Evaluating Strategies Used To Incorporate Technology Into Preservice Education: A Review Of the Literature

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Abstract

The following paper is based on a review of 68 refereed journal articles that focused on introducing technology to preservice teachers. Ten key strategies emerged from this review, including delivering a single technology course; offering mini-workshops; integrating technology in all courses; modeling how to use technology; using multimedia; collaboration among preservice teachers, mentor teachers and faculty; practicing technology in the field; focusing on education faculty; focusing on mentor teachers; and improving access to software, hardware, and/or support. These strategies were evaluated based on their effect on computer attitude, ability, and use. The following patterns emerged: First, most studies looked at programs that incorporated only one to three strategies. Second, when four or more strategies were used, the effect on preservice teacher's use of computers appeared to be more pervasive. Third, most research examined attitudes, ability, or use, but rarely all three. Fourth, and perhaps most important, the vast majority of studies had severe limitations in method: poor data collection instruments, vague sample and program descriptions, small samples, an absence of statistical analysis, or weak anecdotal descriptions of success. It is concluded that more rigorous and comprehensive research is needed to fully understand and evaluate the effect of key technology strategies in preservice teacher education. (Keywords: *preservice computer technology education review strategies.)*

BACKGROUND

Over the past 10 years, researchers, educators, and administrators have debated the value and effect of technology in elementary and secondary education. Several comprehensive studies have concluded that computers have had a minor or negative effect on student learning (e.g., Cuban, 2001; Russell, Bebell, O'Dwyer, & O'Connor, 2003; Roberston, 2003; Waxman, Connell, & Gray, 2002). However, a number of large-scale meta-analyses (Baker, Gearhart, & Herman, 1994; Kozma, 2003; Kulik, 1994; Mann, Shakeshaft, Becker, & Kottkamp, 1999; Scardamalia & Bereiter, 1996; SIIA, 2000; Sivin-Kachala, 1998; Wenglinksy, 1998) have reported significant improvement in achievement scores, attitudes toward learning, and depth of understanding when computers were integrated with learning. Gains observed in these studies, however, were dependent on subject area (Kulik, 1994), type of software used (Sivin-Kachala, 1998), specific student population, software design, educator role, and level of student access (Sivin-Kachala, 1998).

In spite of the conflicting results reported on the effectiveness of technology in the K–12 educational environment, educational policy specialists and administrators have made a concerted effort to increase the presence of technology in classrooms, specifically focusing on student-to-computer ratio, high-speed Internet access, and preservice teacher education. According to the US Department of Education's National Center for Education Statistics (2002), the average student-to-computer ratio in 2001 was 5.4:1, a significant increase from the 12:1 ratio reported in 1998. Furthermore, 99% of all public schools now have access to the Internet, with 94% having high-speed broadband connections (US Department of Education, National Center for Education Statistics, 2002). Other countries have followed a similar pattern of increasing technology access in the classroom (Compton & Harwood, 2003; McRobbie, Ginns, & Stein, 2000; Plante & Beattie, 2004).

The emphasis on integrating technology into preservice education programs had mirrored the rapid rise in computer and Internet access. A large number of nationally recognized organizations (e.g., CEO Forum on Education and Technology, 2000; National Council for Accreditation of Teacher Education, 2003; OTA, 1995; ISTE/NCATE, 2003—see Bennett, 2000–2001 for a review) have developed comprehensive standards for the use of technology in teacher preparatory programs. The stage has been set for preservice teachers to use technology in the classroom.

Assuming that thoughtful use of technology in certain contexts can have a significant and positive effect on student learning (Baker, Gearhart, & Herman, 1994; Kozma, 2003; Kulik, 1994; Mann, Shakeshaft, Becker, & Kottkamp, 1999; Scardamalia & Bereiter, 1996; SIIA, 2000; Sivin-Kachala, 1998; Wenglinsky, 1998), preservice teacher education programs are a natural place to start with respect to integrating technology into education, particularly when there exists a strong infrastructure that supports computer use. Yet the evidence suggests that these programs have not been successful in preparing new teachers to use technology effectively (CEO Forum on Education and Technology, 2000; Moursund & Bielefeldt, 1999; OTA, 1995; US Department of Education, 2000; Yildirim, 2000). A number of obstacles that prevent successful implementation of computers include lack of time (Eifler, Greene, & Carroll, 2001; Wepner, Ziomek, & Tao, 2003), teaching philosophy of mentors and school administration with respect to technology (e.g., Dexter & Riedel, 2003; Doering, Hughes, & Huffman, 2003; Stuhlmann & Taylor, 1999), technological skill of faculty of education members (faculty of education refers to Colleges, Schools, and Departments of Education) (Eifler et al., 2001; Strudler, Archambault, Bendixen, Anderson, & Weiss, 2003; Thompson, Schmidt, & Davis, 2003), fear of technological problems (Bullock, 2004; Doering et al., 2003), a lack of clear 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.

RESEARCH PROBLEM AND PURPOSE

Numerous teacher education programs have made extensive efforts to implement effective and meaningful use of technology, however the strategies used to attain these goals are complex, diverse, often conflicting, and rarely evaluated well. To date, there is no consolidated picture on how to effectively introduce technology to preservice teachers. A comprehensive description and evaluation of strategies is a necessary step, then, to guide researchers, administrators, and educators. The purpose of this paper is to identify, describe, and evaluate strategies used to incorporate technology into preservice education.

