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The Effects of a Constructivist Intervention on Pre-Service Teachers

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Abstract

The purpose of this study was to determine the effect of pre-service teachers' participation in a constructivist intervention supported by technology on their confidence in their own ability to plan and create six technology-supported, constructivist, learning activities, as well as to understand their perceptions of the experience.

Participants were 23 pre-service teachers accepted into the College of Education's Masters program at the University of Tennessee Knoxville and enrolled in an introduction to instructional computing course during the summer of 2001.

A survey was used to assess pre-intervention confidence levels and experience with six technology-supported, constructivist, learning activities. Students were then situated in a class that employed constructivist methodology to facilitate their own exploration of constructivist pedagogy supported by technology. Once students completed the class, they were asked to re-take the survey. A paired samples t-test was used to compare pre-intervention confidence levels with post-intervention confidence levels. The results revealed a significant difference, $p \leq .001$, in each of the six areas.

Journals, focus groups, and interviews were used to gain insight into the participants' perceptions of the experience and suggested a reflective process.

Keywords
Technology, Teacher education, Educational technology, Constructivism

Introduction

As early as 1983, partially in response to *A Nation at Risk* (The National Commission on Excellence in Education, 1983), educators began to look for ways to resolve lagging student performance, including the use of computers and technology. Efforts nationally to advocate and promote the dissemination and use of instructional technology have included Congress' passage of the *Technology for Education Act of 1994*, which asserted technology's value as a critical instructional tool and prompted the development and adoption of many national and state technology plans; and the creation of The Department of Educational Technology to oversee and guide the infusion of technology into educational systems. Since 1995, over $8 billion has been allocated in federal funds alone to assist in integrating computers into education. In one year, 1999-2000, educational technology in K-12 received over $5.67 billion in state and local funds. Due in part to these incentives, the percentage of schools with microcomputers has increased dramatically, from only 30% in 1982 to over 98% in 2000 (Market Data Retrieval, 2000). Over 94% of schools are connected to the Internet, and over 80% of teachers have Internet access in their classrooms (Market Data Retrieval, 2000). Also, the student-to-computer ratio has decreased from 125-to-1 in 1981, to approximately 5-to-1 in 2000 (Market Data Retrieval, 2000). "On the average schools offer 19 hours of technology-related professional development" per year (Market Data Retrieval, 2001).

Problem 1: Inadequate technical preparation

However, counting computers and Internet connections does little to address the more important question of how– and even whether–educators are using technology. In general, educators have not adopted technology as an instructional tool. At the Secretary's Conference on Educational Technology, Goldman, Cole, and Syer (1999) noted while applications such as spreadsheets, simulations, CAD systems, or multimedia software are often used for limited tasks like word processing, they are rarely used for content learning. A 1998 report from the Office of Technology Assessment (OTA) found that fewer than half of all teachers were using computers in their teaching, despite beliefs about their effectiveness and desires to use them.

A report by Scheffler & Logan (1999) suggests a reason for this gap between beliefs and practices: although most of the teachers surveyed expressed the belief that technology is a valuable and important teaching tool, fewer than 20% felt adequately prepared to integrate technology into the curriculum. Recent surveys confirm that many practicing teachers do not feel well prepared to integrate technology in instruction (Education Week, 1999; The National Center for Educational Statistics, 1998).

One might hope that the problem of inadequate technical preparation would recede as new teachers enter the profession. According to estimates from the National Council for Accreditation of Teacher Education (NCATE), over two million teachers, comprising over half of the nation's educators, will be hired over the next decade (Education Week, 1999; Gerald & Husser, 1991). NCATE currently requires all teacher education institutions to include technology training in their programs and further emphasizes technology as central to the teacher preparation process (Wise, 1997). By 1999, forty-two states required a course in instructional technology as part of their teacher education programs. Milkin (1999) reports that 70% of teacher training programs require students to take three or more credit hours of technology-focused courses. While these trends appear promising, a more recent survey by Milkin (2001) indicates that pre-service teachers, like their colleagues already in the classroom, are not adequately prepared to integrate technology into their teaching practices (Milken, 2001).

Problem 2: Persistent inadequacy of technology training for new teachers

What can explain the persistent inadequacy of technology training for new teachers? One problem may be that teachers have few good role models. Even when technology is readily available, faculty in teacher education programs often fail to use technology in their own research or teaching. A study by Persichitte, Tharp, and Caffarella (1997) found that only 45% of education program faculty use technologies in their own classes. Further, only 40% of students enrolled in teacher education programs are required to design and deliver instruction using technology. When asked the extent to which they exposed their pre-service teachers to technology in their classes, field experiences, and curriculum materials, the majority of faculty members at 416 teacher preparation institutions disclosed that they generally do not practice or model the use of technology (Milken, 2001). The problem is exacerbated by the fact that many colleges of education do not have technology-enhanced classrooms that would allow faculty to routinely model the use of the Internet and other technologies (Milken, 2001). This is a case of "do as I say, not as I do."

