.55, range .40 to 2.36). According to Thalheimer and Cook (2002), this is a very large effect based on Cohen's *d* (Table 4). Female effect size appeared to be larger than that of males.

Males vs. Females—Before Laptop Program

From Table 5, it can be seen that males had significantly more positive behavioral attitudes than females (e.g., intentions to use computers). All other attitude constructs showed no significant differences. With respect to ability, males reported significantly stronger skills in higher level computer topics (operating systems, databases, graphics, creating a Web page, and programming). There was no significant difference between males and females with respect to more common, everyday applications (word processing, spreadsheet, World

Table 3. Male Computer Ability and Attitudes Before and After the Laptop Program

Measure	Before laptop *M*	Before laptop *SD*	After laptop *M*	After laptop *SD*	Cohen's *d*	*t*
Attitude						
Affective	53.3	9.9	55.1	11.4	.17	–1.05
Cognitive	79.2	10.9	81.7	9.8	.24	–1.07
Behavioral	59.2	10.4	60.9	9.6	.17	–1.01
Perceived control	34.6	9.9	39.3	8.3	.52	–3.70*
Ability						
Operating system	69.45	17.0	75.3	13.4	.38	–3.95*
Communication	45.5	12.9	51.9	9.4	.57	–3.87*
WWW skills	50.0	14.1	59.5	11.6	.74	–4.50*
Word processing	53.9	15.4	65.9	10.3	.93	–5.06*
Spreadsheet	21.6	6.5	26.1	5.4	.76	–3.86*
Database	17.6	9.3	20.4	8.0	.32	–2.56***
Graphics	16.1	7.8	22.5	7.2	.85	–4.17*
Multimedia	15.4	6.2	24.1	5.5	1.49	–8.62*
Create Web page	30.4	16.5	58.0	15.2	1.74	–8.83*
Programming	30.4	16.1	36.6	18.3	.36	–3.63**

*$p < .001$. **$p < .005$. ***$p < .05$.

Wide Web, communication, and multimedia). This was not due to a ceiling effect as mean scores were sufficiently low for all of these applications. Finally, there were no significant differences with respect to overall use of computers between males and females. Recall, that the pre-laptop survey was a measure of everyday use, whereas the post-laptop survey focused on use in the university and in the field placement.

Males vs. Females—After Laptop Program

There were no significant differences between males and females with respect to any of the computer attitude constructs after the laptop program (Table 6). There were no significant differences between males and females with respect to computer ability either, with one exception. Males reported being significantly stronger programmers. Finally, the difference between males and females regarding computer use was non-significant in both university and field placement environments for all computer use constructs assessed.

Table 4. Female Computer Ability and Attitudes Before and After the Laptop Program

Measure	Before laptop *M*	Before laptop *SD*	After laptop *M*	After laptop *SD*	Cohen's *d*	*t*
Attitude						
Affective	51.2	7.8	53.3	9.3	–0.25	–1.33
Cognitive	78.9	10.7	80.3	11.3	–0.13	–0.83
Behavioral	50.7	15.9	58.8	8.4	–0.67	–3.48**
Perceived control	30.8	10.0	38.0	7.0	–0.85	–5.70*
Ability						
Operating system	54.3	18.3	72.1	10.7	–1.23	–7.90*
Communication	38.6	12.3	51.6	6.8	–1.36	–8.15*
WWW skills	40.7	14.9	59.8	8.1	–1.66	–8.53*
Word processing	51.0	14.1	66.3	8.4	–1.36	–6.27*
Spreadsheet	19.4	7.3	25.9	4.3	–1.12	–5.42*
Database	11.7	7.0	16.9	7.5	–0.72	–4.56*
Graphics	11.9	6.4	21.5	7.0	–1.43	–7.60*
Multimedia	12.6	6.7	24.0	5.4	–1.88	–11.39*
Create Web page	21.9	13.2	56.6	16.2	–2.36	–11.73*
Programming	18.6	13.1	24.5	16.6	–0.40	–2.61***

*$p < .001$. **$p < .005$. ***$p < .05$.