METHOD

Data

A comprehensive search of the literature was done based on two criteria. First, all articles were selected exclusively from refereed print or online journals. Conference papers or reports were not included in this review. Second, the focus of these articles had to be on incorporating technology into preservice education. All relevant articles were included in the analysis. (See Appendix A, page 403, for a complete list of articles included in the review.)

Data Analysis

Each study (the term study refers to either a position paper or one that collects empirical data) reviewed was evaluated in terms of method, strategies used, and the effect of these strategies. An examination of method included the following elements: sample size, teaching level, description of teacher education program, data collection, addressing individual differences, data collection, and data analysis. In addition, each paper was evaluated as to whether it included one or more of the following ten strategies: single technology course; offering mini-workshops; integrating technology in all courses; modeling how to use technology; using multimedia; collaboration among preservice teachers, mentor teachers, and faculty; practicing technology in the field; focusing on education faculty; focusing on mentor teachers; and improving access to software, hardware, and/or support. Finally, the effect of the strategies used was determined by the reported changes in preservice teachers' computer attitudes, ability, and/or use. Appendix B, page 407, provides a detailed description of the coding of variables used in this study.

It should be noted that a meta-analysis was not done because (a) only 14 studies used reliable data collection methods combined with formal statistics, (b) only four of these 14 studies included a complete description of the sample, including teaching level, and (c) a meaningful comparison of these studies was limited due to differences in dependent variables measured (e.g., nine studies looked at attitude, seven looked at ability, and three studies looked at use).

RESULTS AND DISCUSSION

Methodology Used in Reviewed Studies

Sample Size. Sample size varied from 0 to 1,313 subjects. The mean sample size was 52 subjects when extreme cases were removed, however, 28% (n=19) of all studies reported a sample size of zero. In other words, strategies were proposed but never tested or evaluated. Sixty percent (n=41) of all studies looked at 40 or fewer preservice teachers. Although there are no clear guidelines to determine optimum sample size, a minimum of 50–100 subjects has been proposed by Fraenkel and Wallen (2003) as a rule of thumb. Given the cost in time and money of many of these technology-based programs, it is advisable that larger samples be assessed in the future.

Teaching Level. The use of technology in learning is partially dependent on grade level—different educational software is designed with different goals and procedures in mind. Nonetheless, more than 50% of the studies examined (n=35) failed to report specific teaching level. Slightly more than 25% (n=18) of all studies looked at elementary preservice teachers and 12% (n=8) examined mixed teaching levels. Middle school and secondary preservice teachers were clearly under-represented. It would be prudent for future researchers to (a) identify the specific teaching levels of preservice candidates and (b) expand the focus to preservice teachers of older students.

Description of Program. A clear description of the general education program is necessary for a coherent comparison of research on technology and preservice education. Details such as length of program, number of faculty and students, and course organization and focus are important with respect to interpreting results. For example, a single technology course strategy might be effective for a one-year program, but not for a multi-year program. A multimedia approach using online courses might work better for programs in more remote locations. Science and math preservice teachers might adapt more quickly to technology than their social science counterparts. These kind of speculations cannot be addressed by reviewing the studies in this paper, because more than 90% (n=62) of all researchers neglected to describe their educational programs in sufficient detail. A clear, complete description of these programs is necessary to build understanding of how technology is used in preservice education.

Data Collection. Surveys were the predominate mode of data collection, accounting for 44% (n=30) of all studies. However, internal reliability estimates for these surveys were reported only half the time. Scale validity estimates were almost never noted (n=3). Qualitative methods were used exclusively in 16% (n=11) of the papers analyzed. The combination of survey and qualitative methods was employed in only 12% of the papers. If surveys are used, reliability and validity details need to be done to ensure the data are sound. In addition, multiple data collection methods are recommended to help increase the validity of data being collected and presented.

Dependent Variables. Computer attitude, ability, and use are the three key dependent variables in the vast majority of technology and preservice teacher education literature, although clear definitions of ability, attitude, and use are rarely presented or theoretically justified. Computer ability was examined most often (60%, n=41), followed closely by computer attitudes (56%, n=38). Computer use, on the other hand, was looked at in only one third of the studies examined (n=23). Slightly more than one third (n=24) of all studies used more than one dependent variable and only four articles (6%) looked at ability, attitude, and use. Multiple dependent variables are recommended for future research to gain a more comprehensive perspective on the effect of key strategies. Furthermore, computer use needs to be emphasized more, given that the ultimate goal of all programs is to translate strategies into meaningful technological interactions in the classroom.

Individual differences. Only 10 % (n=7) of the studies examined in this paper looked at individual differences among preservice teachers' computer attitudes, ability, or use. However, differences in computer-related behaviors have been observed with respect to gender (see Kay, 1992, in press; Sanders, in press; Whitley, 1997 for a review of the literature), SES (e.g., Becker & Ravitz, 1999; Nolan, 1992; Shashaani, 1994), and culture (Evans, 1995; Hoffman & Novak, 1998; Wilkinson, Buboltz, Cook, Matthew, & Thomas, 2000). Strategies that work well for certain groups may not be effective for others. In order to understand the precise effect of specific strategies on preservice teachers' use of technology, it is important to examine individual nuances in more detail.