Problem 3: Content of technology courses

Another problem is the content of the technology courses that schools of education mandate for their students. In a 2000 survey, Hargrave and Hsu investigated instructional technology courses at 88 institutions of higher education belonging to the Holmes Group, a national consortium of research institutions "committed to making programs of teacher preparation more rigorous and connected to liberal arts education, research on learning and teaching, and wise practice in schools" (p. 305). Seventy-three percent of the colleges reported offering a specific introduction to instructional technology course. At 60% of these colleges, the course was three credit hours with three contact hours per week. Eighty-three percent of those colleges reported that the course was taught in a lecture and lab format, and no prerequisites were required for enrollment in the course. The primary focus of these courses was computer technology. While over 50% of the institutions reported addressing and using computer-based instruction (packaged software such as drill and practice, tutorials, educational games, problem-solving, and simulations), the majority of the institutions identified classroom design, needs analysis, audience analysis, task analysis, and situated cognition as topics not covered in the courses. Yet, teachers are expected to use technology to provide meaningful student-centered curriculum-oriented learning activities for their students. The question of "how" begs an answer.

Clearly, focusing on technology skills alone does little to move teachers to a point where they can use technology meaningfully in their classrooms. Traditionally, both in-service and pre-service technology training programs have focused on software instead of curriculum, leaving teachers unable to create or implement learning activities that use technology meaningfully (Gilmore, 1995; Moersche, 1995; Moursand & Bielefeldt, 1999; Yildirim, 2000). These skills-based and software-based approaches leave teachers without a clear vision of how technology can improve teaching and learning (Office of Educational Research and Improvement, 1993). Training that focuses on specific technologies or the mechanics of computer technology has little carry-over into classrooms (Beavers, 2001). Urgently needed is a change from a skills-based approach to an approach that incorporates technology seamlessly into subject matter in much the same way that the practical applications of technology have permeated society (Williams & Williams, 1997). Teachers should be introduced to a diverse range of technology and a variety of applications, with a focus on the development of creativity, adaptability and collaborative problem-solving skills (Williams & Williams, 1997). The integration of technology happens when tools are presented in the context of meaningful authentic learning situations, where users can see practical applications, engage in reflective teaching, and share their ideas with others (Spady, 1994; Warner, 1999).

Implications for teaching technology

What are the best practices for teaching technology? Research indicates that teachers whose pedagogical beliefs are consistent with constructivist learning theory are more likely to use technology in their practices. Fisher (1997) surveyed 287 Colorado public school teachers to determine the degree of importance they assigned to 10 technology literacy competencies. These teachers viewed the ability to use constructivist teaching pedagogy supported by technology as the most critical technology competency. Becker (1999) surveyed approximately 2,250 teachers to determine Internet use. As part of the study, Becker examined teachers' pedagogical beliefs and practices in relationship to Internet use. What he found was "the more constructivist the teacher the greater their average use and the more positively they viewed the Internet" (para. 56). Teachers' pedagogical beliefs and understanding of constructivistism are critical factors for determining if and how technology is used to enhance learning.

Evidence supports an approach that is integrated and provides students not simply with a single instructional technology course, but also with methods and elective courses that integrate and model technology throughout the program (Todd, 1993; Wetzel, 1993). Institutions that provide routine opportunities for using technology in everyday classroom and practicum experiences report the highest level of student technology skills (Milken, 2001). Skills and processes are best learned when they are not taught in isolation, but are acquired within the context of accomplishing meaningful tasks (Harel & Papert, 1991). In identifying the single change that transformed San Carlos School in Monterey, California, Adams (2000) points to the application of technologies directly and relevantly to classrooms (job-embedded training): "Our technology center ceased to be viewed as a separate entity and has become an extension of each teachers' classroom. What the technology is being used for comes directly from the classroom curriculum" (p. 116). Calls for job-embedded learning are echoed through the literature (Sparks & Hirsch, 1997).

Drawing on adult learning theory, McKenzie (2001) emphasizes the importance of making the learning experience self-directed, contextual, and relevant both to personal interests/needs and to daily practice. Learning to use technology not only involves the acquisition of computer skills, but also is a process whereby students try, fail, access, evaluate, analyze and apply skills meaningfully (McKenzie, 2001; Scheffler & Logan, 1999). Pre-service teachers judge the potential or usefulness of computing by using a relevancy-irrelevancy dimension (Laffey & Musser, 1998). They want to know how to apply the technology skills in the context of learning and teaching. They tend to view technology as an add-on and rely on external factors and facilitators to infuse technology into their classrooms (Beyerbach, Walsh, & Vannatta, 2001). Technology, therefore, needs to become a personal tool for pre-service teachers, one they use expressively, creatively, meaningfully and purposefully. Teachers who personally use and own computers are likely to feel less anxious about integrating them into their practices (Laffey & Musser, 1998; Hochman, Maurer, & Roebuck, 1993; Kearns, 1992).

