Evaluating Strategies Used to Incorporate Technology into Preservice Education

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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. The use of these strategies was evaluated based on impact 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 impact on preservice teacher's use of computers appeared to be more pervasive. Third, most research examined attitudes or ability or use, but rarely all three. Fourth, and perhaps most importantly, 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 need to fully understand and evaluate the impact of key technology strategies in preservice teacher education.

Evaluating Strategies Used to Incorporate Technology into Preservice Education

Background

In the past 10 years, there has been considerable focus on the impact of technology on student learning. Some researchers have argued that computers have had a minor or negative impact on student learning (e.g., Cuban, 2001; Roberston, 2003; Russell, Bebell, O'Dwyer, & O'Connor, 2003; Waxman, Connell, & Gray, 2002). On the other hand, several 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, however these gains were dependent on subject area (Kulik, 1994), type of software used (Sivin-Kachala, 1998), specific student population, software design, educator role, and level of student access (Sivin-Kachala, 1998). Success with respect to technology and education is clearly a complex issue, but one that preservice teachers will have to address.

Educational policy specialists and administrators have made a concerted effort to increase the presence of technology in classrooms, specifically focusing on student-to-computer ratio, high speed Internet access, and preservice teacher education. According US Department of Education, National Center for Education Statistics (2002), the average student-to-computer ratio in 2001 was 5.4 to 1, a significant increase from the 12:1 ratio reported in 1998. Furthermore, 99% of all public schools now have access to the Internet with 94% having high-speed broadband connections (US Department of Education, National Center for Education Statistics, 2002). Other countries have reported similar efforts to promote technology access in the classroom (McRobbie, Ginns, & Stein, 2000; Compton & Harwood, 2003; Plante & Beattie, 2004). Coupled with the rapid increase in hardware and Internet access is a push toward infusing technology into preservice education programs. A multitude 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 influenced policy and set comprehensive standards with respect to technological use in teacher preparatory programs. It is reasonable to conclude, then, that the "technological" environment has been firmly established for preservice teachers to use technology in the classroom.

If we accept that thoughtful use of technology in certain contexts can have a significant and positive impact on student learning, teacher education is a reasonable place to start with respect to integrating technology into education, especially when there appears to be relatively strong infrastructure that supports computer use. However, there is some evidence to suggest that preservice education programs are not preparing new teachers to use technology effectively (CEO Forum on Education and Technology, 2000; Moursund & Bielefeltdt, 1999; OTA, 1995; US Department of Education, 2000; Yildirim, 2000). In fact, there are a number of obstacles that prevent successful implementation of computers including a lack of time (Eifler, 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 (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 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.

Research Problem

Numerous teacher education programs have made extensive efforts to implement and advance 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.

Purpose

The purpose of this paper is to identify, describe and evaluate strategies used incorporate technology into preservice education.

Method

Data

A comprehensive search of the literature was done based on two criteria. First., all articles had to be from refereed journals. Second, the focus of these articles had to be on incorporating technology into preservice education. See Appendix A for a complete list of articles included in the review.

Data Analysis

Each study reviewed was evaluated in terms of method, strategies used, and the impact 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 is 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 impact of the strategies used was determined by the reported changes in preservice teachers' computer attitudes, ability and/or use. Appendix B 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 only 14 studies used reliable data collection methods combined with formal statistics.

Results & Discussion

Methodology Used in Reviewed Studies

Sample Size. Sample size varied from 0 to 1313 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. While there are no clear guidelines to determine optimum sample size, a minimum of 50-100 subjects has been proposed by Fraenkel & Wallen (2003) as a rule of thumb. **Given the cost in time and money of a 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, over 50% of the studies examined (n=35) failed to report specific teaching level. Just over 25% (n=18) of all studies looked at elementary preservice teachers and about 10% (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, 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 with programs that have a large number of students. Science and math preservice teachers might adapt more quickly to technology than their social science counter parts. These kind of speculations can not be addressed by reviewing the studies in this paper, because over 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 was 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 & qualitative methods was employed only 12% of the time. **If surveys are used it is advised provide reliability and validity details to ensure the data is accurate. 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 computers attitudes (56%, n=38). Computer use, on the other hand, was looked at in only one third of the studies examined (n=23). Just over on third (n=24) of all studies used more than one dependent variable and only 4 articles (6%) looked at ability, attitude, and use. **Multiple dependent variables are recommended for future research in order 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 in to meaningful technological interactions in the classroom.**