Data Analysis. The most reasonable design to determine the effect of a set of strategies on computer attitude, ability, or use is a pre-post or experimental analysis; however, this format was used in only 29% (n=20) of all studies. The remaining articles reported no research method (16%, n=11), anecdotal descriptions (28%, n=19), or percentages (27%, n=18). Although there is clearly a role for qualitative research in assessing the effectiveness of specific technology strategies, this role is probably best used in conjunction with quantitative data, at least at the evaluation stage. Future research needs to either (a) employ a pre-post test or experimental design to assess the effect of various strategies on introducing technology to preservice teachers or (b) follow more rigorous protocols in collecting and analyzing qualitative data.

Strategies Used to Incorporate Technology

Overview. At least ten strategies were used to teach technology to preservice teachers, including integrating technology in all courses (44%, n=30); using multimedia (37%, n=25); focusing on education faculty (31%, n=21); delivering a single technology course (29%, n=20); modeling how to use technology (27%, n=18); collaboration among preservice teachers, mentor teachers, and faculty (25%, n=17); practicing technology in the field (19%, n=13); offering mini-workshops (18%, n=12); improving access to software, hardware, and/or support (14%, n=10); and focusing on mentor teachers (13%, n=9).

Most research studies (65%, n=44) have done a good job at clearly describing the strategies used to incorporate technology into their preservice education programs. In addition, the theoretical foundations of these programs are partially (n=30) or fully articulated (n=29) in roughly nine out of every ten studies.

A detailed description of the key characteristics of each of the ten strategies is provided below.

Integrated. An integrated strategy weaves the use of technology in all preservice education courses. There is no single course that teaches basic computer skills. Several prominent organizations have strongly endorsed the integrated philosophy (see Moursund & Bielefeltdt, 1999 or ISTE/NCATE, 2003). Although this approach has been successful in improving confidence (Pope, Hare, & Howard, 2002) and technology skills (Albee, 2003; Pope et al., 2002; Vannatta & Beyerbach, 2000), its main advantage is a focus on meaningful, authentic problem solving where preservice teachers are learning with computers, not about them (e.g., Doering et al., 2003; Halpin, 1999; Milbrath &

Kinzie, 2000). Disadvantages to using this model include the lack of hardware (Vannatta & Beyerbach, 2000), limited faculty expertise and time (Eifler et al., 2001; Vannatta & Beyerbach, 2000; Whetstone & Carr-Chellman, 2001), and the difficulty of transferring what is learned at school to field experience in the classroom (Brush et al., 2003; Eifler et al., 2001; Simpson, Payne, Munro, & Hughes, 1999; Vrasida & McIsaac, 2001).

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

Education faculty. A number of faculties have focused on improving the attitudes, ability, and use of computers by education faculty with the ultimate goal of improving the overall use of technology in preservice education programs (e.g., Davis & Falba, 2002; Eifler et al., 2001; Howland & Wedman, 2004; Seels, Campbell, & Talsma, 2003; Strudler et al., 2003; Thompson et al., 2003; Vannatta & Beyerbach, 2000). The argument is made that if faculty do not buy into the use of technology in education, it is highly unlikely that preservice candidates will be motivated in this endeavor. The advantage of this approach is that a cohesive, coordinated environment can be created to effectively introduce and model technology. It is unclear, however, whether improving faculty attitude and skills actually transfers to preservice teachers' use of technology in the classroom. Creating a strong focus on technology for faculty may be a necessary first step, but other strategies might need to follow.

Single course. Many faculties of education use the single-course strategy to teach technology (Hargrave & Hsu, 2000; Stuhlmann & Taylor, 1999). Typically, a stand-alone course is devoted to teaching a wide range of basic computer skills to all students, although several formats have been used, including content-based (e.g., Doering et al., 2003), project-based (e.g., McRobbie et al., 2000), or process-based (Francis-Pelton, Farragher, & Riecken, 2000; Willis & Sujo de Montes, 2002). Principle advantages of this strategy are that it can improve self-efficacy (Albion, 2001; Gunter, 2001), provide a good overview of the use of technology in teaching (McRobbie et al., 2000) and develop a strong foundation of technology skills (Hargrave & Hsu, 2000; Strudler et al., 2003). Disadvantages observed in using this strategy include learning technology skills in isolation (Gunter, 2001; Whetstone & Carr-Chellman, 2001) and limited extension of skills in the field (Hargrave & Hsu, 2000; Pope et al., 2002; Willis & Sujo de Montes, 2002).

Modelling. The modeling approach involves demonstrating how technology can be used in the classroom and is often combined with an integrated strategy. However, the emphasis with modeling is to provide preservice candidates with concrete examples of how technology can be used in the classroom. The ISTE/NCATE standards (2003) support the use of modeling as an effective approach to teaching technology in preservice education. The clear advantage to using modeling is that it transfers directly to the "real-world" classroom, unlike the single course and integrated strategies (Howland & Wedman, 2004; Marra, 2004). Disadvantages to modeling include the inability of faculty to provide meaningful and effective technology examples (Eifler et al., 2001; Vannatta & Beyerbach, 2000) and preservice teachers not being given the opportunity to construct their own technology-based lessons.

