

# A formative analysis of how preservice teachers learn to use technology

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## Abstract

A comprehensive, formal comparison of strategies used by preservice teachers to learn how to use new technology has yet to be researched. Understanding the relative strengths and weakness of learning strategies would provide useful guidance to educators and students. The purpose of the current study was to explore the effectiveness of four learning strategies: collaboration, using authentic tasks, formal instruction and exploratory learning. Seventy-four preservice teachers (25 male, 49 female) were surveyed at the beginning and end of an 8-month, consecutive, Bachelor of Education programme, with respect to their learning strategies, change in computer knowledge and use of computers in the classroom. Collaborative learning and use of authentic tasks were the most preferred strategies – formal instruction was the least preferred. A collaborative approach to learning was the best predictor of gains in computer knowledge. Authentic tasks and collaborative strategies were significant predictors of teacher use of computers in the classroom. Preference for authentic tasks was the only predictor of student use of computers. Regardless of strategy preference, selecting more than one primary learning tool was significantly correlated with amount learned and use of the computers in the classroom. Ability was not related to strategy preference. Finally, females preferred collaborative approach to learning, although they were significantly more open to using multiple strategies than males.

## Keywords

computer resource learning, help software, learn, preservice teachers, strategies.

## Overview

Over the past 10 years, educational policy specialists and administrators have made a concerted effort to increase the presence of technology in classrooms, specifically focusing on increasing student–computer ratios (US Department of Education, National Center for Education Statistics 2002), maximizing the number and speed of Internet connections (McRobbie *et al.* 2000; US Department of Education, National Center for Education Statistics 2002; Compton & Harwood 2003; Plante & Beattie 2004) and emphasizing technology as

a critical component of preservice teacher education (e.g. OTA 1995; CEO Forum on Education and Technology 2000; ISTE/NCATE 2003; National Council for Accreditation of Teacher Education 2003 – see Bennett 2001/2001 for a review). While considerable success in improving the hardware infrastructure in schools has been attained (McRobbie *et al.* 2000; US Department of Education, National Center for Education Statistics 2002; Compton & Harwood 2003; Plante & Beattie 2004), integrating the use of technology into preservice education has proven to be more of a challenge.

The purpose of this study was to explore and evaluate the effectiveness of strategies used by preservice teachers to learn new technology in order to gain insights on how to design more successful technology and education programmes. Note, for the purposes of this article,

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learning 'new technology' refers to learning 'new software'; however, other elements of technology come into play like understanding how to use technology in a classroom environment and operating digital equipment.

## Literature review

### Technology and preservice teachers

Assuming that thoughtful use of technology in certain contexts can have a significant and positive impact on student learning (Baker *et al.* 1994; Kulik 1994; Scardamalia & Bereiter 1996; Sivin-Kachala 1998; Wenglinsky 1998; Mann *et al.* 1999; SIIA 2002; Kozma 2003), preservice teacher education programmes are a reasonable place to start with respect to integrating technology into education, particularly when a strong infrastructure that supports computer use is in place. Yet, the evidence suggests that these programmes have not been successful at preparing new teachers to use technology effectively (OTA 1995; Moursund & Bielefeldt 1999; CEO Forum on Education and Technology 2000; US Department of Education 2000; Yildirim 2000). A number of obstacles that prevent successful implementation of computers include lack of time (Eifler *et al.* 2001; Wepner *et al.* 2003), teaching philosophy of mentors and school administration (e.g. department heads, principals, superintendents) 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 preservice teachers are perceived as unprepared to use technology.

A comprehensive review of strategies used to integrate technology into preservice education revealed that thoughtful technology-based programmes have been developed, but only a handful of studies have conducted careful and rigorous evaluations of these programmes (Kay 2006b). Less than 8% of all studies reviewed looked at changes in computer ability or classroom use of computers as a result of these programmes. Clearly, a more in-depth analysis is required.

One approach, not yet followed, is to examine actual strategies that preservice teachers employ to learn how to use technology. Comparing learning strategies might provide insights into which approaches have the most significant impact on improving computer ability and increasing effective use of technology in the classroom. Part of the challenge for this type of research is finding a technology-based teacher education programme that provides sufficient range of choices so that meaningful comparison among strategies can be made. Kay (2006b) noted that less than 5% of the 68 preservice programmes examined used four or more methods of integrating technology into preservice education.

### Strategies for learning to use technology

There are four key learning strategies that have been previously investigated including collaboration, formal instruction (workshops, manuals, software help), exploratory learning and completing authentic tasks. While this is not an exhaustive list, it is largely representative of the literature on approaches used to learn new technology. These four strategies align reasonably well with the ten methods that emerged from Kay's (2006b) review including:

- 1 collaboration among preservice teachers, mentor teachers and faculty, focusing on education faculty, focusing on mentor teachers (collaboration).
- 2 delivering a single technology course, offering mini-workshops, using multimedia (formal instruction).
- 3 improving access to software, hardware and/or support (time for exploratory learning).
- 4 integrating technology in all courses, modeling how to use technology, practising technology in the field (completing authentic tasks).