Because there are various definitions of the term constructivism, it is important for the researcher to provide a working definition. A constructivist approach "involves having students work on complex projects, often in groups, and often with different groups working on different projects. In this model, students learn skills and concepts in the context of using them to *do* something—for example, in making a project. These projects follow from a

constructivist theory of learning that suggests that subject matter becomes meaningful, and therefore understandable, only when it is *used* in context-rich activities. Teachers whose instructional plan follows from constructivist learning theory not only use group projects more than other teachers; they will, for example, emphasize the student's own responsibility for designing their own tasks, for figuring out their own methods of solving problems, and for assessing their own work —all as a means of making learning tasks more meaningful to students" (Becker, 1999, para. 53). Learning, as such, moves beyond skills that are externally imposed and irrelevant to the learners' lives, to contextual, personally relevant processes of exploration, manipulation of information, and investigation of possibilities (Robyler & Edwards, 2000; Wilson, Teslow, & Osman-Jouchoux, 1999; Jonassen, 1994). Under these assumptions, meaningful learning occurs when the goal of education is to "help students learn how to recognize and solve problems, comprehend new phenomena, construct mental models of those phenomena, and given a new situation, set goals and regulate their own learning" (Jonassen, Peck, & Wilson, 1999, p. 3). Technology, when used in a constructivist manner, becomes a tool that students learn with. Learners use technologies to manipulate data, to explore relationships, to intentionally and actively process information, to construct personal and socially sha
red meaning, and to reflect on the learning process (Jonassen, Peck, & Wilson, 1999).

Purpose of the study

The purpose of this study is to determine the effects of situating pre-service teachers in a constructivist learning environment supported by technology. From the problems discussed above, the following research questions emerge:

- What is the effect of an instructional approach that focuses on constructivist pedagogy supported by technology on pre-service teachers' confidence in their own ability to plan and develop constructivist learning activities supported by technology?
- How do pre-service teachers perceive the experience of participating in an instructional technology course that employs a constructivist pedagogical approach and uses?

Methods and Procedures

Constructivism and adult learning theory provided the conceptual framework for the study and guided the design, execution, and framework for the analysis of data. Using a quasi-experimental approach, this study explores the effect of a constructivist pedagogical intervention on the confidence of pre-service teachers in their own ability to develop constructivist learning activities that use technology to enhance learning as well as the participants' perceptions of the experience.

The participants in the study were 23 pre-service teachers at the University of Tennessee Knoxville (UTK) College of Education's teacher education program who were enrolled in a Summer 2001 course titled *Instructional Technology, Curriculum, and Evaluation 486: Introduction to Instructional Computing (ITCE 486).* To answer the research questions, a variety of methods were used: pre- and post-intervention surveys, journal entries, interviews, and focus groups. Participants were given a pre-intervention survey and asked to rank their confidence in their ability to plan and create various constructivist learning activities supported by technology.

Drawing on constructivism and adult learning theory, the intervention was designed to situate participants in a course that would both model and teach constructivist methods as well as how those methods could be supported by technology. These learning activities were developed with five attributes of constructivist learning in mind: they were active, constructive, intentional, authentic, and cooperative (Jonassen, Peck, and Wilson, 1999). Each of these attributes were defined:

- Active (Manipulation/Observant): Participants "actively [manipulate] the objects and tools of the trade and [observe] the effects of what they have done" (p. 8).
- Constructive (Articulative/Reflective): Participants construct meaning by reflecting on the process and articulating their experiences and conceptual understandings.
- Intentional (Reflective/Regulatory): Participants engaging in intentional learning while trying to achieve a cognitive goal, reflecting, evaluating, and articulating the process, "decisions they make, strategies they use, and the answers they found" (Jonassen, Peck, & Wilson, 1999, p. 9).
- Authentic (Complex/Contextual): Participants engage in learning activities that are complex and contextual.

- Cooperative (Collaborative/Conversational): Participants engage in collaborative activities during which they dialog about a task, the methods they will use to accomplish the task, as well as seeking out alternative ideas and opinions.

An example of a learning activity that met this criteria was to ask elementary science pre-service teachers to become familiar with insects that are native to East Tennessee by spending twenty minutes outside observing insects, taking digital pictures of the insects, documenting the behavior of the insects, and researching the insects online or using field guides. From these data, *elementary* science pre-service teachers were asked to draw conclusions about insects in East Tennessee and then sharing their findings with the class via a slideshow presentation (see Appendix A). Similarly, secondary art pre-service teacher were ask to investigate the relationship between form and function in architecture by exploring campus buildings with unique designs, documenting those designs with a digital video camera, and finding out the use of the building by walking around in the building and taking field notes. Students were then asked to draw conclusions about form and function of building and asked to create a slideshow presentation using the pictures they had taken to support their conclusions (Appendix B). It was from this framework that students both explored learning strategies and the use of technology to support learning. It was during activities such as these that students acquired technology skills—within the context of using them. The emphasis of these activities was always on exploring content or concepts. For each of the technologies (web-based inquiry, slideshows, database, and spreadsheets) similar learning activities were developed by the researcher for each grade level and subject area of the pre-service teachers. These are identified as integrated constructivist learning activities aligned to curriculum standards supported by technology.