Individual differences. Only 10 (n=7) percent of the studies examined in this paper looked at individual differences among preservice teachers' computer attitudes, ability, or use. However, differences in computer related behaviours have been observed with respect to gender (see Kay, 1992 for a review of the literature), SES (e.g., Becker and Ravitz, 1999; Nolan, 1992; Shashaani, 1994) and culture (Evans, 1995; Hoffman and Novak, 1998; Wilkinson, Buboltz, Cook, Matthew, and 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 impact 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). While 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 employ a pre-post test or experimental design to assess the impact of various strategies on introducing technology to preservice teachers.**

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). While 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, Hughes, & Huffman, 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 , 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, yet 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., David & Falba, 2002; Eifler, Greene, & Carroll, 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, though, 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, 2001; 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, 2001; 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, 2001; Pope, Hare, & Howard, 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 (2003) supports 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 in-service teachers in teams to collaboratively identify ways to integrate technology into the curriculum has a number of benefits including providing opportunities to explore and 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, while highly recommended by the ISTE/NACTE (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 exclusively or to support other aspects of a technology enhanced program (e.g., Balli, Wright, & Foster, 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 impact of a workshop on preservice teachers' attitudes and use in classroom has yet 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, in press; Pierson, 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, in press; Strudler et. al. 2003; Wright et. al., 2002). Without key access elements, other strategies are bound to have limited impact. In other words, you can provide extensive training and guidance, but if there is limited access to computers, the technology will not be used. Nonetheless, only a handful of studies used an access strategy (e.g., Howland & Wedman, 2004; Johnson-Gentile & LonBerger, 2000; Kay & Knaack, in press; Pierson, 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, 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 latest technology and software. This is a strategy, while used sparingly, appears to have considerable potential for promoting effective use of technology in the classroom, although empirical evidence is equally sparse. 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. Over 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 factor analysis on the ten key strategies in this paper revealed four combination patterns. 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 a de-emphasis on using a single course. Third, workshops and multimedia strategies tend to be applied together. Finally, the modeling strategy stands on its own, statistically disconnected from any of the other strategies. While less than half of the studies use multiple strategies, there is evidence that a number of programs systematically attempted to combine methods of including technology in preservice education.

Impact of Strategies

It is challenging to assess the impact 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 1). These studies will be used to offer a preliminary evaluation of strategies used to implement technology into preservice education.

Insert Table 1 about here.

Several descriptive observations can be made of the data displayed in Table 1. First, 64% (n=9) of the studies showed a significant increase in computer attitude, 50% (n=7) significant increase in computer ability, and 21% (n=3), 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 chose not to examine those variables with one exception (Snider, 2003). 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 technology into preservice education. Third, while these studies are the best quantitative examples in this review paper, they are far from exemplar. 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 blue prints 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 & LonBerger, 2000; Pierson, 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 impact on education.

Consequently, it would be irresponsible to provide any strong recommendations with respect to which strategies work and how well. When more careful 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 number of strategies leads to increases in computer use in the classroom which, in the long run, is the ultimate goal.

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 & LonBerger, 2000; Pierson, 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 of 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. While 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 silent 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.

Insert Figure 1 about here.

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

A sensible starting point is to examine the exemplar programs noted early (e.g., Beyerbach et. al., 2001; Gillingham & Topper, 1999; Howland & Wedman, 2004; Johnson-Gentile & LonBerger, 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 paper. While 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 teacher sin 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 paper offered a detailed analysis of 68 studies examining the use of technology in preservice education. While some solid, thoughtful technology-based programs have been developed, only a handful of studies have carefully and rigorously pursued the evaluations 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 computer by preservice teachers in the classroom. In order to build a more coherent knowledge base in technology and preservice education there is a clear mandate for more thorough analysis which 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.

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Figure 1. Guiding Model for Incorporating Technology into Preservice Education