#### *Collaboration*

While the benefits of collaborative learning are well documented (e.g. Johnson & Johnson 1994, 1998; Kagan 1997; Sharon 1999), no formal studies have systematically examined the effect of collaboration on improving computer-related ability or use of technology in the classroom. Most research in this area has looked at the general impact of human assistance. Simmons and Wild (1991) noted that a majority of individuals end up asking for help from a more knowledgeable person. Rieman (1996) also observed that asking another person

for help is a natural strategy but that there can be several barriers – availability, feeling like you are bothering an experienced user too often, time spent on finding someone, and being too proud to ask for help. E-mailing a person for help is rarely done because most people need a quick answer to their problems (Rieman 1996). It should be noted that some researchers have reported that users would rather ask for help on an ‘as needed basis’ rather than be controlled by a tutor or trainer (Simmons & Wild 1991; Bannert 2000).

#### *Authentic tasks*

Several prominent organizations have strongly endorsed the use of authentic tasks as a viable method for introducing technology to preservice teachers (see Moursund & Bielefeldt 1999 or ISTE/NCATE 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 problem solving where preservice teachers are learning with computers, not about them (e.g. Milbrath & Kinzie 2000; Doering *et al.* 2003). Disadvantages to using this model include lack of hardware (Vannatta & Beyerbach 2000), limited faculty expertise and time (Vannatta & Beyerbach 2000; Eifler *et al.* 2001; Whetstone & Carr-Chellman 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; Vrasida & McIsaac 2001; Brush *et al.* 2003).

#### *Formal instruction*

In 2001, US companies spent approximately 21 billion dollars in improving computer skills of employees. The most typical response of institutions to the need for Information and Communication Technology (ICT) education is to focus on developing effective ‘stand-and-deliver’ training programmes (Niederman & Webster 1998; Olfman *et al.* 2003; Mahaptra & Lai 2005); however, there is evidence to suggest that this teaching approach is not particularly effective (Olfman & Bostrom 1991; Shayo & Olfamn 1993; Olfman & Mandviwalla 1995). It has been estimated that more than 50% of the participants in software workshops fail to use the software they were trained on (Olfman & Bostrom 1991; Olfman & Mandviwalla 1995). Other disadvantages observed 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).

Manuals can provide extensive information in the form of task-oriented instructions, indexes, table of contents, pictorial representations and specialized short-cut guides (Rettig 1991). In spite of these advantages, most new users, regardless of ability level, begin using new software without reading the manual (Carroll 1990; Rettig 1991; Simmons & Wild 1991; Taylor 2003). Rettig (1991) refers to computer manuals as the best-sellers that no one reads; however, Dryburg’s (2002) extensive report on over 25 000 users noted that manuals are used 60% of the time at some point in the software learning process.

There is some evidence to suggest that using a manual actually improves learning performance. For example, Rieman (1996) noted that individuals can find out how to do tasks without manuals, but more advanced features remain untouched or unresolved. Bannert (2000), though, observed that acquiring new software skills with a manual was significantly faster and more productive than tutor-guided instruction. However, not all manuals are the same. Manuals that contain ample error information (minimal manuals) help students perform better than manuals with limited error information (Carroll 1990; Lazonder 1994; Lazonder & Van der Meij 1995; Van der Meij & Carroll 1995). Van der Meij (2000) adds that the most successful format of a manual is a two-column layout with instructions and full-screen images presented side by side.

Software help features are designed to provide hints, instructions and immediate feedback to guide new learners (Patrick & McGurgan 1993; Draper 1999). However, designing good help systems is not an easy task because it requires one to anticipate the needs and behaviours of a variety of learners (Duffy *et al.* 1992; Allwood & Kalen 1993; Patrick & McGurgan 1993; Lazonder & Van der Meij 1995). Many users appear to spend little time using software help (Aleven & Koedinger 2000; Bartholomé *et al.* 2006). Nonetheless, there is some evidence to suggest that properly designed help features can foster learning (Wood & Wood 1999; Bartholomé *et al.* 2006), particularly context-sensitive help (Patrick & McGurgan 1993; Bartholomé *et al.* 2006).

#### *Exploratory learning*

Self-regulated or exploratory learning is a common method that many people use to acquire new software

skills (Bartholomé *et al.* 2006). In one report assessing over 25 000 computer users, 96% of respondents reported that they taught themselves to learn software through trial and error (Dryburg 2002). Limited research, though, has been performed by looking at the effectiveness of exploratory learning. Several researchers have examined a 'training wheels' approach to learning software where cognitive load is reduced by limiting the number of functions available (Guzdial 1999; Bannert 2000; Leutner 2000). Users who learn with a reduced command set outperform those individuals presented with a full array of options (Leutner 2000). Other research suggests that the successful exploration of software depends on whether the new software is consistent with previously learned software and how easy it is to guess at commands (Guzdial 1999).

#### *Comparing methods*

The little evidence that has been gathered comparing the use of resources suggests that people prefer to 'try things out' (Carroll 1990, 1998; Rieman 1996; Dryburg 2002), read the manuals (Rieman 1996), ask for some form of human assistance (Rieman 1996; Dryburg 2002) and, in some cases, consult the software help system if they are particularly aggressive explorers (Rieman 1996). Reimann and Neubert (2000) add that users tend to consult a hybrid of resources while learning instead of relying on a single support tool.

#### **Individual differences**

##### *Ability*

It is reasonable to speculate that novices and experienced learners have different perspectives and methods while learning new technology (Lazonder & Van der Meij 1995). Novices appear to be inconsistent in their approach to learning software and using resources (Rieman 1996). They are inefficient and often aimless when engaging in exploratory learning (Kamouri *et al.* 1986; Kluwe *et al.* 1990; Polson & Lewis 1990; Reimann & Neubert 2000), have difficulty controlling their learning activities and knowing where to search for answers (Bannert 2000; Van der Linden *et al.* 2001), and scan or act upon information very quickly (Brandt & Uden 2003).