Collaboration. A collaboration strategy involves establishing partnerships among universities, colleges, and public schools to create technology-rich learning experiences. This approach involves developing communities of practice, knowledge repositories, expertise directories, peer and mentor assistance, and best practice examples (Carroll et al., 2003). Placing preservice and inservice teachers in teams to collaboratively identify ways to integrate technology into the curriculum has a number of benefits, including providing opportunities to explore and practice technological applications in a supportive environment, developing positive relationships between local public schools and the university, and increasing the comfort level of using technology (Dawson & Norris, 2000; Thompson et al., 2003). The key challenges of applying this approach are (a) the considerable organization and time needed to develop effective learning communities and (b) the requirement that all parties must be motivated (Carroll et al., 2003; Dawson & Norris, 2000; Thompson et al., 2003). If one part of the community is resistant to the use of technology, the effectiveness of the strategy is compromised (Carroll et al., 2003).

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

Workshops. A number of education faculties use workshops either exclusively or to support other aspects of a technology enhanced program (e.g., Balli et al., 1997; Bashman, Palla, & Pianfetti, 2005; Beyerbach et al., 2001; Collier, Weinburgh, & Rivera, 2004; Seels et al., 2003). The idea is that short, focused seminars or labs can help preservice teachers and faculty in key areas. Within a workshop other strategies can be used, including modeling, integrating technology with specific teaching activities, and creating artifacts for digital portfolios. If this strategy is used instead of a single technology course, it could save time;

however, some computer skills might be sacrificed. As well, the long-term effect of a workshop on preservice teachers' attitudes and use in classroom has yet to be established.

Access. This strategy addresses the access that preservice teachers have to software, hardware, and support. For example, some programs provide preservice students with laptops and software (e.g., Kay & Knaack, 2005; Pierson & McNeil, 2000). Other programs offer "technology on wheels" to be used in the classroom and in the field (Wright, Wilson, Gordon, & Stallworth, 2002). Still others provide extensive technological support for faculty and preservice teachers (e.g., Kay & Knaack, 2005; Strudler et al. 2003; Wright et al., 2002). Without key access elements, other strategies are bound to have limited effect. In other words, one can provide technological training and guidance for preservice candidates in a computer lab, but if there is limited access to computers at the university or in the K–12 schools, it is difficult to use the technology in an effective manner. Nonetheless, only a handful of studies used an access strategy (e.g., Howland & Wedman, 2004; Johnson-Gentile, LonBerger, Parana, & West, 2000; Kay & Knaack, 2005; Pierson & McNeil, 2000; Strudler et al. 2003; Thompson et al., 2003; Wright et al., 2002) to improve preservice technology education programs. It should be noted that providing software, hardware, and support is critical, but other strategies will have to come into play if technology is to be used in a meaningful and effective manner.

Mentor teachers. This strategy is typically used with the collaborative approach; however, special emphasis is placed on the relationship between the preservice and mentor teacher who work together to produce meaningful use of technology (e.g., Aust, Newberry, O'Brien, & Thomas, 2005; Bullock, 2004; Dawson & Norris, 2000, Doering et al., 2003; Pierson & McNeil, 2000; Seels et al., 2003; Strudler et al. 2003; Thompson et al., 2003; Wright et al., 2002). The preservice teacher is often guided by the mentor teacher in terms of pedagogy and "real world" experience. The mentor teacher, in turn, is supported by the preservice teacher with respect to the latest technology and software. This strategy, although used sparingly, appears to have considerable potential for promoting effective use of technology in the classroom, even though empirical evidence is limited. It also takes less time than the full-collaborative model involving partnerships among faculty, mentor teachers, and preservice candidates.

Combination of strategies. The combined strategy involves using two or more approaches to incorporating technology. For example, modeling/integration, single-course/integration, and integration/community strategies are combinations regularly observed in faculties of education (e.g., Collier et al, 2004; Compton & Harwood, 2003; Smith & Robinson, 2003). Thirty percent (n=21) of all studies evaluated in this paper used only one strategy. More than half (57%, n=39) used two or fewer strategies to help introduce technology to preservice teachers.

Strudler & Wetzel (1999) reported that exemplary colleges of education use a combined strategy for introducing technology and include stand-alone technology courses, integration of technology in subject areas, and assimilation of technology in student field experiences. The challenge of using this strategy is that it requires considerable organization, time, training, and design.

A principal components analysis was done to explore whether certain combinations of the ten strategies examined in this paper were evident. Because all communalities were above 0.4 (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 (0.546) and Bartlett's test of sphericity (p <.001) indicated that while the sample size was small (n=68), it was acceptable.

Based on the point of inflexion on the scree plot, Eigenvalues set over one, and accepting factor loadings of .4 or greater, the principal components analysis extracted four patterns of strategy use. (See Table 1, page 392.) First, collaboration, mentor teachers, field-based, and access strategies tend to be applied together. Second, integration of technology is typically coupled with an emphasis on faculty training and the absence of a single technology course. Another way of interpreting this factor is that if a single technology course is offered, faculty training and the integration of technology in other courses may be considered unnecessary. Third, workshops and multimedia strategies appear to be used together. Finally, the modeling strategy stood on its own, statistically disconnected from any of the other strategies. Although less than half of the studies used multiple strategies, there is evidence that a number of programs systematically attempted to combine methods of including technology in preservice education.

