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Technology Integration in a Science Classroom: Preservice Teachers' Perceptions

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Abstract The challenge of preparing students for the information age has prompted administrators to increase technology in the public schools. Yet despite the increased availability of technology in schools, few teachers are integrating technology for instructional purposes. Preservice teachers must be equipped with adequate content knowledge of technology to create an advantageous learning experience in science classrooms. To understand preservice teachers' conceptions of technology integration, this research study explored 15 elementary science methods students' definitions of technology and their attitudes toward incorporating technology into their teaching. The phenomenological study took place in a science methods course that was based on a constructivist approach to teaching and learning science through science activities and class discussions, with an emphasis on a teacher beliefs framework. Data were collected throughout the semester, including an open-ended pre/post-technology integration survey, lesson plans, and reflections on activities conducted throughout the course. Through a qualitative analysis, we identified improvements in students' technology definitions, increased technology incorporation into science lesson plans, and favorable attitudes toward technology integration in science teaching after instruction. This research project demonstrates that positive changes in beliefs and behaviors relating to technology integration in science instruction among preservice teachers are possible through explicit instruction.

Keywords Preservice teacher attitudes · Qualitative research · Technology integration · Teacher beliefs

Introduction

Technology in today's society is rapidly evolving, influencing many aspects of our social and professional lives. In a classroom setting, a crucial factor for successful integration of technology is the teacher, as she directly determines the best instructional practices for her students (Hite 2005; O'Bannon and Judge 2004). Given that teachers are the instructional drivers in the classroom, it is important to help prepare and assist preservice teachers in acquiring technological expertise to better facilitate learning for today's diverse student population (Pan and Carroll 2002).

Once preservice teachers move into their own classrooms, what might their technology accessibility and use look like? Work with in service teachers can provide some insights on what we might expect. For example, it is common to see teachers use technology for a variety of purposes such as keeping records, creating lesson plans, and communicating within the school as well as with parents. Even with such a widespread use of technology in the schools, however, it seems that teachers are hesitant to use technology to support higher-order thinking, student-centered learning, or student enrichment. Ertmer (2005) stated that most teachers, regardless of whether they are veterans or novices, have limited understanding and experience about how technology should integrate into education to facilitate teaching and learning.

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Gray et al. (2010) report that 97 % of US public school teachers have one or more computer available in their classrooms every day, and 54 % can bring additional computers into their classrooms (such as through laptop carts). Ninety-five percent of those computers are Internet accessible, although access may be limited by filters, firewalls, and the like. Just because the computers may be in the room, though, does not mean they are used in such a way that directly supports student learning. In fact, earlier reports suggested that, at the time of their writings, teachers primarily used computer technology for communications (50 %) (Barron et al. 2003) or for classroom management tasks rather than for increasing student achievement (Littrell et al. 2005). Likewise, a survey conducted by the National Snapshot indicated that only about 18 % of K-12 public schools teachers utilized computers for instructional purposes (Norris et al. 2003).

Many researchers agree that the use of technology for instructional purposes can improve students' learning (e.g., Hite 2005; O'Bannon and Judge 2004). Thus, it is discouraging that the use of technology in the public schools is so limited despite school officials increasing investments in computer technology for classrooms (O'Bannon and Judge 2004). This begs the question, why are teachers reluctant to use technology where it can greatly assist them?

One possible reason for the lack of change toward a technologically enhanced student-centered pedagogy could be the viewpoints that teachers hold. Chen (2008) states that teachers refer to their preexisting beliefs and experiences when trying to integrate technology into their instructional practices. Such beliefs can influence the development of new ideas regarding technology integration and related instructional practices. If those beliefs focus only on using technology for administrative tasks or to enhance traditional content delivery—rather than to support a more student-centered view of learning as an active construction of knowledge—then it should come as no surprise that technology use is limited. Hite (2005) suggests that a transformation in the behaviors of traditional teachers is necessary to increase the integration and use of new technology in curriculum.

The present study provides an account of changes with respect to beliefs about technology integration encountered among preservice teachers in an elementary science methods class. The following questions will be addressed:

- How do preservice teachers define technology integration, and how has their interpretation of technology with respect to a science classroom changed over the course of instruction?
- What tools did preservice teachers use to effectively integrate technology into their science lessons?
- After learning about the various methods of integrating technology into the K-5 science curriculum, was there positive momentum toward intent to incorporate technology into their lessons?