DISCUSSION

Overall Results

It is clear that the ubiquitous and integrated approach to using technology in pre-service education had a significant and positive impact on both male and female computer attitudes and ability. However, females appeared to benefit more than males with respect to behavioral attitude, perceived control, and all computer ability constructs, particularly those involving higher level software skills.

Computer Attitudes

Males and females did not differ markedly with respect to their attitudes toward computers before the laptop program, with one notable exception: behavioral attitude or intentions to use computers in the future. In other words, before the laptop program, female pre-service teachers reported that they would be less likely to use computers in the future. This difference could have had a significant and direct impact on their students. However, after the laptop program, males and

Table 5. Gender Differences in Computer Ability, Attitudes, and Use Before the Laptop Program

	Females		Males			
Measure	*M*	*SD*	*M*	*SD*	*df*	*t*
Attitude						
Affective	51.9	7.6	51.0	13.1	62	–0.34
Cognitive	79.2	10.9	81.7	9.8	63	0.97
Behavioral	51.1	15.8	58.3	9.5	63	2.18*
Perceived control	30.4	10.2	34.0	10.3	63	1.42
Ability						
Operating system	54.8	18.6	67.6	17.5	63	2.84*
Communication	38.8	12.3	44.2	13.3	62	1.69
WWW skills	41.3	15.1	48.6	14.7	63	1.97
Word processing	51.1	14.1	51.8	18.0	63	0.17
Spreadsheet	19.3	7.4	21.2	6.4	63	1.08
Database	11.7	6.7	16.9	8.6	63	2.76*
Graphics	11.7	6.4	16.2	7.4	63	2.62**
Multimedia	12.3	6.5	15.0	6.0	63	1.67
Create Web page	21.4	12.5	29.3	15.1	63	2.31**
Programming	19.3	12.5	31.5	16.4	62	3.35*
Overall use	66.6	20.4	76.2	18.7	63	1.96

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

females did not differ on any of the attitude constructs assessed. Active use of computers in an ubiquitous, interactive computing environment for a period of eight months helped to level the "computer attitude" playing field with respect to behavioral intentions to use computers.

Computer Ability

Males reported stronger higher level computer skills before being exposed to the laptop program, although there were no gender differences with respect to basic applications. After the laptop program, males and females were essentially equivalent with respect to all computer ability constructs, except programming. It could reasonably be argued that basic application skills are all a teacher needs to integrate computers into either elementary or secondary education. Therefore, the laptop program, while helping to balance gender differences in ability, might have no "real" effect on the use of computers in education. However, having stronger

Table 6. Gender Differences in Computer Ability, Attitudes, and Use After the Laptop Program

Measure	Females		Males			
	M	*SD*	*M*	*SD*	*df*	*t*
Attitude						
Affective	52.8	9.7	55.1	11.4	50	0.78
Cognitive	80.3	11.3	84.7	10.3	50	1.47
Behavioral	58.8	8.4	60.9	9.6	49	0.82
Perceived control	38.0	7.0	39.3	8.3	50	0.58
Ability						
Operating system	72.1	10.6	75.3	13.4	50	0.96
Communication	51.7	6.8	51.9	9.4	50	0.08
WWW skills	59.8	8.2	59.6	11.6	50	–0.12
Word processing	66.3	8.4	65.9	10.3	50	–0.17
Spreadsheet	25.9	4.3	26.1	5.4	49	0.17
Database	16.9	7.5	20.3	8.0	49	1.59
Graphics	21.5	7.0	22.5	7.2	48	0.51
Multimedia	24.0	5.4	24.1	5.5	48	0.05
Create Web page	56.6	16.2	58.0	15.2	49	0.31
Programming	24.9	16.5	36.7	18.2	49	2.41**
Use						
University	99.0	15.1	100.2	28.9	49	0.22
Field	74.2	25.7	79.9	26.7	46	0.71

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

operating system skills, and better graphics and Web page creation ability, could be a definite asset in terms of efficient use and opening up potential learning opportunities for students. In short, the integrated laptop program provided more possibilities for female teachers in their future classrooms.