Effect of Strategies

It is challenging to assess the effect of specific strategies used to introduce technology to preservice teachers because of the numerous methodological limitations noted above: small samples, poor population and program descriptions, an absence of formal analysis, limited reporting of reliability and validity estimates, neglecting to look at individual differences, and a narrow range of outcome measures. Only 14 studies emerged as reasonable models based on the following two characteristics: (a) reliability estimates for data collection measures and (b) formal experimental or pre-post analysis. (See Table 2, page 393.) These studies will be used to offer a preliminary evaluation of strategies used to implement technology into preservice education.

Several descriptive observations can be made of the data displayed in Table 2. First, 64% (n=9) of the studies showed a significant increase in computer attitude, 50% (n=7) showed a significant increase in computer ability, and 21% (n=3) showed a significant increase in computer use. It is important to note that when attitude, ability, or use did not show significant gains it was because the authors, with one exception (Snider, 2003), chose not to examine those variables. Second, the three studies that reported significant increases in computer use employed four or more strategies. One cannot make any strong conclusions, but there is some support for using a combined approach to incorporating

Table 1: Varimax Rotated Factor Loadings on Strategies Used to Incorporate Technology

Strategy	Factor 1	Factor 2	Factor 3	Factor 4
Collaboration	.87			
Mentor teacher	.77			
Field based	.69			
Access	.61			.45
Single Course		-.78		
Integrated		.77		
Faculty		.40	.48	
Multimedia			.77	
Workshops			.77	
Modeling				.88

FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
1	2.42	24.2	24.2
2	1.56	15.6	39.8
3	1.44	14.4	54.2
4	1.08	10.8	65.2

technology into preservice education. Third, although these studies are the best quantitative examples in this review paper, they are far from exemplary. Most of the methodological problems reported in the larger sample apply to this subset. In addition, only one study (Strudler et al., 2003) used qualitative methods to support the quantitative survey data.

Implications for Education

After reading, coding, analyzing, and evaluating the 68 studies for this paper, one conclusion is irrefutable. Extensive time and money has been spent developing strategies and programs to help preservice teachers use technology effectively. A number of elaborate, theory-driven blueprints have been collaboratively crafted to address the technology needs of preservice teachers, faculty, mentor teachers, and students (Beyerbach et al., 2001; Gillingham & Topper, 1999; Howland & Wedman, 2004; Johnson-Gentile et al., 2000; Pierson & McNeil, 2000; Seels et al., 2003; Strudler et al., 2003; Thompson et al., 2003; Wright et al., 2002). It is unfortunate that many of the authors of these programs have not put the same effort into systematically evaluating their effect on education.

Consequently, it would be irresponsible to provide any strong recommendations with respect to which strategies work and how well. When more thorough research is done, it appears that the strategies used have a significant and positive effect on preservice teachers' computer attitudes, ability, or use. Furthermore, there is some indication that increasing the number of strategies leads to increases in computer use in the classroom, which in the long run is the ultimate goal.

Table 2: Top Quantitative Studies in Technology and Preservice Education

Authors	Survey	Qual*	TL*	Size	Program Desc.	Model Desc.	Tot. Strat.	Theory	Att. Chng.	Abil. Chng.	Use Chng.
Albion (2001)	Yes	No	Elem	89	No	Partial	2	Part	Yes	Yes	NE[2]
Collier et al. (2004)	Yes	No	Elem	43	No	Yes	2	Yes	NE	Yes	NE
Ertmer et al. (2003)	Yes	No	NR[1]	69	No	Yes	2	Yes	Yes	NE	NE
Gunter (2001)	Yes	No	NR	171	No	Yes	2	Partial	Yes	NE	NE
Howland & Wedman (2004)[3]	Yes	No	NR	21	Partial	Yes	5	Yes	Yes	Yes	Yes
Kay & Knaack (2005)[3]	Yes	No	Mix	52	Yes	Yes	4	Yes	Yes	Yes	Yes
Luan et al. (2003)	Yes	No	NR	102	No	Partial	1	Partial	Yes	NE	NE
Peters et al. (1995)	Yes	No	NR	17	No	Yes	1	Yes	Yes	Yes	NE
Snider (2003)	Yes	No	NR	66	Partial	Yes	2	Yes	No	Yes	NE
Strudler et al. (2003)[3]	Yes	Yes	NR	273	No	Yes	6	Yes	NE	NE	Yes
Vannatta & Beyerbach (2000)	Yes	No	Mix	122	No	Yes	3	Yes	NE	Yes	NE
Wang (2002)	Yes	No	NR	74	No	Partial	1	Partial	NE	NE	NE
Wang et al. (2004)	Yes	No	NR	280	Partial	Yes	2	Yes	Yes	NE	NE
Yildirim (2000)	Yes	No	NR	114	No	Yes	1	No	Yes	NE	NE

[1] *NR – Not Reported*
[2] *NE – Not Examined*
[3] *More than 4 strategies used*

Finally, a guiding model, based on a number of well-developed programs reported in this paper (e.g., Beyerbach et al., 2001; Gillingham & Topper, 1999; Howland & Wedman, 2004; Johnson-Gentile et al., 2000; Pierson & McNeil, 2000; Seels et al., 2003; Strudler et al., 2003; Thompson et al., 2003; Wright et al., 2002), is presented in Figure 1. The dynamics of this model include several critical and interactive components.