A Working Definition of Technology Integration in Science

Integrating technology into instructional practice presents a challenge for most teachers. As teaching methodologies evolve, technology provides copious resources and potential to enhance the teaching and learning process. The technological pedagogical content knowledge (TPCK, later TPACK) framework provides an understanding of the knowledge required by teachers for effective technology integration (Harris et al. 2009; Mishra and Koehler 2006). In the TPACK model, a Venn diagram illustrates the interactions that exist among content, pedagogical, and technological knowledge. Technology skill training alone leaves teachers without the knowledge of how to use technology to teach more effectively, disregards the relationship between technology and content knowledge, and does not address curriculum content standards with students while using technology (Harris et al. 2009). The application of TPACK by preservice science teachers can aid them in establishing a modern set of tools and strategies to effectively integrate technology, science content, and pedagogy in their teaching (Jang and Chen 2010). Foulger et al. (2012) state, "standalone courses are ineffective in providing teacher education candidates with appropriate preparation to successfully integrate technology into their instruction" (p. 48). Thus, it is essential that teacher education programs refocus their attention toward providing preservice teachers with the experiences, knowledge, and skills that can promote teaching and learning in their content areas rather than knowledge of technology in standalone courses. As stated, "it is teachers *with* technology who will make the difference. Students are third partner. All three are co-essential" (Fullan 2012, p. 72).

The TPACK framework for science helps us define technology integration for the purposes of this study: the appropriate selection and use of technology within a science lesson or unit to facilitate or enhance student learning of the content. Technology integration requires a more sophisticated understanding of technology use than what is described in previous studies (Barron et al. 2003; Gray et al. 2010; Littrell et al. 2005; Norris et al. 2003)—it is not simply limited to the selection of, for example, an electronic slide show presentation rather than writing notes on the board. Instead, it must include understanding of the content at hand and effective instructional practices and build upon those strategies through the inclusion of relevant technological tools. Examples of effective technology integration might include students' use of probeware to collect and analyze data in a lesson on forces and motion or the use of interactive simulations to model earthquakes.

Theoretical Framework and Background Literature

Learning and teaching require implementation of effective instructional practices. Teachers' knowledge and beliefs play a vital role in their practices, shaping the learning that goes on inside their classroom (Pan and Carroll 2002). According to Loucks-Horsley et al. (1998), beliefs are defined as "ideas people are committed to—sometimes called core values. …They shape goals, drive decisions, create discomfort when violated, and stimulate ongoing critique" (p. 18). Pajares (1992) and Bandura (1997) assert that beliefs lead to action agendas or goals that guide people's decisions and behaviors. Teachers' beliefs are formed during their time spent in the classroom either as students or teachers as well through their experiences. In order to adapt new educational innovations, i.e., technology integration, teachers must "think in new ways about students, subject matter, and the teaching–learning process" (Pan and Carroll 2002, p. 38). Fostering technology integration in the classroom requires educational programs to be designed such that they change teachers' beliefs. These changes should be facilitated through practices that emphasize reflection about those personal beliefs and hands-on experiences (Park and Ertmer 2007).

Preservice Teachers' Beliefs Regarding Technology

Teachers' individual beliefs guide their teaching practices. According to Chen (2008), the "types of applications and to what degree technology will be integrated into a classroom depend on each teacher's beliefs" (p. 67). Limited technology integration by a teacher can be associated with three reasons: (a) external factors (e.g., lack of funding, lack of administrative support), (b) lack of understanding of constructivist instruction (e.g., pedagogical content knowledge), and (c) conflicting beliefs (e.g., pedagogical beliefs) (Chen 2008). Additionally, interactions between these three reasons can contribute to inconsistency in teachers' technology integration.

An educational technology course can aid in understanding and changing teachers' beliefs regarding technology integration, leading to increased content knowledge and self-efficacy. Abbitt (2011) examined the relationship between preservice teachers' TPACK and their self-efficacy beliefs about technology integration. He found a dynamic relationship between the variables, with technological knowledge predicting self-efficacy beliefs at the start of a technology integration course, but multiple factors (technological knowledge, pedagogical knowledge, technological pedagogical knowledge, and pedagogical content knowledge) predicting self-efficacy at the end. Anderson and Maninger (2007) investigated the changes that occurred over an educational technology course among preservice teachers' abilities, beliefs, and intentions, and the factors associated with preservice teachers' intentions to use a variety of software in their future classroom. All of the measured variables were found to improve over the semester, and self-efficacy beliefs were the strongest predictor of intentions to use technology in teaching.