As learners grow and develop understanding and expertise, their need for software support and functionality changes (Jackson *et al.* 1998). More experienced

users read manuals in greater depth (Rieman 1996) and are more proficient in selecting and executing search strategies (Wood & Wood 1999; Lazonder 2000; Bartholomé *et al.* 2006). However, domain-specific software expertise appears to be more important than general expertise (Draper 1999). For example, specific knowledge of spreadsheet software would help an individual learn a new spreadsheet software package more than overall software expertise (Draper 1999). It is also interesting to note that the differences between novice and experts begin to disappear when tasks become more complex (Lazonder 2000).

##### *Gender*

Gender differences in computer attitudes, use, ability and behaviour (e.g. Kay 1992a, 2006a; Whitley 1997; Sanders 2006) have consistently been reported in favour of males. It is reasonable to speculate, then, that differences may occur with respect to the use of learning strategies. To date, little research has been performed on gender differences and methods to learn new technology. In one large-scale study (Dryburg 2002), men were more likely to use exploratory learning, whereas women preferred facilitated methods (e.g. on the job training, help from friends, family, coworkers).

#### **Purpose and specific research questions**

While multiple strategies used to learn technology have been examined in previous research (Borenstein 1985; Bannon 1986; Norman & Draper 1986; O'Malley 1986; Carroll *et al.* 1987/88; Rieman 1996; Dryburg 2002), a comprehensive, formal evaluation of the effectiveness of a wide range of strategies has yet to be completed. A majority of studies focus on a single approach (e.g. Carroll 1990; Rieman 1996; Guzdial 1999; Bannert 2000; Belanger & Van Slyke 2000; Bartholomé *et al.* 2006).

The purpose of this article was to examine and compare the effectiveness of four learning strategies used by preservice teachers to learn how to use new technology: collaboration, authentic tasks, formal instruction and exploratory learning. The specific research questions were as follows:

- 1 Is there a significant difference among learning strategies with respect to perceived helpfulness?

- 2 Is there a significant difference among learning strategies with respect to impact on learning new technology?
- 3 Is there a significant difference among learning strategies with respect to predicting use of technology in the classroom?
- 4 Are there individual differences in the use of learning strategies with respect to computer ability and gender?

## Method

### Sample

Eighty-nine preservice teachers completed the pre-laptop programme survey, while 74 completed the post-laptop programme survey. Both pre- and post-test scores were necessary; therefore, the final sample population was 74 (83%). The sample consisted 25 males and 49 females, from a variety of cultural backgrounds (North America, Asia, Europe – 81% English as a first language) ranging in age from 23 to 53 years ( $M = 33.1$ ,  $SD = 8.7$ ). All students had at least a 4-year university degree in their area of teaching specialty. With respect to years of computer experience, 3% had 0–2 years, 10% had 3–5 years, 38% had 6–10 years and 81% had 10 or more years. It is important to note that years of computer experience in this study was not necessarily equivalent to computer knowledge. Preservice teachers' pre-laptop scores on the computer ability survey (see Table 2) were relatively low for 12 sub-scales except word processing and spreadsheets.

### Description of the programme

The Bachelor of Education degree at this university was an 8-month consecutive programme, focusing on computer science, math and science (physics, chemistry, biology and general science) at the intermediate-secondary school level (grades 7–12). 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 preservice teacher education programme was given an IBM R51 ThinkPad at the beginning of the year loaded with a wide range of educational and application-based programmes. 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 preservice education. In other words, students used their laptop computers in all courses offered, but did not take a stand alone course in technology use. Mini-workshops (1–2 h) were offered throughout the year on various software packages. Finally, there was one support person available 8 h 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.

### Data sources

#### *Learning strategies survey*

This survey consisted of 13 items based on a 5-point Likert Scale (0 = no help, 1 = little help, 2 = some help, 3 = much help, 4 = a great deal of help) focusing on various strategies that an individual could use to learn new technology. The items were based on the results from a pilot study (see Kay 1993) and the literature review (see Appendix I). The assumption is made that if preservice candidates did not find a particular learning strategy helpful, they probably did not use it as their main source of guidance. Similarly, if they found a strategy to be a great deal of help, they probably used it regularly to guide learning.

A principal components analysis was performed to explore whether certain combinations of the 13 strategies examined in this article were evident. As all communalities were above 0.5 (Stevens 1992), the principal component analysis was deemed an appropriate exploratory method (Guadagnoli & Velicer 1988). Both orthogonal (varimax) and oblique (direct oblimin) rotations were used given that the correlation among potential strategy combinations was unknown. These rotational methods produced identical factor combinations, so the results from the varimax rotation (using Kaiser normalization) are presented because they simplify the interpretation of the data (Field 2005). The Kaiser-Meyer-Olkin measure of sampling adequacy (0.763) and Bartlett's test of sphericity ( $P < 0.001$ )

Table 1. Varimax rotated factor loadings on strategies used to learn new technology.