First, good access to software, hardware, and support is necessary in the university classroom and in the field placement. If you do not have adequate access in either area, it is unlikely that the other strategies will work. Second, regardless of whether the strategy is single-course, workshop, integration, multimedia-based, or a combination, it is important that every effort be made to model and construct authentic teaching activities. Although a number of leading organizations have strongly endorsed an integrated approach (e.g., Moursund & Bielefeltdt, 1999 or ISTE/NCATE, 2003), the empirical evidence supporting one strategy over another is lacking at this point. Third, collaboration among preservice teachers, faculty, and mentor teachers is ideal; however, partnerships between preservice and mentor teachers may work just as well. Without collaboration involving the mentor teacher, it seems unlikely that gains in attitude and ability will translate to meaningful use of technology.

Recommendations for Future for Research

First and foremost, future researchers of preservice technology in education need to include the following six elements in their investigations:

1. a clear description of the sample including, as the minimum, number of students, age, gender, and teaching level
2. a comprehensive description of the education program including number of years of study, number of students, and organization of the program with respect to the use of technology
3. reliability and validity estimates of any data collection instruments used
4. both qualitative and quantitative data

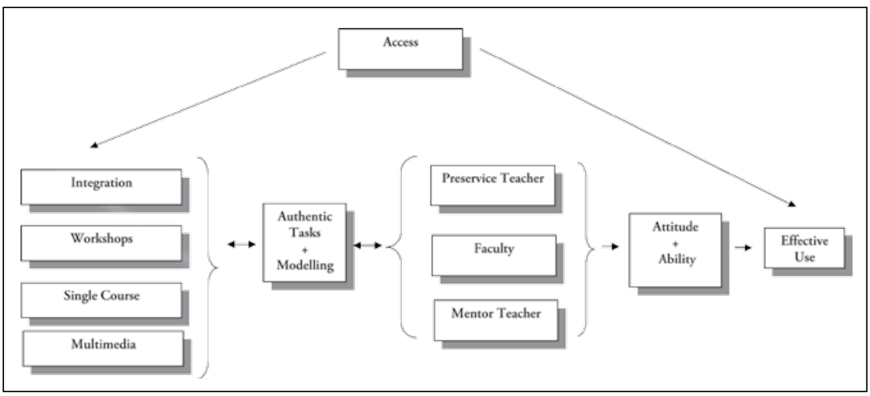

Figure 1. Guiding model for incorporating technology into preservice education

5. formal analysis of individual differences if the sample size is large enough, and
6. measures that look at attitude, ability and use in the same study.

A sensible starting point is to examine the exemplar programs noted earlier (e.g., Beyerbach et al., 2001; Gillingham & Topper, 1999; Howland & Wedman, 2004; Johnson-Gentile et al., 2000; Pierson, 2000; Seels et al., 2003; Strudler et al., 2003; Thompson et al., 2003; Wright et al., 2002). Good theory and structure is the foundation of any good program. It would also be beneficial to look at research practices in the 14 quantitative studies (see Table 2) already investigated in this article. Although these studies have flaws, the research designs are reasonably solid.

It is critical to address the methodological concerns noted above in order to build a coherent understanding of how to guide preservice teachers in the use of technology. Without these key changes, researchers, administrators, and educators will continue along a rudderless path of using technology in education.

Summary

This article offered a detailed analysis of 68 studies examining the use of technology in preservice education. Although some solid, thoughtful technology-based programs have been developed, only a handful of studies have carefully and rigorously pursued the evaluation process. The jury is still out on which strategies work best, although there is some preliminary evidence to suggest that multiple strategies work well with respect to use of computers by preservice teachers in the classroom. In order to build a more coherent knowledge base in technology and preservice education, there is a obvious mandate for more thorough analysis that includes a clear description of the sample and program being evaluated, reliable and valid measures to collect data, and a broader focus that looks at changes in computer attitudes, ability, and use.

Contributor

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APPENDIX A

Details of Studies Reviewed

Authors	Survey	Rel*	Qual*	TL*	Size	Program Desc.	Model Desc.	Tot. Strat.	Theory	Data Anal.	Att. Chng.	Abil. Chng.	Use Chng.
Albee (2001)	Yes	No	No	Elem	57	Partial	Partial	1	No	Form[4]	No	Yes	No
Albion & Gibson (2000)	Yes	No	No	NR[1]	14	No	Yes	1	Yes	Desc[2]	No	No	No
Albion (2001)	Yes	Yes	No	Elem	89	No	Partial	2	Part	Form	Yes	Yes	No
Albion (2003)	No	No	No	NR	0	No	Yes	1	Yes	None	No	No	No
Aust et al. (2005)	Yes	Yes	Yes	Mix	244	No	Yes	4	Yes	Form	No	No	No
Balli et al. (1997)	No	No	Yes	Mix	285	No	Yes	3	Part	Perc[3]	No	No	No
Bartlett (2003)	No	No	Yes	Elem	26	Yes	Partial	1	Part	Perc	No	No	No
Basham et al. (2005)	Yes	No	No	NR	34	Partial	Yes	4	Part	Form	No	Yes	No
Beyerbach et al. (2001)	Yes	No	Yes	NR	60	No	Yes	5	Yes	Form	No	Yes	No
Blocher et al. (2003)	No	No	Yes	NR	1	No	Partial	1	Part	Desc	No	No	No
Brush et al. (2003)	Yes	Yes	Yes	Elem	100	Partial	Yes	4	Part	Perc	No	No	No
Bucci (2003)	No	No	Yes	Elem	21	No	Yes	1	No	Perc	No	No	No
Bullock (2004)	No	No	Yes	MS	2	No	No	2	Part	Desc	No	No	No
Cherup & Snider (2003)	No	No	No	NR	0	No	Yes	1	Yes	None	No	No	No
Clift et al. (2001)	Yes	No	Yes	Mix	0	No	Yes	2	Part	Desc	No	No	No
Collier et al. (2004)	Yes	Yes	No	Elem	43	No	Yes	2	Yes	Form	No	Yes	No
Compton & Harwood (2003)	No	No	No	NR	0	No	Yes	2	Yes	Desc	No	No	No