Computer Use

Males and females did not differ with respect to computer use before or after the laptop program. At first, one might be tempted to conclude that the impact of changes in computer attitude and ability are minimized because there were no gender differences in use before the laptop program. In other words, even though males and females differed in their attitude and ability, this had no impact on their actual use. Ultimately use is what we are concerned about with respect to technology and education.

On the other hand, the "before" laptop survey did not look at use of computers in the classroom. It simply assessed everyday use of computers. While it is interesting that pre-program attitudes and ability did not appear to be related to everyday use of computers, the pre-program use measure is probably not an accurate measure of whether pre-service teacher candidates would have used computers to enhance education. The after laptop survey looked at both university and field placement use of computers where no gender differences were observed. This result is consistent with the post-laptop program attitude and ability results observed.

Model of Technology Integration Used

Two key components need to be recognized when interpreting the impact of the laptop program on addressing gender inequalities in computer attitude, ability, and use. First, twenty-four hour access to a wide range of software programs and the Internet was critical in establishing a natural, everyday philosophy to using computers. Having a laptop computer was like having a pen or pencil. The second key component was the meaningful, pedagogically sound, highly interactive approach to using technology used by the faculty. This teaching approach further cemented the idea that the computer was a tool necessary to solve teaching-related problems. However, it is difficult to determine the relative importance of ubiquitous access and teaching method on balancing gender differences in this study. It is conceivable, for example, that authentic computer activities based on sound educational theory using standard or mobile computer labs might have similar effects in addressing gender differences in computer attitude, ability, and use.

Importance of Measurement Tools

The emphasis placed on using theoretically sound, reliable constructs to assess both attitude and ability proved to be quite valuable in this study. A global measure of attitude or ability would not have uncovered important details about male-female differences in computer-related behaviors. For example, there appears to be a practical and theoretical difference between cognitive, affective, perceived control, and behavioral constructs, a result predicted by Ajzen and Fishbein (1977). In addition, a less comprehensive measure of computer ability focusing only on basic computer skills would not have captured the gender differences observed. Well-developed, well researched assessment measures are critical to understanding and addressing gender differences.

Limitations

The results of this study should be interpreted with caution for several reasons. First, the sample size, while diverse, was relatively small. Second, the measures of attitude, ability, and use were based on self-reports—the validity of the scales remains to be established. Finally, it is unclear whether the changes observed as a result of the laptop program will persevere once pre-service candidates are actually teaching in real classrooms.

Future Research

The results of this study suggest that gender differences in pre-service teachers' computer attitudes and ability can be virtually eliminated in a relatively short time period using the thoughtful integration of readily accessible technology. Given the limitations of this study, there remain a number of unanswered questions that need to be addressed by future researchers including:

1. Would other strategies used to infuse technology into pre-service programs achieve the same "gender" effect as the integrated laptop program observed in this study?
2. Will reduced gender differences in computer ability and use continue when pre-service students graduate and start teaching?
3. What is the practical impact of significantly improved pre-service teachers' computer attitudes and ability in the real world classroom?

A systematic comparison of strategies used to impart technology into pre-service programs, then, is necessary to determine the relative importance of ubiquitous access and integration. Ideally, this comparison of strategies would assess computer attitudes, ability, and use at the end of the pre-service program and when pre-service students are employed and teaching in actual classrooms.

Summary

The pre-service teacher candidates in this study participated in a laptop computer teacher education program designed to integrate technology meaningfully into a wide range of courses. Both males and females improved significantly with respect to perceived control over the computer and all computer ability constructs. However, initial differences in computer attitude and ability in favor of males essentially disappeared by the end of the program. This is a noteworthy finding suggesting that a relatively short but highly integrated technology-based program can help to reduce gender imbalances. It is speculated that this gender equalization effect could have a significant impact on the extent to which technology is used by future pre-service teachers and their students, especially given recent trends in promoting the use of technology in the classroom.