Strategy	Factor 1	Factor 2	Factor 3	Factor 4
<b>Collaboration</b>				
Working with a classmate or a friend	0.86			
Asking face-to-face questions	0.84			
Working with a group of people	0.80			
E-mailing questions to instructor or friend	0.60			
<b>Formal instruction</b>				
Using help menu offered by software package		0.84		
Working through online tutorials		0.76		
Attending computer workshops		0.55		
<b>Exploratory learning</b>				
Systematic, slow trial and error on my own			0.91	
Random trial and error			0.83	
<b>Authentic tasks</b>				
Teaching with computers				0.80
Reading article/books				0.73
Using computers for planning/research/organizing for teaching				0.68
Completing assignments that require me to use the computer				0.52
<hr/>				
FACTOR	EIGENVALUE	CUMULATIVE PER CENT	PER CENT VARIANCE	
1	4.94	37.9	38.0	
2	1.59	12.2	50.2	
3	1.44	11.1	61.3	
4	1.23	9.4	70.7	

indicated that while the sample size was small ( $n = 74$ ), it was acceptable.

Based on the point of inflexion on the scree plot, eigenvalues set over one, and accepting factor loadings of 0.4 or greater, the principal components analysis extracted four patterns of strategy use that were labeled collaboration, formal instruction, exploratory learning and authentic tasks (learning to use the computer by completing a meaningful task) (Table 1).

The internal reliability estimates for the four learning factors were moderate, but acceptable, particularly for a formative analysis (Nunnally 1978; Kline 1999): collaboration ( $r = 0.85$ ), use of authentic tasks ( $r = 0.75$ ), formal instructions ( $r = 0.73$ ) and exploratory learning ( $r = 0.78$ ).

#### Computer ability

Several researchers (e.g. Kay 1989a, 1989b, 1992b, 1993; 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: preservice teachers (grades 7–12), 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 tool that would be used in an educational setting. Therefore, a composite survey of ten 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 that were measured in the current study included: operating systems, communication, World Wide Web, word processing, spreadsheet, database, graphics, multimedia, web page creation and programming. In addition, two new scales were created to assess the use of educational software in math and science. It is important to note that all scales were designed to be education-specific. In other words,

Table 2. Description of survey.

Scale construct measure	No. items	Range	Mean (SD)	Type of question	Internal reliability
<b>Ability</b>					
Operating system	10	0–40	25.0 (9.8)	5 pt Likert Scale	$r = 0.95$
Communication	10	0–40	22.1 (10.1)	5 pt Likert Scale	$r = 0.90$
WWW skills	9	0–36	22.6 (7.8)	5 pt Likert Scale	$r = 0.95$
Word processing	10	0–40	31.5 (8.0)	5 pt Likert Scale	$r = 0.98$
Spreadsheet	6	0–24	17.9 (5.9)	5 pt Likert Scale	$r = 0.97$
Database	10	0–40	17.2 (10.7)	5 pt Likert Scale	$r = 0.95$
Graphics	6	0–24	10.3 (7.4)	5 pt Likert Scale	$r = 0.94$
Presentation	6	0–24	10.6 (7.3)	5 pt Likert Scale	$r = 0.93$
Create web page	10	0–40	8.1 (10.8)	5 pt Likert Scale	$r = 0.95$
Programming	10	0–40	22.9 (12.0)	5 pt Likert Scale	$r = 0.98$
Science	11	0–44	7.8 (6.3)	5 pt Likert Scale	$r = 0.94$
Math	7	0–28	5.0 (5.5)	5 pt Likert Scale	$r = 0.98$
<b>Use</b>					
Teacher	7	0–28	N/A	5 pt Likert Scale	N/A
Student	18	0–72	N/A	5 pt Likert Scale	N/A

N/A, not available; WWW, World Wide Web.

survey items focused on tasks that a teacher would most likely need for the classroom. It is also critical to recognize that this was a self-assessment of computer ability using an online survey. While there is solid evidence to suggest that the scale was valid (Kay 2005), actually computer behaviour was not assessed. The reliability estimates for the computer ability skills assessed in this study were high ranging from 0.90 to 0.98 (Table 2).

#### *Computer use in the classroom*

A composite measure of computer use was developed based on a comprehensive review of research designed to assess computer use in preservice teachers (Garland 1999; Halpin 1999; Wang & Holthaus 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). In the classroom environment where preservice teachers did their practice teaching (field placement), two categories of computer use were examined – teacher-based and student-based. The teacher-based items consisted of tasks that directly supported the teachers (e.g. creating lesson plans, handouts, PowerPoint presentations and searching the web for teaching resources), whereas the student-based items consisted of tasks that directly supported student learning in class (e.g. using word processing or spreadsheet software, creating a web page, using subject-

specific software like ChemSketch, Fathom, or Geometer's Sketchpad, and interacting with learning objects).

The items from this scale were not designed to form coherent, reliable structures. The scale was designed to be a comprehensive checklist of technology tools that preservice candidates could use. However, given the wide range of tools examined and the limited time in the field placement (6 weeks), consistent and frequent patterns of use would be difficult to attain. Therefore, factor analyses and internal reliability estimates were not calculated.

#### **Procedure**

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 15–20 min to complete.

#### **Results**

##### **Perceived helpfulness**

Overall, preservice teachers appeared to find collaborative learning strategies the most helpful ( $M = 2.59$ ,  $SD = 0.88$ ), followed by authentic tasks ( $M = 2.41$ ,

Table 3. Mean score for strategies used to learn new technology.