APPENDIX A, CON'T

Authors	Survey	Rel*	Qual*	TL*	Size	Program Desc.	Model Desc.	Tot. Strat.	Theory	Data Anal.	Att. Chng.	Abil. Chng.	Use Chng.
Davis & Falba (2002)	Yes	No	Yes	Elem	101	No	No	2	Part	Desc	No	No	No
Dawson & Norris (2000)	No	No	Yes	NR	16	Partial	Yes	4	Partial	Desc	No	No	No
Dexter & Riedel (2003)	Yes	No	No	Mix	201	Partial	Partial	3	Partial	Perc	No	No	No
Doering et al. (2003)	No	No	Yes	NR	10	Partial	Partial	3	No	Desc	No	No	No
Doty & Hillman (2000)	No	No	No	NR	0	No	Partial	4	No	Desc	No	No	No
Eifler et al. (2001)	No	No	Yes	Fac	12	Partial	No	2	Partial	Perc	No	No	No
Ertmer et al. (2003)	Yes	Yes	No	NR	69	No	Yes	2	Yes	Form	Yes	No	No
Evans & Gunter (2004)	Yes	No	No	NR	40	No	Partial	3	Partial	Perc	No	No	No
Flores et al. (2002)	No	No	No	Sec	0	Yes	Yes	3	Yes	None	No	No	No
Francis-Pelton et al. (2000)	No	No	No	NR	0	No	Yes	2	Partial	None	No	No	No
Gibson (2002)	No	No	No	Elem	18	No	Yes	3	Yes	Perc	No	No	No
Gillingham & Topper (1999)	No	No	No	NR	0	No	Yes	5	Yes	None	No	No	No
Gimbert & Zembal-Saul (2002)	No	No	Yes	Elem	0	No	Yes	3	Partial	Desc	No	No	No
Gunter (2001)	Yes	Yes	No	NR	171	No	Yes	2	Partial	Form	Yes	No	No
Halpin (1999)	Yes	Yes	No	Elem	73	Partial	Yes	1	Partial	Perc	No	No	No
Hattler (1999)	No	No	No	NR	0	No	Yes	1	Yes	None	No	No	No
Howland & Wedman (2004)	Yes	Yes	No	NR	21	Partial	Yes	5	Yes	Form	Yes	Yes	Yes

Authors	Survey	Rel*	Qual*	TL*	Size	Program Desc.	Model Desc.	Tot. Strat.	Theory	Data Anal.	Att. Chng.	Abil. Chng.	Use Chng.
Johnson-Gentile & Lon-Berger (2000)	Yes	No	No	Elem	0	Partial	Yes	5	Partial	Perc	No	No	No
Kariuki & Duran (2004)	No	No	No	NR	22	No	Yes	2	Yes	None	No	No	No
Kay & Knaack (2005)	Yes	Yes	No	Mix	52	Yes	Yes	4	Yes	Form	Yes	Yes	Yes
Krueger et al. (2004)	Yes	No	No	Fac	0	No	Yes	3	Yes	Perc	No	No	No
Lohr et al. (2003)	Yes	Yes	No	NR	570	No	Yes	3	Partial	Desc	No	No	No
Luan et al. (2003)	Yes	Yes	No	NR	102	No	Partial	1	Partial	Form	Yes	No	No
Maeers et al. (2000)	No	No	No	Elem	0	No	Yes	2	Yes	Desc	No	No	No
McRobbie et al. (2000)	No	No	Yes	Elem	21	Partial	Yes	2	Partial	Desc	No	No	No
Milbrath & Kinzie (2000)	Yes	No	No	NR	42	Yes	Partial	2	No	Form	Yes	No	No
Mullen (2001)	No	No	Yes	NR	4	No	Partial	1	Partial	Desc	No	No	No
Niess (2001)	No	No	No	NR	0	Partial	Yes	1	Partial	None	No	No	No
O'Reilly (2003)	Yes	No	Yes	NR	18	Partial	Partial	1	Partial	Perc	No	No	No
Peters et al. (1995)	Yes	Yes	No	NR	17	No	Yes	1	Yes	Form	Yes	Yes	No
Pierson & McNeil (2000)	No	No	No	NR	0	Yes	Yes	9	Yes	None	No	No	No
Pope et al. (2002)	Yes	No	No	Elem	26	No	Yes	2	Partial	Form	Yes	No	No
Rowley et al. (2005)	Yes	No	No	NR	0	No	Yes	3	Yes	Perc	No	No	No
Sahin (2003)	Yes	No	No	Elem	80	No	No	1	Yes	Perc	No	No	No
Seels et al. (2003)	Yes	No	Yes	NR	98	Partial	Yes	5	Yes	Perc	No	No	No
Shoffner et al. (2001)	Yes	No	No	MS	0	No	Yes	3	Yes	Desc	No	No	No