These two studies (Abbitt 2011; Anderson and Maninger 2007) clearly support the need for the inclusion of an educational technology course that provides preservice teachers with effective methods and skills required to incorporate technology in their classrooms. Hernández-Ramos (2005) stated that students exposed to technology use in preservice education programs are knowledgeable in the use of software applications and have constructivist beliefs concerning the use technology in classrooms. However, the nature of the course can make a difference: In a study examining the level of technology instruction students received in preservice education programs, Littrell et al. (2005) concluded that the instruction was more *about* technology rather than adequately preparing future teachers on *how to use* technology. Therefore, the more exposure we give to our preservice teachers, the more knowledge and confidence they can gain, potentially improving their beliefs about technology integration.

A positive attitude develops with knowledge and competency. Thus, for teachers to have increased self-efficacy in technology integration, they need to have a positive attitude and be motivated; only then are they able to absorb information. Sang et al. (2010) found that Chinese student teachers' attitudes, computer self-efficacy, and constructivist teaching beliefs were the strongest predictors of intent to use instructional technology. Likewise, Cullen and Greene (2011) found that positive attitude was a major predictor of technology use in the classroom and that motivation is related to teachers' self-efficacy.

Wang et al. (2004) explored how a vicarious learning experience and goal setting can influence preservice teachers' self-efficacy for technology integration into the classroom. The findings revealed that preservice teachers who were exposed to vicarious teachings in the treatment groups experienced significant increases in self-efficacy for technology integration in the classroom compared with those in the control group. Wang et al. (2004) therefore argue that vicarious learning experiences are integral to developing self-efficacy among preservice teachers for technology integration.

The studies described in this literature review emphasize the practical significance for improving the quality of teaching and learning through technology. We have also seen how teachers' beliefs about the use of technology in classrooms affects the way they integrate technology in their curricula (Littrell et al. 2005). Therefore, preservice teacher training programs must teach effective technology integration into the curriculum in order to change teachers' beliefs (Littrell et al. 2005).

Technology as an Effective Tool

Changing teachers' beliefs in such a way as to support technology integration assumes that such inclusion will improve student learning. There have been numerous studies conducted to comprehend the effectiveness of technology in K-12 education (e.g., Adams 2011; Hite 2005; Hughes 2008; Lee et al. 2010; O'Bannon and Judge 2004; Oblinger and Oblinger 2005; Watson 2007). Technology integration into K-12 classrooms is integral to providing the education needed for the success of today's students (Watson 2007) and is one way to begin an educational reform of the way teachers teach and think. Teachers who understand the need to integrate technology typically have higher achieving students (Watson 2007). Technology-equipped classrooms can produce critical thinkers and leaders (Bingimlas 2009; McMahon 2009). Use of technology in the classroom could mark a shift from traditional methods of teaching to a more constructivist method of teaching, thus enhancing student learning (Matzen and Edmunds 2007). Constructivism, related specifically to science education, allows students to be actively involved in interpreting and understanding new science content, and connecting this new knowledge to prior knowledge in meaningful ways (Sivertsen 1993). In a survey conducted by Goldenberg (2011), eight New York City public schools revealed that the majority of students felt science learning is more meaningful "when they can actively engage in hand-on activities, group work, discussions, and explore through digital resources" (p. 52). It is important for teachers to know how to use technology as a tool to support the learning process (Hughes 2008; Oblinger and Oblinger 2005). Therefore, it is important to expose preservice teachers to various technologies that can be used to support many diverse teaching and learning activities (Lei 2009).

According to Roschelle et al. (2004), technology can provide support for student learning in four major dimensions: "active engagement, collaborative learning, real world contexts and frequent and immediate feedback" (p. 253). Technology can also assist the learner by promoting "high-order thinking and metacognitive skills that are essential to meaningful learning" (Wang et al. 2010, p. 382). Moreover, technology can promote science learning by developing interest and motivation in science, for example by allowing students to participate in real data analysis such as through citizen science projects (Price and Lee 2013); providing access to information, such as to data not otherwise gatherable in the classroom (Adams 2011; Bailey et al. 2011); and scaffolding the learning process with tactile and strategic support (Wang et al. 2010). Learners need to learn and master important skills, some of which can be complex, and transfer their knowledge to new situations. Technology can promote mastery learning by using similar material multiple times, but in various forms (Wang et al. 2010), such as using both probeware and computer simulations to study forces and motion. In addition, technology can support the development of "expert thinking" in students and be an effective tool for teachers to create enhanced learning models (Wang et al. 2010, p. 383).