Item	% rated as little or no help	Mean	SD
<b>Collaboration</b>			
1. Working with a classmate or a friend	10.8	2.73	1.09
2. Asking face-to-face questions	9.5	2.92	1.10
3. Working with a group of people	10.8	2.46	0.92
4. E-mailing questions to instructor or friend	17.6	2.24	1.11
Total collaboration		2.59	0.88
<b>Formal instruction</b>			
5. Attending computer workshops	20.3	2.26	1.21
6. Using help menu offered by software package	25.7	2.12	1.17
7. Working through online tutorials	21.6	2.27	1.11
Total formal instruction		2.21	0.70
<b>Exploratory learning</b>			
8. Systematic, slow trial and error on my own	9.5	2.55	0.89
9. Random trial and error	18.9	2.20	0.97
Total exploratory learning		2.37	0.42
<b>Authentic tasks</b>			
10. Teaching with computers	18.9	2.27	1.06
11. Reading article/books	39.2	1.74	1.02
12. Using computers for planning/research/organizing for teaching	12.2	2.64	1.17
13. Completing assignments that require me to use the computer	6.8	3.00	1.03
Total authentic tasks		2.41	0.81

SD = 0.81), exploratory learning ( $M = 2.37$ ,  $SD = 0.42$ ) and formal instruction ( $M = 2.21$ ,  $SD = 0.70$ ). Referring to the Likert rating scale (0 = no help, 1 = little help, 2 = some help, 3 = much help, 4 = a great deal of help), it appears that collaborative learning provided 'much help', whereas authentic tasks, exploratory learning and formal instruction provided 'some help'. It is important, though, to look at the individual items within each learning strategy category when interpreting helpfulness (Table 3). With the exception of formal instruction, all categories had at least one item that was perceived as less helpful and one item that was perceived as more helpful. For example, e-mailing questions was not perceived as helpful as the other strategies within the collaborative learning category. Systematic trial and error was highly rated in the exploratory category, but random trial and error did not fair as well. Teaching with computers and using a manual were not well received within the authentic learning category, but completing assignments and preparing for teaching were. All items in the formal instruction category, though, were consistently rated lower than most other help strategies.

With respect to average rating of helpfulness, completing assignments, asking face-to-face questions,

working with a classmate and using computers to prepare for teaching were rated highly. Consulting a book and using the software help menu were cited as the least helpful learning strategies (see Table 3).

It is worth noting that the correlations among all four learning strategies were moderate, positive and significant ( $r = 0.28$  to  $r = 0.51$ ) except for the correlation between formal instruction and exploratory learning which was not significant. The correlation among perceived helpfulness of collaboration and authentic task strategies was the highest observed (Table 4).

Over 58% ( $n = 42$ ) of all preservice teachers preferred a single learning strategy, 25% ( $n = 18$ ) selected two primary strategies, and 16% ( $n = 12$ ) select three or more strategies. In other words, preservice teachers tend to depend on a single learning approach to the exclusion of others. Accounting for overlap, preferences for specific strategies were as follows: 38% ( $n = 28$ ) for collaborative, 31% ( $n = 22$ ) for authentic learning tasks, 24% ( $n = 17$ ) for formal instructions and 35% ( $n = 25$ ) for exploration. Note that the criterion for determining a primary strategy was to select those with an average preference rating of 3 or more.

Table 4. Correlations among learning strategies.

	Collaborative	Authentic tasks	Formal instruction	Exploratory
Collaborative	1.00	0.51**	0.44**	0.32**
Authentic tasks		1.00	0.48**	0.28*
Formal instruction			1.00	0.21
Exploratory				1.00

\* $P < 0.05$  (two-tailed); \*\* $P < 0.01$  (two-tailed).

Table 5. Correlation among perceived helpfulness of learning strategies and change in amount learned.

	Collaborative	Authentic tasks	Formal instruction	Exploratory
Operating system	0.19	0.18	-0.07	0.00
Communication	0.27*	0.22	0.15	0.10
WWW skills	0.23	0.18	0.07	0.10
Word processing	0.17	0.19	0.11	0.10
Spreadsheet	0.30**	0.29*	0.07	0.18
Database	0.36**	0.21	0.08	0.20
Graphics	0.31**	0.24	0.15	-0.03
Presentation	0.20	0.21	0.17	0.07
Create web page	0.38**	0.19	-0.24	0.04
Programming	0.19	0.11	-0.23	0.27
Science	0.54**	0.53**	0.38*	0.42**
Math	0.37*	0.53**	0.21	0.21

\* $P < 0.05$  (two-tailed); \*\* $P < 0.01$  (two-tailed).

WWW, World Wide Web.

## Learning strategies and amount learned

### Correlations

A *t*-test comparing pre- ( $M = 178.5$ ,  $SD = 73.9$ ) and post- ( $M = 271.3$ ,  $SD = 60.8$ ) scores for total amount learned revealed a significant increase ( $t = 14.2$ ,  $d.f. = 72$ ,  $P < 0.001$ ). This change was significantly correlated with perceived helpfulness of collaboration ( $r = 0.44$ ;  $P < 0.001$ ), using authentic tasks ( $r = 0.36$ ;  $P < 0.005$ ), and formal instruction ( $r = 0.24$ ;  $P < 0.05$ ), but not exploratory strategies ( $r = 0.17$ ; ns).