Once students completed these learning activities in teams, individually they developed their own *learning* activities that were aligned to curriculum standards, fit within an interdisciplinary unit theme, that were designed to engage learners in similar constructivist learning activities. Through their work on a series of activities, students produced an interdisciplinary thematic curriculum-based instructional unit that contained a series of constructivist lessons supported by those technologies (listed above).

After participating in this course, (see Table 1 note for activities), they were given a post-intervention survey and again asked to rank themselves in the same areas, in order to determine the effect of the intervention. The surveys used a five-point Likert Scale, and were developed by the researcher using technology standards set by the International Society for Technology in Education's (ISTE) National Educational Standards (NETS): Professional Preparation Profile (ISTE, 2000) as well as course goals developed collaboratively during team meetings Fall semester 2000 and Spring semester 2001 by instructors of the course. A two-sample paired t-test was used to analyze the difference in pre-intervention and post-intervention results. Because one of the goals of this study was to give a voice to pre-service teachers situated in a course that used constructivist methodology as well as to understand their perceptions of being situated in such a course, participants were asked to keep a weekly journal of their thoughts about the experience. Once data from the journals were gathered and analyzed, themes were identified and shared in focus groups with all the members of the study or used to develop interview questions. Journal entries, focus groups, and interview data were used to reveal participants' experience of being situated in the course.

Findings

The data gathered via a pre- and post-intervention survey revealed a significant difference in participants' pre- and post-intervention confidence in their abilities to plan and create various constructivist learning activities supported by technology, $p \leq .001$ (Table 1: Paired-Samples T-Test for Pre- and Post Survey). The Cronbach alpha reliability of this instrument is .93 and was calculated using the six items on the pre-test that related to confidence in ability to plan and create constructivist learning activities supported by technology.

The following is an explanation of pre- and post-survey items:

- Pair 1, Pst 1, and Pre 1: Plan and create a multidisciplinary unit with constructivist learning activities supported by technology;
- Pair 2, Pst 2, and Pre 2: Plan and create a constructivist learning activity supported by a slideshow;
- Pair 3, Pst 3, and Pre 3: Plan and create an inquiry-based learning activity supported by a WebQuest;

- Pair 4, Pst 4, and Pre 4: Plan and create a constructivist learning activity that makes use of categorizing, sorting, and classifying supported by a database;
- Pair 5, Pst 5, and Pre 5: Plan and create a constructivist learning activity that makes use of predicting, hypothesizing, and calculating supported by a spreadsheet;
- Pair 6, Pst 6, and Pre 6: Identify and evaluate resources for constructivist learning activities.

Table 1: Paired-Samples T-Test for Pre- and Post Survey

Source	***DF***	***m***	***SD***	***T***	***P***
Pair 1	14	1.53	.99	5.996	<.001
Pst 1		4.60	.51		
Pre 1		3.07	1.22		
Pair 2	14	1.80	1.37	5.077	<.001
Pst 2		4.80	.41		
Pre 2		3.00	1.41		
Pair 3	14	2.07	1.33	5.998	<.001
Pst 3		4.27	.59		
Pre 3		2.20	1.47		
Pair 4	14	2.13	1.51	5.488	<.001
Pst 4		4.60	.51		
Pre 4		2.47	1.64		
Pair 5	14	1.73	1.28	5.245	<.001
Pst 5		4.33	.82		
Pre 5		2.60	1.45		
Pair 6	14	1.20	1.08	4.294	<.001
Pst 6		4.67	.62		
Pre 6		3.47	1.25		

Data from journals and interviews were analyzed and coded to identify patterns and themes. Data were triangulated by comparing journals and interviews. Themes identified in the journals were used to generate questions for the focus groups and interviews. This strategy served as a method of member-checking and also allowed the researcher to explore topics introduced in the journals during the interviews. Data from journal entries and interviews reveal participants' perceptions of participating in a constructivist intervention as a process of analyzing, reflecting, evaluating, and adjusting their ideas about their own teaching and learning as well as the learning of their future students.

Many of the students had limited constructivist experiences. These unfamiliar experiences resulted in initial feelings of being confused, frustrated, intimidated, or overwhelmed. One participant spoke of those feelings after the first class session that situated them in Activity 1: Direct and Constructivist Instructional Methods: "The first week … was very confusing to be quite honest. At this point I am not exactly sure of everything that is expected me during this course. However, I am motivated and interested." Another participant spoke of feeling initially challenged and overwhelmed: "This has been a challenging week. It seemed over-whelming ...at first. But after the initial shock wore off and I just 'did it,' my confidence level began to rise." By the third week of the course, none of the participants mentioned feeling confused, frustrated, intimidated, or overwhelmed in their journal entries.