APPENDIX A

Authors	Validity	Reliability	Population	Attitude	Ability	Use	Behavior
Adrianson, 2001	No	No	Graduate students	No	No	No	Yes
Atan et al., 2002	No	Yes	Undergraduate	No	No	Yes	No
Aust et al., 2005	No	No	Preservicve teachers	No	Yes	No	No
Brosnan & Lee, 1998	No	Yes	Undergraduate	Yes	No	Yes	No
Busch, 1995	No	No	Undergraduate	Yes	No	No	No
Ching et al., 2000	No	No	Middle school	No	No	Yes	No
Colley, 2003	No	Yes	Middle & high school	Yes	No	Yes	No
Colley, 2003	No	Yes	High school	Yes	No	No	No
Comber et al., 1997	No	Yes	Middle & high school	Yes	No	Yes	No
Christensen et al., 2005	No	Yes	Grade 3-12	Yes	No	Yes	Yes
Durndell & Haag, 2002	No	Yes	Undergraduate	Yes	No	Yes	No
Durndell, Haag, & Laithwait, 2000	Yes	No	Undergraduate	Yes	No	No	No
Garland & Noyes, 2004	No	No	Undergarduate	Yes	No	No	No
Jackson et al., 2001	Yes	Yes	High school	Yes	No	Yes	No
Karavidas et al., 2005	No	No	Undergraduate	Yes	Yes	No	No
King et al., 2002	Yes	Yes	Middle & high school	Yes	No	No	No
Lanthier & Windham, 2004	No	No	Undergraduate	Yes	No	Yes	No
Lupart & Cannon, 2002	No	Yes	Middle	No	No	Yes	No
Light et al., 2000	No	No	Middle school	No	No	No	Yes

Lowe et al., 2003	No	Yes	Undergraduate	No	No	Yes	No
McIlroy et al., 2001	Yes	No	Undergraduate	Yes	No	No	No
Miller et al., 2001	No	Yes	Middle school	Yes	No	Yes	No
North & Noyes, 2002	No	Yes	Middle school	Yes	No	Yes	No
Ono & Zavodny, 2003	No	No	Adults	No	No	Yes	No
Oosterwegel et al., 2004	No	Yes	Middle school	Yes	No	No	No
Papastergiou & Solomonidou, 2005	Yes	Yes	Middle school	No	No	Yes	No
Passig & Levin, 1999	No	Yes	Kindergarten	No	No	No	Yes
Ray et al., 1999	No	No	Undergraduate	Yes	No	No	No
Schumacher & Morahan-Martin, 2001	No	Yes	Undergraduate	No	Yes	Yes	No
Shapka & Ferrari, 2003	No	Yes	Preservice teachers	Yes	No	Yes	Yes
Shashaani & Khalili, 2001	No	Yes	Undergraduate	Yes	No	No	No
Shaw & Marlow, 1999	Yes	No	Undergraduate	Yes	Yes	No	No
Solvberg, 2002	Yes	Yes	Middle school	Yes	No	Yes	No
Sussman & Tyson, 2000	No	No	Adults	No	No	Yes	No
Todman, 2000	No	Yes	Undergraduate	Yes	No	No	No
Tsai et al., 2001	Yes	No	High school	Yes	No	No	No
Volman et al., 2005	No	Yes	Primary & high school	Yes	Yes	Yes	No
Voyles & Williams, 2004	Yes	Yes	Middle school	No	No	No	Yes
Young, 2000	Yes	Yes	High school	Yes	Yes	Yes	No
Yuen & Ma, 2002	Yes	No	Preservice teachers	Yes	No	No	No
Zhang, 2005	No	No	Adults	Yes	No	No	No

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