APPENDIX A, CON'T

Authors	Survey	Rel*	Qual*	TL*	Size	Program Desc.	Model Desc.	Tot. Strat.	Theory	Data Anal.	Att. Chng.	Abil. Chng.	Use Chng.
Simpson et al. (1999)	Yes	No	No	Mix	243	No	No	1	Partial	Perc	No	No	No
Simpson et al. (1998)	Yes	No	No	Mix	1313	Yes	No	0	No	Perc	No	No	No
Smith & Robinson (2003)	No	No	Yes	Spec	1	No	Partial	2	Partial	Desc	No	No	No
Snider (2003)	Yes	Yes	No	NR	66	Partial	Yes	2	Yes	Form	No	Yes	No
Stuhlmann & Taylor (1999)	No	No	Yes	Elem	4	No	Partial	4	No	Desc	No	No	No
Strudler et al. (2003)	Yes	Yes	Yes	NR	273	No	Yes	6	Yes	Form	No	No	Yes
Thompson et al. (2003)	No	No	Yes	Elem	28	No	Yes	6	Yes	Desc	No	No	No
Vannatta & Beyerbach (2000)	Yes	Yes	No	Mix	122	No	Yes	3	Yes	Form	No	Yes	No
Vrasidas & McIsaac (2001)	No	No	No	NR	0	No	No	3	Yes	None	No	No	No
Wang (2002)	Yes	Yes	No	NR	74	No	Partial	1	Partial	Form	No	No	No
Wang et al. (2004)	Yes	Yes	No	NR	280	Partial	Yes	2	Yes	Form	Yes	No	No
Wang & Holthaus (1998–99)	Yes	No	No	Elem	64	No	Partial	1	No	Perc	No	No	No
Wilkerson (2003)	No	No	No	NR	0	No	Yes	1	Partial	None	No	No	No
Wright et al. (2002)	No	No	Yes	Sec	10	Partial	Partial	6	Partial	Desc	No	No	No
Yildirim (2000)	Yes	Yes	No	NR	114	No	Yes	1	No	Form	Yes	No	No

[1] *NR – Not Reported*
[2] *Desc – Descriptive Data Only*
[3] *Perc – Percentages Reported*
[4] *Form – Formal Statistics (e.g., t-test, ANOVA, correlations)*

APPENDIX B

Variables and Criteria Used to Code Studies

Variable	**Description**	**Scoring Criteria**
METHODOLOGY		
Sample Size	Number of preservice teachers	0 – None or not reported Otherwise report actual number of subjects
Teaching Level	Teaching level for preservice teachers	0 – Not reported 1 – Elementary 2 – Middle School 3 – Secondary 4 – Mixed 5 – Special Education 6 – Faculty
Description of Program	Was a clear description of the program provided (e.g., number of years, focus of program, structure)	0 – Not provided 1 – Partially (number of years left out) 2 – Yes
Data Collection (survey)	Was a survey used?	0 – No 1 – Yes
Data Collection (qualitative)	Were qualitative methods used (e.g., interview, journals, essays, observations)	0 – No 1 – Yes
Individual differences	Were individual differences (e.g., gender, teaching level, age) assessed?	0 – No 1 – Yes

Variable	**Description**	**Scoring Criteria**
STRATEGY		
Single Course	Was there a single course dedicated to teaching technology?	0 – No 1 – Yes
Workshops	Were workshop(s) used to teach technology?	0 – No 1 – Yes
Integrated	Was technology integrated throughout the teacher education program?	0 – No 1 – Yes
Modeling	Was the use technology modeled for preservice students?	0 – No 1 – Yes

APPENDIX B, CON'T

Variable	Description	Scoring Criteria
Multimedia	Was multimedia (e.g., portfolios, online learning, video case studies) used to teach technology?	0 – No 1 – Yes
Collaborative	Was there collaboration among preservice teachers, education faculty, and mentor teachers to use technology?	0 – No 1 – Yes
Field Based	Did preservice teachers practice the use of technology in the classroom?	0 – No 1 – Yes
Faculty	Did the technology program focus on improving faculty use of technology?	0 – No 1 – Yes
Mentor Teachers	Did the technology program focus on improving mentor teacher's use of technology?	0 – No 1 –Yes
Access	Did the technology program focus on access to software, hardware, and/or technological support?	0 – No 1 – Yes
Theory behind Strategies	Was the theory behind using specific strategies used to incorporate technology based on sound theory?	0 – Not provided 1 – Partially 2 – Yes
Description of Strategies	Was there a clear, coherent description of the strategies used to incorporate technology into the teacher education program?	0 – Not provided 1 – Partially 2 – Yes
EFFECT ON LEARNING		
Computer Attitudes	Did computer attitudes improve as a result of the strategies used to incorporate technology?	0 – No 1 – Yes
Computer Ability	Did computer ability improve as a result of the strategies used to incorporate technology?	0 – No 1 – Yes
Computer Use	Did computer use improve as a result of the strategies used to incorporate technology?	0 – No 1 – Yes