"Teacher thinking" was a self-reflective process whereby participants analyzed their ideas about teaching and learning. They thought about their constructs of teaching, their teaching methods, and their experiences during the courses. They compared those constructs, experiences, and methods with what they viewed as their own teaching styles. Further, they examined assumptions each method made about teaching and tried to judge how those assumptions fit into their constructs of teaching and learning. If assumptions seemed valid but did not fit into their construct, they adapted their models to include the new ideas. One student, a pre-service kindergarten teacher who was the most computer-savvy participant in this study, was initially vehemently opposed to kindergarten students using computers. She discussed her assumptions about the abilities of kindergarten students when asked to create an assignment that focused on students using a slideshow to demonstrate a concept they had learned or to express themselves in some way:

> I found it challenging to create a way for students to use PowerPoint since it is unreasonable for them to actually use the computers. (A few may have that capability, but most will not have the coordination or skill level to use keyboards, etc.) However, I did come up with a project- modified from a paper project- that allows students to participate and use PowerPoint.

Participants thought about their experiences, worked through the process of adapting their ideas about teaching and learning and evaluated how their new experiences and ideas might work in their future classrooms and how they might affect their future students. A pre-service science teacher analyzed how a constructivist activity supported by a slideshow might work in a future class:

> I am very excited about all of the technology and skill I am learning to bring to the classroom. My concern is will we have enough computers and technology to make this a viable learning process for the classroom? I would like to hear more about how we are going to accomplish these activities if we have limited computer time and availability. I'm thinking we may need to rotate projects and computer use. For example, in the science classroom, I might have students working on different projects at the same time. Some might be involved in hands-on inquiry while others are preparing their PowerPoint presentations. This would make sense, except it might be hard to keep everyone on track and be available to assist the students as they need help.

Throughout the intervention, participants engaged in "group thinking," self- reflection about and evaluation of their feelings when situated in cooperative groups in terms of their relationships with others and in terms of the application to their learning. In general, they were positive about working in a collaborative setting in terms of relationships with others, although there were times when students felt awkward or that the work in the group was not equally distributed. Participants valued getting to know each other and being members of a group, and having colleagues with whom to share ideas. This sense of community facilitated the sharing of ideas both within and among groups. The group process was seen as a way to capitalize on the strengths of each person. Working in teams improved participants' confidence in their ability to complete learning activities. One student with limited technology experience described his feelings when he completed a group assignment:

> This was most productive for me because I got through this PowerPoint presentation, and in my opinion, did quite well. I am not a huge fan of computers, they intimidate me, but I was able to conquer this challenging task. I got finished with my presentation on Wednesday and it is due on Monday, so I feel very accomplished. My self-esteem benefits when I can do something that I previously thought would be nearly impossible for me. I appreciate the opportunity to work in groups on the PowerPoint (the insect assignment). That was a much better way to lead us into use of this technology than simply handing out a tasksheet, or instructions, and leaving us to fend for ourselves. I knew the value of the group work, so I tried to absorb all that I could about using PowerPoint by watching (names group member) who understood it better than me.... The atmosphere is supportive not scary. We are not a class full of students all worried about our grades and being nervous about our abilities not being good enough to get us the grade we want. No, we are more relaxed (which in my opinion makes for a better learning environment.

Participants engaged in metacognition by spending time reflecting on their learning processes ("process thinking") in a constructivist learning environment. They generally agreed that the constructivist learning environment challenged them to be self-reliant in evaluating and adjusting their learning and learning strategies. Participants evaluated their knowledge and skills and identified and developed processes by which to acquire new knowledge and skills. Further, they evaluated those processes and their new knowledge and skills. Participants felt the focus of the course was on processes. Because they felt that the focus of their efforts should be processes, self-directed learning, and self-evaluation rather than products, they were motivated to do more than the minimum to complete an assignment. A special education major who worked for several years as a technology lab aide in an elementary public schools noted:

> It is like an artist's canvas. Okay, so you know what you have to come up with so now you have to actually come up with it. And people who don't have the opportunity to do it that way get stuck in a box and all they do is fill in templates and fill out forms and they don't see the ability to go beyond and create beyond what's there. Because they don't know how to get there

A process-related theme that reoccurred throughout the journals and interviews was creativity. Students felt that constructivist methodology allowed and encouraged them to be more imaginative and creative. As one participant said, “It’s like giving you the guidelines, being there to help you if you have difficulties. But it was a lot of self-motivation. It’s a method that is going to leave us a lot more flexible and a lot more creative.” Another pre-service science teacher discussed how constructivist methods influence creativity,

> We are all going to be different, we’re all going to have different styles, we are all going to enjoy doing different things and out students are going to enjoy doing different things. So it’s a method that is going to leave us more flexibility and a lot more creativity and a lot more room to use things in the way that is going to suit our style. Whereas you know, the directive method is like you need to stamp out like a cookie-cutter.