Many of these aspects support science education reforms, which suggest that students should frequently and actively engage in the natural world by mimicking the work of scientists using technology (National Research Council 1996, 2012). For example, data acquisition instruments (e.g., probeware) and websites can both provide real scientific data for use in scientific inquiry. In a study conducted by Adams (2011), middle school students engaged with technology by utilizing real-time data (RTD) to test predictions in the aquatic ecosystem. The RTD actively engaged students in developing a deeper understanding of the various factors that affect tidal creeks. Adams (2011) stated that technology allowed teacher to bring "babbling brooks, raging rivers, serene lakes, fluctuating tidal creeks, dynamic estuaries, and ocean basin into their classroom" (p. 37). Likewise, technology-enhanced lessons that incorporate visualizations for phenomena that are not easily investigated in a classroom (e.g., size or time scales are outside those of our everyday experiences) and designed under an inquiry framework have been shown to be more effective than typical classroom instruction in a variety of science topics and teacher contexts (Lee et al. 2010). Technology can aid in making science content knowledge concrete and spark students' interest in science. Although it is evident that technology integration in the science curriculum can enhance student learning, there is a still need to understand preservice teachers' conceptions about technology assimilation in the science classroom.

Methodology

Research Design

In order to address our research questions regarding science preservice teachers' beliefs about technology integration in their classrooms, the elementary science methods course was newly designed to include technology-enriched science activities. Hence, this was a preliminary study that included a small sample size due to class enrollment. We employed a qualitative methodology that follows a phenomenological design (Creswell 2007). The phenomenological design was selected due to common lived experienced shared by all the participants during the duration of the study (Lichtman 2010). In this study, the common phenomenon shared by the participants was a technology-enriched elementary science methods course. As Creswell (2007) describes, phenomenology provides "a deep understanding of a phenomenon as experienced by several individuals" (p. 62). The design of the study is strengthened through triangulation of various artifacts, such as students' pre/post-surveys, reflections on model lessons, and lesson plans. Creswell (2007) states that triangulation is best strategy to utilize to "shore up the internal validity of the study" (p. 215).

Participants and Setting

The participants in this study were preservice teachers in an elementary science methods course at a large university in the Southwestern US during the Spring 2012 semester. The selection of preservice teachers as the sample population was instrumental in understanding the interaction between their beliefs regarding technology integration in science teaching, experiences and actions. This selection was also in part due to the claim that teachers teach as they are taught (Kennedy 1999). Thus, it was essential to model and provide a rich experience that can foster a shift in thinking regarding technology integration prior to their entrance into the classroom. The study took place within the boundaries of the classroom and the class periods, which were twice per week, 75-min each, over a 15-week semester.

The class consisted of 15 students, 3 males and 12 females. The classroom demographics were diverse as 7 of the 15 students were Caucasian, 4 were Hispanic/Latino, 3 were African American, and 1 was Asian. The students' ages ranged from 21 years of age to approximately 35 years. The majority of students in this course were undergraduate students. Also in the class was one student simultaneously working toward her initial licensure and master's degree. The graduate student's work on the assignments of interest in this study was comparable with the rest of the class, and so was not separated from other data during the analysis.

All of the students had completed methods courses in other subjects (e.g., literacy) and a first field experience prior to the science methods course. During the semester of the study, all students were concurrently enrolled in a second field experience (Practicum II, or P2) that included 20 h per week in an elementary classroom. The P2 fieldwork allowed them to gain experience with various aspects of teaching, such as practice with different classroom management and instructional strategies. After the science methods course, students were scheduled to student teach during the Fall 2012 semester.

Given that these students were from a technology era, and they had taken a required introductory course on technology (in which they discussed key technology hardware, software such as Microsoft office, and web searching), they were somewhat comfortable with using computers, yet lacked the knowledge of various technology resources such as probeware, iPad apps, online simulations and websites available specifically for science teaching and how to integrate them into a science classroom. Additionally, they had mixed feeling about teaching science due to their personal experience as students in a science classroom. The majority of participants stated in their science autobiography assignment that science was not a subject that they experienced particularly in their primary years and they lacked comfort, interest and content knowledge in the subject because of the traditional textbook teaching methodology that had been applied in their experiences. This raised concerns among the majority on how to effectively teach science.