An analysis of the correlations among individual ability sub-tasks (see Table 2) and perceived helpfulness of learning strategies revealed a more complicated pattern. Significant positive changes in operating systems skills, using the World Wide Web, presentation software and programming ability were not significantly correlated with any of the learning strategies examined in this article. With the exception of programming, these software areas are relatively common tools for most users. Perceived helpfulness of collaborative learning strategies was significantly and positively cor-

related with significant increases in more advanced, specialized software areas involving spreadsheets, databases, graphics, web page design, science and mathematics. Authentic tasks were also correlated with many of the more advanced software areas with the exception of web page design. Perceived helpfulness of formal instruction and exploratory methods were not correlated of with significant changes in any of the software ability sub-tasks, with the exception of science (see Table 5).

The number of primary learning strategies (rating of 3 or more) preferred by preservice teachers was significantly correlated with positive gains in more advanced software packages including spreadsheets ( $r = 0.29$ ;  $P < 0.05$ ), databases ( $r = 0.42$ ;  $P < 0.01$ ), web page design ( $r = 0.32$ ;  $P < 0.01$ ), science ( $r = 0.50$ ;  $P < 0.01$ ) and math ( $r = 0.41$ ;  $P < 0.01$ ). Correlations with more basic software packages (e.g. basic operating skills, word processing, using the World Wide Web and e-mail) and the number of primary learning strategies were not significant, with the exception of presentation software ( $r = 0.24$ ;  $P < 0.05$ ).

### *Regression analysis*

A stepwise multiple regression analysis was performed to examine the relationship among the four learning categories (collaborative, authentic tasks, exploratory, formal instruction) and the change in total amount learned. The stepwise method was chosen because there was no previous theory to guide selection of predictors. Collaborative learning was the only significant predictor of change in total amount learned ( $R = 0.443$ ,  $F = 17.4$ ,  $P < 0.001$ ). Multicollinearity did not appear to be a problem because no Variance Inflation Factor (VIF) was over the acceptable level of 10 (Bowerman & O'Connell 1990; Myers 1990) and the average VIF ( $M = 1.4$ ) was not substantially greater than 1 (Bowerman & O'Connell 1990) when all variables were entered into the equation. The Durbin-Watson test produced a value of 1.96 indicating no problems with respect to autocorrelation of errors (Durbin & Watson 1951).

### **Learning strategies and use of technology in the classroom**

#### *Correlations*

Perceived helpfulness of authentic tasks was significantly and positively correlated with use of computers in the classroom for teacher-related tasks ( $r = 0.41$ ;  $P < 0.001$ ) and student-related tasks ( $r = 0.31$ ;  $P < 0.01$ ). Perceived helpfulness of collaborative learning was significantly and positively correlated with teacher-related tasks only ( $r = 0.26$ ;  $P < 0.05$ ). All other correlations among learning strategies and classroom use were not significant.

The number of primary learning strategies preferred was significantly correlated with teacher-related tasks ( $r = 0.26$ ;  $P < 0.05$ ) and student-related tasks ( $r = 0.31$ ;  $P < 0.01$ ). In other words, students who used multiple learning strategies were more likely to use computers in their classrooms for administration, preparation and student use.

#### *Regression analysis – teacher use*

A stepwise multiple regression analysis was performed to examine the relationship among the four learning categories (collaborative, authentic tasks, exploratory, formal instruction) and use of computers in the classroom for teacher-related tasks. Perceived helpfulness of authentic tasks was the only significant predictor of a preservice candidate completing teacher-focused com-

puting tasks ( $R = 0.41$ ,  $F = 14.1$ ,  $P < 0.001$ ). Multicollinearity did not appear to be a problem because no VIF was over the acceptable level of 10 (Bowerman & O'Connell 1990; Myers 1990) and the average VIF ( $M = 1.4$ ) was not substantially greater than 1 when all variables were entered into the equation (Bowerman & O'Connell 1990). The Durbin-Watson test produced a value of 2.04, indicating no problem with respect to autocorrelation of errors (Durbin & Watson 1951).

#### *Regression analysis – student use*

A stepwise multiple regression analysis was performed to examine the relationship among the four learning categories (collaborative, authentic tasks, exploratory, formal instruction) and use of computers in the classroom for student-related computer tasks. Perceived helpfulness of authentic tasks as a learning strategy was the only significant predictor of student-related computer tasks ( $R = 0.32$ ,  $F = 8.2$ ,  $P < 0.01$ ). Multicollinearity did not appear to be a problem because no VIF was over the acceptable level of 10 (Bowerman & O'Connell 1990; Myers 1990) and the average VIF ( $M = 1.4$ ) was not substantially greater than 1 when all variables were entered into the equation (Bowerman & O'Connell 1990). The Durbin-Watson test produced a value of 1.8, indicating no problem with respect to autocorrelation of errors (Durbin & Watson 1951).

### **Individual differences (ability and gender)**

#### *Ability*

Total computer ability was assessed by adding up all the ability sub-tasks score at the end of the programme (Table 2). There were no significant correlations among perceived helpfulness of learning strategies (collaboration, authentic tasks, formal instruction, exploration) and total computer ability. Ability level was not correlated with the number of primary learning strategies preferred either.

#### *Gender*

Males and females did not differ with respect to perceived helpfulness of learning strategies with one exception. Females perceived collaborative learning as significantly more helpful than males ( $P < 0.05$ ). Note that the probability level was adjusted to compensate for the number of  $t$ -tests performed (see Kirk 1982, p. 102) (Table 6).