Participants spent time thinking about the instruction (“instruction thinking”). They evaluated the instructor and her role in their learning. Students valued the freedom that the instructional approach gave them to chart their own learning and acquisition of skills. They felt the method allowed them to explore topics at a greater depth, but wanted to know that the instructor or peers would support them if needed. One student wrote: “You are trying to let us figure out what to do after a little guidance from you. I appreciate that a lot and think that is a great way of teaching. Do it for them and they will never learn. Show them and they will never learn. Let them do it hands on, they will learn.”

They valued the collegial approach, noting with approval that their own ideas were as valued as the instructor’s, they were viewed as peers, and they were encouraged to build active partnerships in learning, sharing their knowledge and teaching each other. One student described this:

> She’s very open to, ‘No, I don’t know everything, I don’t know every version of software, I’m not supposed to. That’s what help is for. You know, let’s create, let’s do this, let’s go in and figure out how to do it.’ A lot of teachers are so scared that they don’t know everything. They are afraid to let the kids on there because they don’t want to be in a position to say I don’t know. And that’s a really scary position to be in if you look at a little kid who thinks you are this really awesome person and say I don’t know, but there are lots of ways to say I don’t know, well I am not sure, let’s figure this out. I mean there is just so much to learn from each other. When one of us comes up with something that she does not know, oh that’s cool, I hadn’t seen that before! and really encourages us to explore and discover and go beyond what she’s shown us.

Participants also wrote of feeling supported or valued by the instructor and their peers. They appreciated having access to the instructor via e-mail as well as via phone and office hours, receiving prompt responses to their concerns, questions, and thoughts even outside class. Although they generally felt the instructor was accessible to them in class, they did voice some frustration at having to wait for the instructor’s help during class. They valued being able to share ideas and discuss ideas with peers. One participant reflects on the value of sharing with peers: “It is a really good environment. There seems to be a lot of peer support also. The young man who sits next to me, (name), is so very helpful. There seems to be that cooperative spirit in this classroom and that is encouraging.”

Students evaluated the materials used in the course and how they could adapt those materials for their own use both during the course and after the course. The website proved challenging initially because of an unfamiliar interface, but once students became acclimated to it, it provided them with a central location to access information about the course, assignments, and grades, and alerted them to daily agendas. They supplied on-going feedback about the organization of the website and appreciated seeing their suggestions incorporated into its structure. It was important that the website be kept current. In addition, they spent time analyzing the other materials used in the class -- the course packet, the book, instructor-created handouts, and software demos (free 30 day trial versions provided by publishers). They felt that the course packet was unnecessary. The course packet contained technology related articles. While they believed the book had useful information, they felt its usefulness was not commensurate with its expense. They suggested alternate resources that were not as costly, such as websites and handouts.

Participants valued the instructor-made handouts that were specific to each assignment. Students commented on the usefulness of the skill tasksheets (addressing technology specifics as needed) that were created for each of the technology components. As one student put it, “She has a handout for every skill, every piece of software so that you could always kind of teach yourself, walk yourself through, and learn the software.” While having access to such reference materials was important, students did not want to be made to work through tasksheets, but to use them as needed in the content of creating projects or practicing skills. Participants commented on how they might use skill sheets with their future students or personally as they apply the skills they had acquired in their future teaching.

Software demos were important to students because they felt the demos allowed and encouraged them to explore software outside of class. In some instances, they were frustrated because some of the software demos were not fully functional and because they encountered some problems with the platforms they were using, but the general consensus was that demo software was valuable and important to their developing their projects.

Participants spent time thinking about the accessibility of technology, their own skill levels using technology, and their hardware and software successes and problems ("technology thinking"). They also compared their new experiences with their prior knowledge and experiences. While a list of critical technology skills was identified for students in the course packet, students did not use the list to assess their technology skills. Instead they assessed their skills contextually within the scope of the tasks they were accomplishing. They identified their deficit technology skills and how those skills affected their use of the technology to accomplish tasks. One student assessed his own Internet searching skills and how his lack of Internet searching strategies affected his ability to find information related to his unit theme of geology:

> One problem I am having using the Internet as a resource is that I end up finding lots of advertising material and less raw information. I need to know how to get sites that simply have lots of information on the subject of geology (like an online encyclopedia resource). I don't want to end up using mediocre Internet resources because I don't know how to best search the web.

Students considered it important to have hands-on access to the technology they were learning. After participating in Activity 2: Constructivist Slideshow: Slopes which required learners to use a digital camera to document slopes in their environment, one student commented on how he felt when he was given a digital camera to use during the activity:

> I also had a chance Wednesday to use a digital camera. I have always wanted to use one but no one has ever let me. It may have not meant much to you to let me use it but it meant a lot to me. Using it was so awesome and it is so neat to know you can now keep pictures you want and throw away the ones you don't before even developing them.