Materials and Procedures

The materials used to investigate the research questions consisted of an open-ended pre- and post-Preservice Teachers Technology Integration Survey (PTTIS; "Appendix"), created by the first author, and artifacts such as lesson plans and reflections about in-class activities. These specific data sources were selected for data analysis due to their direct relation to the study in addressing the research questions. While the course also contained other components (such as using science notebooks and completing a long-term Moon phase observation project), they were not directly related to this study and so are not discussed here. The science notebooks were excluded as data source because they were primarily used to take class notes and long-term Moon Phase observation project required the preservice teachers to observe the moon 3 days a week and draw their observation for a month and did not include a technology-enriched component. The research study, reviewed and approved by the university's Institutional Review Board, asked only that students allow course artifacts to be used as data; no additional effort was expected outside of the course requirements. All students in the class provided consent.

After examining various studies (Abbitt 2011; Anderson and Maninger 2007; Wang et al. 2004), the authors decided to create their own survey as none of the existing surveys were appropriate for answering the current study's research

Table 1 Technology integrated activities

Activity (Date)	Technology application	Product
Forces and motion (2/9/2012)	Laptops, interactive online simulation, motion probeware, "Sid the Science Kid" force investigation	PowerPoint presentation, reflection #1
Animal habitats (2/16/2012)	Laptops, National Geographic Kids site, interactive online simulation	Poster presentation, reflection #2
Mixtures and solutions (2/23/2012)	Laptops, interactive online simulation	Video advertisement of home product, reflection #3
Plate tectonics (3/8/2012)	Laptops, websites, BrainPop video	Cmaps concept map, reflection #4
Human bones (3/23/2012)	iPad app (How my Body Works), video	Reflection #5

Table 2 Coding themes and sample statements

Codes	Sample student statements
Engagement	"The strengths of this lesson are the technology incorporation, the use of great websites, how engaging the lesson is, and the information covered" (S3, R4, 3/8/2012)
Multimedia	"The websites were interactive, which would keep the students attention focused on hand" (S7, R1, 2/9/2012)
Organization/cost/safety	"Allowing this lesson to be done online also avoids any messy clean up and the cost of providing the supplies" (S5, R3, 2/23/2012)
Definition a: personal use (phone, car, PC to write papers)	"Technology is anything that makes life easier. Ex. calculator made processing quicker. Typewriters made writing more uniformed, and cars made travel easier" (S2, Pre, 1/17/2012)
Definition b: classroom support (teacher PC, PowerPoint, grade book)	"Technology aids teaching. Things like computers and Elmo help teach" (S14, Post, 5/8/2012)
Definition c: technology integration	"TW explain to the students that they will complete a scavenger hunt on their computers. TW assist students in finding the Round Hunt site" (S15, LP, 4/24/2012)

questions. However, these surveys laid the foundation in formulating the PTTIS. The open-ended survey was designed to elicit the preservice teachers' definitions of technology and their perceptions regarding the integration of technology in the elementary science classroom. The PTTIS contained nine questions about technology integration, as well as two demographic questions (gender and race/ethnicity); at the posttest, two additional questions relating specifically to the impact of the course were included. The PTTIS was given at the start and end of the semester to investigate whether any changes in their definitions or perceptions occurred.

Along with the surveys, the students completed reflections each week on the science activities that were modeled in class. Each week a technology-enriched and non-technology-enriched activity was conducted in class. All of the activities were science standards based and crafted using the 5E Learning Cycle (Bybee et al. 2006), and some of the lessons integrated technology (see Table 1 for a brief description of the technology-integrated activities used). The technology employed varied, and included activities such as use of the computer to gather data and other information, exploring websites, watching videos, playing educational games, and using iPad applications and simulations. The technology-integrated science activities were adapted from *Full Option Science System* (FOSS; Lawrence Hall of Science) but modified to incorporate technology. For example, one lesson from FOSS Mixtures and Solutions Investigation # 2 was fused with an interactive simulation that allowed students to create their own mixtures and solutions, making them acids and bases. After each activity, the students participated in a discourse about several of the course objectives (e.g., standards, developmental appropriateness) and, when used, technology integration in science and whether the technological tool utilized was standards and grade appropriate. Students were required to write an individual reflection after each activity indicating the strengths, weaknesses, and their likes and dislikes about each activity. The reflections were one to two pages long and were due before the next class each week, e.g., the reflection for an activity conducted on Tuesday was due before class on Thursday. This process was repeated multiple times throughout the semester.