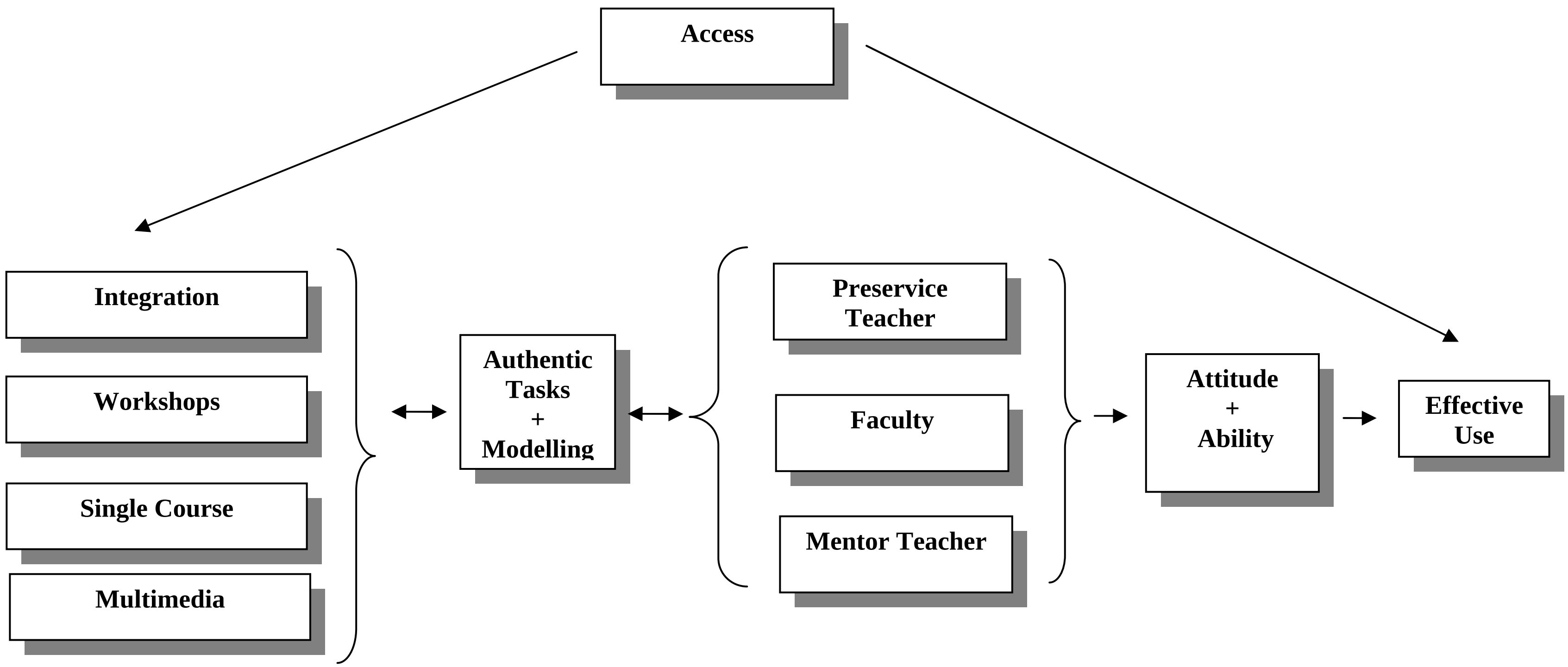

Table 2

Varimax Rotated Factor Loadings Strategies Used to Incorporate Technology

Strategy	Factor 1	Factor 2	Factor 3	Factor 4
Collaboration	.87			
Mentor teacher	.77			
Field based	.69			
Access	.61			
Single Course		-.78		
Integrated		.77		
Faculty		.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

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)	Yes	No	NR	21	Partial	Yes	5	Yes	Yes	Yes	Yes
Kay & Knaack (in press)	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)	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

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
Bashman 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
Davis & Falba (2002)	Yes	No	Yes	Elem	101	No	No	2	Part	Desc	No	No	No

Authors	Survey	Rel*	Qual*	TL*	Size	Program Desc.	Model Desc.	Tot. Strat.	Theory	Data Anal.	Att. Chng.	Abil. Chng.	Use Chng.
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
Johnson-Gentile & LonBerger (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 (in press)	Yes	Yes	No	Mix	52	Yes	Yes	4	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.**
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 (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
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

Authors	Survey	Rel*	Qual*	TL*	Size	Program Desc.	Model Desc.	Tot. Strat.	Theory	Data Anal.	Att. Chng.	Abil. Chng.	Use Chng.
Snider (2003)	Yes	Yes	No	NR	66	Partial	Yes	2	Yes	Form	No	Yes	No
Strudler et.al. (2003)	Yes	Yes	Yes	NR	273	No	Yes	6	Yes	Form	No	No	Yes
Stuhlmann & Taylor (1999)	No	No	Yes	Elem	4	No	Partial	4	No	Desc	No	No	No
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 & Holthaus (1998-99)	Yes	No	No	Elem	64	No	Partial	1	No	Perc	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
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
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

Variable	**Description**	**Scoring Criteria**
IMPACT 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