Learning strategy	Females		Males		d.f.	t
	M	SD	M	SD		
Collaborative	2.78	0.68	2.20	1.10	69	-2.83*
Authentic task	2.50	0.75	2.23	0.89	69	-1.39
Formal instruction	2.26	0.99	2.12	0.84	69	-0.63
Exploration	2.37	0.85	2.40	0.84	69	-0.15

**Table 6.** Gender differences in perceived helpfulness of learning strategies.

\* $P < 0.05$ .

Actual probability value was adjusted based on number of  $t$ -tests performed (see Kirk 1982, p. 102).

A  $t$ -test indicated that females ( $M = 1.51$ ,  $SD = 1.1$ ) were significantly more likely than males ( $M = 0.83$ ,  $SD = 0.98$ ) to use more than one primary learning strategy ( $t = -2.44$ ,  $d.f. = 70$ ,  $P < 0.05$ ). Over 50% ( $n = 25$ ) of females used two or more strategies, whereas only 22% ( $n = 5$ ) of males chose this multiple methods approach.

## Discussion

The purpose of this article was to examine and compare the effectiveness of four strategies used by preservice teachers to learn how to use new technology: collaboration, authentic tasks, formal instruction and exploratory learning, and four research questions were asked:

- 1 Is there a significant difference among learning strategies with respect to perceived helpfulness?
- 2 Is there a significant difference among learning strategies with respect to impact on learning new technology?
- 3 Is there a significant difference among learning strategies with respect to use of technology in the classroom?
- 4 Are there individual differences in the use of learning strategies with respect to computer ability and gender?

### Perceived helpfulness of learning strategies (question 1)

The learning strategies explored in this study appeared to differ with respect to perceived helpfulness. Collaboration was seen as the most helpful learning approach, a result that is consistent with previous research on the positive effects of collaborative learning in general (e.g.

Johnson & Johnson 1994, 1998; Kagan 1997; Sharon 1999). While Rieman (1996) noted that there are a number of barriers to asking other people for help, pre-service teachers in a laptop environment, particularly females, appeared to overcome these challenges. The relatively limited usefulness of e-mailing a person for help is also consistent with Rieman's (1996) observations.

Authentic tasks were also rated relatively highly with respect to perceived helpfulness. This approach has been strongly endorsed, but not rigorously evaluated by a number of previous studies (Halpin 1999; Moursund & Bielefeldt 1999; Milbrath & Kinzie 2000; Vannatta & Beyerbach 2000; Pope *et al.* 2002; Albee 2003; Doering *et al.* 2003; ISTE/NCATE 2003). It is interesting to note that reading a book or manual was associated with authentic learning tasks, but not highly rated. It is possible that users consulted written guidance when they had to get a specific task performed, but that they found this kind of resource not particularly helpful. It is not surprising that books/manuals in this study were not perceived as being helpful given that there was no formal textbook or resource library with well-designed print materials (Carroll 1990; Lazonder 1994; Lazonder & Van der Meij 1995; Van der Meij & Carroll 1995). It is also important to note, though, that simply teaching with computers was not rated as a particularly helpful 'authentic task'. Subjects had to be completing assignments, using the computer to organize, or planning for a class to gain the full benefit of authentic learning.

Exploratory learning was thought to be relatively helpful and this finding is supported by the literature (Dryburg 2002; Bartholomé *et al.* 2006). Systematic, slow exploration where user takes time to observe the screen was rated as being reasonably helpful, whereas

as more random, trial and error was not thought to be particularly useful.

Several researchers (Simmons & Wild 1991; Bannert 2000) noted that users would rather use collaborative methods than take formal courses to learn new software and these findings are consistent with the results observed in the current study. Formal instruction received the lowest ratings with respect to perceived helpfulness.

It is interesting to note that preservice teachers appear to prefer a single learning strategy above all others, a finding that was not supported by Reimann and Neubert (2000). This is a potentially risky approach that could limit overall learning and increase frustration.

### **Impact of learning strategies on learning**

It is worthwhile to note that preservice teachers were reasonably accurate with respect to their ratings of how helpful specific strategies were. Collaboration was rated the highest and it was significantly and positively correlated with significant increases in higher level technology skills. Authentic tasks were correlated with subject-specific software skills (math and science software). In other words, preservice teachers appeared to prefer learning subject-specific software in context. Exploratory learning and formal instruction approaches were not significantly related to acquiring higher levels of technological proficiency with the expectation of science software. However, this connection was eliminated once a regression analysis was performed. In other words, compared with other learning strategies, these approaches do not translate into improved computer-related knowledge.

It is critical to note that the number of primary learning strategies was significantly correlated with positive and significant increases in more advanced software tools. If an individual prefers collaborative learning or using authentic tasks, gains in amount learned may be achieved, whereas if formal instruction or exploratory learning is the primary learning strategy, learning could be severely inhibited because of a reluctance to try other methods.

### **Impact of learning strategies on classroom use**

Preservice teachers who preferred authentic tasks were significantly more likely to use technology to support

their teaching and their students learning in the classroom. Students who favoured collaboration, on the other hand, used computers for teaching-related tasks only. This is an interesting reversal to the findings observed for total amount of computer knowledge learned. Collaboration appears to improve personal gains in technology use, but preservice teachers may need to use computers in more authentic situations if gains in used are to be realized by the students they instruct. One of the difficulties observed in previous studies was that preservice teachers had difficulty translating authentic experiences in school to field experiences in the classroom (Simpson *et al.* 1999; Eifler *et al.* 2001; Vrasida & McIsaac 2001; Brush *et al.* 2003). Clearly, this was not the case for teachers in the current study. The highly integrated philosophy of incorporating technology into numerous aspects of teacher education, coupled with ubiquitous access to computers, may have contributed to more successful transfer into the 'real world' of teaching.