Finally, students each wrote two lesson plans during the course. Students were required to use the 5E Learning Cycle to structure the lesson; however, they were not specifically instructed or required to integrate technology in their lesson plans. Only the second lesson plan was used for analysis because the first lesson plan was submitted early in the semester, and students had not been exposed to technology-enriched science activities; therefore, it lacked technology integration and was more formative in nature. The second set of lessons plans was examined to see whether technology was incorporated, and if so, the kind of technological tool integrated in the lesson, the grade and standards appropriateness of the technology utilized in the lesson, and whether the technology was more teacher-directed or student-centered.

Analysis

A content analysis was conducted on all the data to identify preservice teachers' perspectives about technology. This analysis helped in forming valid inferences from data within their context and "provided knowledge and understanding of the phenomenon under study" (Hsieh and Shannon 2005, p. 1278). The analysis began by first open coding the pre/post-surveys, then lesson plans, followed by student reflections to identify evidence of themes related to the research questions (Glesne 2006). The codes used and sample student statements for each code are presented in Table 2. Furthermore, the students' lesson plans were re-examined for technology integration, to determine if it was included to promote student inquiry or for just for teacher demonstration. We followed this with coding, highlighting, and identifying the emerging themes across the data set. Lastly, a description of each case with supporting evidence was written (Glesne 2006).

In the next section the major results are presented as themes: improvements in students' technology definitions, increased technology incorporation into science lesson plans, and favorable attitudes toward technology integration in science teaching after instruction, with the relevant data that supports each theme presented as appropriate. This is followed by illustrative cases of two students, one student relatively comfortable with technology at the start of the course and another student who lacked initial comfort with technology. The following abbreviation identifiers are used when quoting from the data: "Pre" for presurvey, "Post" for post-survey, "LP" for lesson plans, "R#" for the reflection number, and "S#" for student identification. Furthermore, for the lesson "SI" indicates student inquiry and "TD" represents teacher demonstration. Dates of each source are also included. All quotations are presented verbatim from the original data source, without any correction of spelling or grammatical errors.

Results and Discussion

Improvement in Students' Technology Definition

In analyzing the initial presurvey questions for this research study, we discovered that preservice teachers had a limited definition of technology in regards to science education, i.e., they focused primarily on cell phones, computers, and calculators. They also lacked knowledge of technological tools that can be integrated into science beyond the use of Internet for research and computers for word processing and creating presentations. In response to defining technology, student 8 states, "technology to me is anything that can make life easier. Some form of technology is computers, cell phones and calculators" (S8, Pre, 1/17/2012). Similarly, another student indicates, "technology is the use of simple machines to compute, equate and impact our daily lives" (S11, Pre, 1/17/2012).

The post-survey revealed a dramatic yet positive change in students' definitions of technology, including, for example, iPads, simulations, web games, a SMART Board, cameras, and videos. As one student mentioned, "technology is anything electronic, computers, iPads, iPods, SMART boards, cell phones, etc. They are used by most people at school and at home" (S10, Post, 5/8/2012). Another student stated, "technology is supplemental tool that will help engage students in teaching as well as help with differentiation" (S12, Post, 5/8/2012).

Students' change in definition of technology was also apparent in their lesson plans. All of the students integrated technology in their science lesson plans, although not all the technology that was incorporated into students' lesson plans facilitated a constructivist approach to teaching science. However, the attempt to enhance their science activities through technology integration (as discussed below) is evidence of a change in their definition of technology.

Increased Technology Incorporation into Science Lesson Plans

The lesson plan assignments directed the students to use the 5E instructional model, and the major components of the written lesson plan included standards, objectives, materials, safety, procedures, and student assessment/evaluation. It was not required that students integrate technology in the lesson. However, the evaluation of the second lesson plans revealed that preservice teachers' beliefs regarding technology integration could influence their intent to use it. A variety of technology integration choices, such Brain Pop videos, the use of SMART Board, and iPad simulation applications ("apps"), as well as other simulations from websites in students' lesson plans demonstrated a change in students' perceptions regarding technology integration. Every preservice teacher in the study incorporated some sort of technology in their lesson plans (Table 3). For example, a video clip and activity from PBS's "Sid the Science Kid" (http://pbskids.org/sid/isense.html) was incorporated into a science lesson about senses and their function. This particular lesson was teacher directed although the video clip utilized for the lesson was interactive. The teacher engaged the students with a