Participants gauged their technology proficiency by comparison to their peers as well as to their own prior experiences. Although some of the students were proficient and experienced in using some of the technologies, they felt the constructivist environment allowed them to explore the technologies in greater depth. A participant with high technology skills acquired during her career in business, compared her skills to those of her classmates and also discussed challenging herself to learn an unfamiliar platform,

> This week was exciting and frustrating. As I talk with some of the other students, I find that I am much slower in catching on to the technology. Some of the others are commenting on the slow pace of the class. I, however, do not find the class to be moving too slowly. It seems about right for me, so I hope the pace does not pick up. I think one other difference exists between me and the others too. Most of the other students selected a computer that they are already comfortable with and are working on what they usually use at home. I decided to work with a Mac, because I know a lot of schools have Macs and I want to be able to use one if need be. That may also account for my slow pace. The Mac is not all that different, but it does take a little more thought. (journal entry from week two of the intervention).

Having a choice of platforms was important to students. Generally students elected to use the platform that they were already most comfortable with or one that was compatible with the system they had access to outside of the class. Although students were free to sit wherever they wanted and use whichever platform they chose, three of the students in the class self-elected to use a platform that was unfamiliar to them because they saw value in learning both Windows and Macintosh operating systems.

Participants discussed their access to computers, software, and other technologies. While noting minor problems, students felt technologies were generally accessible to them both in and out of the classroom. They noted that the computer lab hours, software, and hardware in the College of Education and other labs around campus met their needs. However, there was concern about the lack of access to color printers and other peripheral devices such a digital cameras and scanners. Students wanted to be able to use these technologies to complete their projects outside of class as well as having access to them in class.

When students encountered hardware or software problems, they tried to work through the problems themselves. Participants described this process as playing around or exploring the software and felt the environment in the classroom allowed them to work in this way:

> I have realized my biggest problem is patience. I don't like "playing" around on the computer. But I have found that this is a good way to learn my way around. I am a very procedural type person and I like to do things right the first time. This is an excellent tool, though, because my students will not do things right the first time, and if I can't have the patience with myself, there is NO WAY I will have the patience with my students that I definitely must have. (I guess I'll be doing some "growing" in this class, won't I?!)

If they could not solve their own problems, they relied on peers or the instructor, but generally only as a last resort.

In sum, participants felt the intervention engaged them in a reflective process that led them to challenge their constructs of teaching.

Conclusions

A review of the literature indicates that a skills-based approach to teaching technology and its integration into the classroom has not had the desired outcome: it has not adequately prepared teachers to integrate computer technology into instruction as a tool for data analysis, exploration, simulation, or other high order thinking-skills. Learning is a complex process. Cognitive psychology reveals that learning is grounded in active participation, that knowledge is constructed, and that the situation and context influence not only what we learn, but also how we can use what we learn. To short cut the learning process by offering learners bits of decontextualized information divorces learning from reality. Direct instruction may not allow learners to go through the process of actively and intentionally constructing, adapting, and adjusting mental models.

Situating pre-service teachers in an intervention that employs a constructivist methodology honors learning processes in several ways. First, it honors learning as a natural, adaptive process that allows students to act on and manipulate their environment and observe the results of their actions. (Jonassen, Peck, & Wilson, 1999). Many of the students in the study had either limited or no exposure to constructivist experiences or to planning and creating constructivist learning activities supported by technology. Thus their mental models of both were limited by their prior experiences. As evidenced in many of their journal entries, the students initially tried to fit their new experiences into their old teaching/learning paradigm. At times they admittedly clung to their pre-intervention mental models: "I found it challenging to create a way for students to use PowerPoint since it is unreasonable for them to actually use the computer." The difference between their intervention experiences and their prior experiences and mental models of teaching, learning, and the use of technology created cognitive dissonance that was evident from their initial reports of confusion and frustration, of being intimidated and overwhelmed. These initial responses required learners to reflect upon, manipulate, self-regulate, and adjust their construct of teaching, learning, and the role of technology in their future teaching practices.

For these pre-service teachers, being situated in a constructivist intervention evoked a reflective process: students analyzed their ideas about teaching and learning by comparing their new experiences to what they had viewed as effective teaching and learning before the intervention. They examined their own assumptions and tried to judge how those assumptions fit into their construct of teaching and learning. They actively and collaboratively adjusted their constructs of teaching and learning, thereby creating new mental models. They tested their assumptions against their constructs of how they would teach, how their students would learn, and how their adjusted models might work in their future classrooms. As students actively worked through this process, their confidence significantly increased. They became self-directed, self-regulated, and motivated. They felt valued and important. And most importantly, they were encouraged to be creative and imaginative, to explore, discover, and "go beyond." In short, they *wanted* to learn.