Note that the number of preferred learning strategies was significantly related to both teacher and student use of computers in the classroom. One could speculate that preservice teachers who are open to using more learning strategies are more confident because they are better able to handle challenges that could arise.

### **Individual differences**

Ability was not significantly related to perceived usefulness of the four help strategies examined in this study. This finding appears to contradict previous research, indicating that novices differ considerably in their choice and use of learning strategies and resources employed to learn new software and technology (Rieman 1996; Jackson *et al.* 1998; Wood & Wood 1999; Lazonder 2000; Bartholomé *et al.* 2006). It is also important to note that ability was not related to the number of learning strategies preferred. In other words, preservice teachers do not prefer more strategies simply because they are more able users.

While previous bias in favour of males with respect to computer attitude, ability and computer use has been observed in the past (e.g. Kay 1992b, 2006a; Whitley 1997; Sanders 2006), this pattern was not repeated in this study. In fact, females preferred collaborative learning, the most influential predictor of amount learned, significantly more than males. This result, though, was

partially supported by Dryburg's (2002) observation that females preferred facilitated methods. Males and females did not differ significantly with respect to the other three strategies assessed. There is some evidence to suggest that (1) ubiquitous access to computers and the Internet can eliminate gender differences in preservice teachers' ability to use computers; and (2) females benefit from this kind of environment more than males (Kay 2006a). It is possible that preservice female teachers thrive more in a laptop teacher education programme because it encourages collaboration. Students can ask about a computer-related problem anytime, anywhere. On the other hand, an exploratory approach, preferred by males (Dryburg 2002), may not serve them as well with respect to learning and using new technology.

Another critical finding was that females were more likely than males to select a hybrid of learning tools, an approach that was significantly correlated with the amount learned and use of the computers in the classroom by teachers and students. This pattern is new and has not been reported in previous literature.

### Caveats

The results of this study should be interpreted with caution for the following reasons:

- 1 The sample size was relatively small and consisted of Canadian preservice teachers – the results may not generalize to different educational systems in other countries.
- 2 Actual use of strategies was inferred from preference ratings, but it was never assessed.
- 3 The teacher education programme evaluated was unique involving ubiquitous access to computers, integration of technology into all courses as opposed to offering a single computer course – different environments might yield different strategy preferences.
- 4 There were no formal computer manuals and textbooks used in this study. Well-designed written materials might alter strategy preferences.

### Suggestions for educators

The current study is a first look at the effectiveness of strategies used by preservice teachers to learn new

technology. The results provide useful information for integrating technology into preservice education more successfully.

Both collaborative learning and the use of authentic tasks should be encouraged and facilitated in order to increase preservice computer-related knowledge and to have that knowledge translated into the classroom. Programmes that rely solely on formal instruction in computer laboratories are unlikely to be successful. In fact, workshops and non-integrated computer courses may inhibit the progress of female preservice teachers who prefer collaboration. Note that if only 'basic' software skills are promoted, the approach one chooses to learn appears to be irrelevant. It is only when more advanced and subject-specific skills are required that collaboration and authentic tasks may be required.

Exploratory learning, a practice followed by a majority of new learners, was not particularly useful unless it was systematic and slow. Random searching and trial and error should be discouraged. Using a manual and the software help menu were the least preferred learning approaches, so extensive efforts to buy written materials or have students rely on software help may not be fruitful.

Finally, and perhaps most importantly, preservice teachers, particularly males, should be encouraged to use more than one learning strategy. Having more than one tactic to rely on can lead to more gains in learning and more frequent use of computers in the classroom.

### Summary

A comparison of four strategies used by preservice teachers to learn new technology was completed. The scale for assessing perceived usefulness of strategies showed construct validity and a moderate level of reliability. Collaborative learning, authentic tasks and exploratory learning were the most preferred strategies – formal instruction was the least preferred. A collaborative approach to learning was the best predictor of gains in computer knowledge. Authentic tasks and collaborative strategies were significant predictors of teacher use of computers in the classroom. Preference for authentic tasks was the only predictor of use of computers by students. Regardless of strategy preference, selecting more than one primary learning tool was significantly correlated with amount learned and use of the comput-

ers in the classroom. Ability was not related to strategy preference. Finally, females preferred collaborative

approach to learning, although they were significantly more open to using multiple strategies than males.

## Appendix I

### Learning strategies scale items

#### Collaboration

- 1 Working with a classmate or a friend
- 2 Asking face-to-face questions
- 3 Working with a group of people
- 4 E-mailing questions to instructor or friend

#### Formal instruction

- 5 Attending computer workshops
- 6 Using help menu offered by software package
- 7 Working through online tutorials

#### Exploratory learning

- 8 Systematic, slow trial and error on my own
- 9 Random trial and error

#### Authentic tasks

- 10 Teaching with computers
- 11 Reading article/books assigned in class
- 12 Using computers for planning/research/organizing for teaching
- 13 Completing assignments that require me to use the computer

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