Table 3 Students' Technology-Integrated Lesson Plans

Student	Lesson title	Technology application	Technology integration
S1	Tornadoes	Laptops, interactive simulation, video	SI
S2	Solar system	Laptops, online website	SI
S3	Solar system scavenger hunt	PowerPoint	TD
S4	Soil	Laptops, video	SI
S5	Constellations	PowerPoint, video	SI
S6	Human body	iPad app ("3D Cells")	TD
S7	The structure of a goldfish	SMART board, PowerPoint presentation	SI
S8	The life of a plant/flowers	Laptops, online simulation	SI
S9	The apple and the earth	BrainPop video	TD
S10	Senses	Elmo, "Sid the Science Kid" video	TD
S11	The effects of soda on our teeth	Colgate video ("How to have a bright smile")	SI
S12	Mixtures	Video	TD
S13	Balance and motion	"Sid the Science Kid" video	TD
S14	Balance	Laptops, online simulation	SI
S15	The rock cycle	Laptops, PowerPoint, interactive games	SI

SI student inquiry, *TD* teacher demonstration

book, *My Five Senses* (Brandenberg 2000) to begin the lesson, then the students were directed to complete a worksheet on the five senses and their function and finally the students watched the interactive video clip as a reinforcement/assessment. While technology was integrated in this lesson, it lacked a constructivist teaching methodology.

In another lesson, a SMART Board was integrated to assist students in observing and categorizing different properties of matter. This lesson promoted students' inquiry since students were allowed to come up to the front and categorize directly on the SMART Board, while the rest of the class categorized the same object with their peers in their seats during the engage portion of the lesson. Furthermore, teacher/student discussion took place regarding each group's category scheme afterward.

Although all lesson plans integrated technology in science, some of the technology choices were not suitable for the grade level and not all technology integration promoted student inquiry. For example, in one particular lesson developed for 4th graders, the iPad app "3D Cells" was incorporated to teach the functions of the human cells. This app was not appropriate because it discussed advanced functions of the human body, which are not taught at this grade level. In addition, since there was only one iPad available for the teacher the lesson was more teacher directed.

Students indicated that technology integration could promote a more constructivist teaching approach in a science classroom, by helping to break down difficult science concepts and promote peer collaboration. As a student noted in a reflection,

> One of the strengths of this lesson was the fact that students were able to collaborate on creating the concept map from the interactive websites. I think the students would really enjoy working together. I liked the idea of tackling a huge topic like plate tectonics in this type of manner. It enables the students to discover and examine on their own without having to listen to a long boring lecture about the topic. (S7, R4, 3/8/2012)

Simulations are another example of technology integration that enhanced the learners' overall educational experience. Per the reflections, the preservice teachers felt that technology simulations were an effective way to model science concepts to enhance students' understanding. "The multimedia approach would certainly reach more students. Simulations allow students to manipulate items and the process while viewing its different results" (S9, R3, 2/23/2012). Another student stated, "simulations are interactive, and presents a very organized and controlled environment for students to explore a very action based activity without a lot of chaos" (S15, R3, 2/23/2012).

Favorable Attitudes Toward Technology Integration in Science Teaching After Instruction

Students' attitudes about technology integration in science teaching also changed according to their pre to post-surveys. All students agreed that technology is beneficial to enhance society and boost student learning in science. However, in response to what are their thoughts regarding technology integration in science prior to taking this course, student 3 indicates,

> I want to integrate technology in my classroom so my students know how to use a mouse, keypad, and type. I will allow my students to use calculators to check their work. I will communicate with my parents via emails and encourage students to use the program setup by the school. (S3, Pre, 1/17/2012).

Also due to their high anxiety for teaching science, several preservice teachers were reluctant to incorporate technology, as exemplified in the statement, "I am not super comfortable with integrating technology in my science classroom" (S1, Pre, 1/17/2012). Another student indicated, "I am very uncomfortable about my ability and knowledge about basic technology" (S2, Pre, 1/17/2012).

The post-survey indicated a positive change in attitudes: "I love technology… I am becoming confident" (S4, Post, 5/8/2012). Another student affirmed, "My attitude is great regarding technology integration because I have learned ways to integrate it" (S6, Post, 5/8/2012). This change in attitude due to exposure to technological tool was also noted by student 8 who stated, "[My attitude] has increased after this semester because of the exposure to what is out there and how it can be used" (S8, Post, 5/8/2012). In response to a question on their thoughts regarding technology in science prior to this course, one student indicated, "I never thought about it prior to this course" (S10, Post, 5/8/2012), while another student affirmed, "I was against it, prior to this course" (S15, Post, 5/8/2012). Students' ideas on how they plan to integrate technology into a classroom setting also varied from pre to post. As student 4 indicated, "I want to use videos, computers, iPads, SMART boards, and various child friendly websites" (S4, Post, 5/8/2012).