The question remains, "How can we best train teachers to use technology to facilitate student learning?" In this study, related literature has been reviewed**;** pre-service teachers have been asked to describe their own perceptions of an introduction to instructional technology class that used a constructivist approach**;** and changes in the confidence levels of pre-service teachers in their ability to plan and create constructivist activities supported by technology have been observed. The relationship between the increase in confidence among pre-service teachers and the literature related to pre-service training and technology and teacher beliefs, practices, and technology use is clear. Teaching technology skills in isolation has not been effective in training teachers to use technology to support learning, nor has direct traditional instruction in technology integration. However, when teachers are situated in a learning environment where constructivist instructional methods are modeled and implemented, they develop confidence in their abilities to produce constructivist learning activities that are tied to curriculum and supported by technology.

Both this study and others, (Milken, 2001; Todd, 1993; Wetzel, 1993) suggest that teacher education programs need routinely to model the use of technology as an integrated teaching tool. That cannot happen when the technology is isolated in computer labs. It may happen when computers, software, and materials are integrated, physically as well as in their use, into methods classes or other classes where pre-service teachers learn. By using computers as a vital tool to facilitate their own learning, using computers to express themselves creatively, and using computers for personal purposes, teachers are more likely to learn to like using computers and find value in technology as an instructional tool (Laffey & Musser, 1998; Hochman, Maurer, & Roebuck, 1993; Kearns, 1992). People want to see relevance in what they are learning. For pre-service teachers, relevance means not only how they are personally affected, but also how methods and tools might affect the learning of their future students (Valdez, et al, 1999, Rodriguez & McDonald, 2001). Engaging pre-service teachers in the constructive processes of analyzing, adapting, testing, negotiating, retrying, and reflecting allows them to examine teaching and learning and to determine for themselves how to teach, how students learn, and how technology can support learning.

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Appendix A
Bugs

Group Members:

Context:
Your class is in the middle of a unit on insects. Your teacher wants you to become familiar with the insects that are native to East Tennessee. Once you become a "bug expert," you will share your findings with the class by creating a book using a slideshow.

Task:
When you are done with this activity, you will:
1. Have an idea of some of the insects that are native to East Tennessee.
2. Have created a slideshow book that documents your findings and provides information about each of the insects you have identified.

Process:
- Get in your group and read the poem "Neighbors" by Marchette Chute. In that poem Marchette Chute lists several types of insects that she saw while watching.
- Make a list of the type of insects you think you might see outside the classroom in East Tennessee.
- Take the digital camera and some paper, go outside, find a nice quiet place in the grass, and spend about 20 minutes observing a patch of grass. Take pictures of any insects you see. Make field notes about where and when you saw the insect and its behavior. After about 20 minutes, come back in the classroom.
- Sort your pictures. Use field guides or the Internet to try to identify each insect that you observed. Draw some conclusions about insects in East Tennessee based on your observations.
- Use a slideshow to create a book about the insects you observed. Make an introduction page and a page for each insect that you observed. On the page about each insect include your picture of the insect, your field notes, and any other information that you found about the insects that you'd like to include. If you use any outside sources, be sure to cite them (tell the source).

Evaluation:
You will be evaluated according to the following:
- Did all members of your team participate and work as a team?
- Did you spend 20 minutes outside observing an area for insects? Did you take field notes about the insects you observed? Did you take pictures of the insects you observed?
- Did you identify the insects you observed or make a reasonable effort to identify them?
- Did you create a book that includes a title page and a page for each insect with your field notes, the photographs, and any other information you found about the insects?
- What conclusions can you draw about insects in East Tennessee?
- Describe the process your group used to complete the activity.

Appendix B
Forms and Function in Architecture

Group Members:

Context
You are in a high school art class. Your class is in the middle of a unit on architecture. Your teacher has asked you to look at forms that are found in buildings and how those forms serve a purpose.

Task:
When you have finished this assignment, you will have:
- Investigated the relationship between form and function in architecture.
- Create a slideshow presentation that illustrates the relationship between form and function in building on the UTK campus.

Process:
- In your group gather the following resources:
  - A digital camera with a few disks
  - Paper and Pencil
- Now go outside and walk around the campus take 4 pictures of 4 different buildings. Select buildings that have unique designs. Now find out what the building is used for and what happens inside that building. You may need to walk inside the buildings to investigate. Make notes about the buildings as you are taking
- Come back to the classroom and in your group, discuss the form of the buildings and they way the building is used. Are there any conclusions that you can draw about the way the architect designed the building and its use? Do you think the architect used had the purpose of the building in mind when he designed it? What makes you think he/she did or did not?
- Use a slideshow to create a presentation that uses your pictures to illustrate your conclusions about the relationship between the form and the function of the buildings. Be sure to have a title slide and then content slides for each building. Add any other slides that you feel are necessary.

Evaluation:
You will be evaluated according to the following criteria:
- Did your team work as a group and each member participate?
- Did you spend about 30 minutes walking around campus taking pictures of at least 4 buildings and investigate the purpose or use of the building?
- Did your group create a slideshow presentation that includes a title page and content pages that uses your pictures to illustrate your conclusions about the relationship between the form and the function of the buildings?
- Describe the process your group used to complete the activity.