The analysis of student reflections about technology-infused activities and non-technology activities clearly showed that students enjoyed those activities that integrated technology. They felt the technology lessons were more creative, enjoyable, and engaging. As one student indicated, "incorporating technology into the lessons is always a great idea, so being able to access two different websites was an awesome way to teach a lesson on plate tectonic" (S5, R4, 3/8/2012). Another stated, "I really enjoyed that art and technology were both used in this lesson" (S6, R4, 3/8/2012). Student 8 indicated, "I liked the ability to use the computers, even though I have limited experience using Macs [which were available in the science methods classroom], it was still fun using technology in the classroom" (S8, R4, 3/8/2012). Lastly, "what I liked about this lesson was the use of computer. The class was very engaged!" (S2, R2, 2/16/2012).

Finally, students also noted the advantages afforded by technology in terms of organizing of the classroom environment, particularly with regard to science materials. An unorganized environment can create havoc in science classrooms, but technology can provide a method of reducing classroom mess, decreasing costs, and increasing safety. This view is evident in the following statement, "using technology extremely cuts down on cost and danger. In an elementary level classroom, danger is something that needs to be considered greatly" (S8, R4, 3/8/2012). Additionally, "incorporating technology into the classroom is a great way to save money, prevents messes, and allows students to practice using technology" (S14, R4, 3/8/2012).

Illustrative Cases

We examined two students' artifacts (pre/post-surveys, reflections, and lesson plan) in depth to evaluate what, if any, changes occurred in each student's perceptions of technology integration. They are presented here as illustrative cases of the changes observed more broadly across the group of preservice teachers in the study.

Student 9

Student 9 was an undergraduate Hispanic/Latino female approximately 21 years of age, pursuing her Bachelor's degree in Elementary Education. On the initial PTTIS survey in response to her thoughts regarding technology integration in science prior to taking this course, she stated that she was "not a huge proponent of the integration since science is a hands on learning experience" (S9, Pre, 1/17/2012). However, by the end of the semester, in the post-PTTIS survey, her response indicated that she began to think more about technology integration in science because of her exposure to various technological tools and methods of integration into science teaching. She stated, "I never thought too much about technology integration in science before taking this class" (S9, Post, 5/8/2012). In addition, when asked how she plans to integrate technology into classroom setting she initially stated, "Power Point projects and projectors can be used to cut down on time needed to write information for a lecture" (S9, Pre, 1/17/2012); in the post-survey that changed, as she indicated, "I plan on using the videos and games from the sites that I was introduced to during this course" (S9, Post, 5/8/2012). Also, describing her attitude/comfort toward technology integration in a science classroom, initially her answer showed hesitancy: "I am still reluctant in using technology because some of the problems that may and probably will occur outweigh their benefits, in my opinion" (S9, Pre, 1/17/2012). Nevertheless, by the end her reply showed that her attitude/comfort level had shifted: "I am very comfortable with integration of technology in my classroom" (S9, Post, 5/8/2012).

Student 9's reflections on the technology-enriched activities illustrated a positive attitude regarding technology integration. In the first reflection, her response was very general, "students were engaged and got a chance to explore with the use of technology" (S9, R1, 2/9/2012). As the class progressed, however, her responses seemed to be crafted more thoughtfully and became detailed. For example, she later states, "a second strength is using the technology in the lesson. So much of the world is built on technology and the more often students are able to explore and learn using technology, I think the better" (S9, R3, 2/23/2012). In her final reflection, she indicated, "using the computers was a fantastic idea we had a great time using the interactive games and I think students in the classroom would enjoy them as well. The science video presented in class was fun, interesting, and educational" (S9, R5, 3/23/2012).

The lesson plan student 9 created for her first grade P2 class was about the Earth's layers. In this lesson she contrasted how an apple resembles the layers of the Earth. She incorporated a BrainPop video regarding the Earth's structure to introduce the Earth's structure to the class. The video she employed was age and science content appropriate. The spoken language in the video was clear and understandable. The video was engaging and would help to spur interest on the topic. Her willingness to assimilate technology in her lesson demonstrated that she had become comfortable with technology integration in her instructional practices. Although, she had shifted toward more use, it is not yet as sophisticated as we would hope since this particular use does not specifically support student inquiry.

Student 13

Student 13 was an African American/Black female undergraduate student approximately 22 years old, also pursuing an undergraduate degree in Elementary Education. Her initial response to thoughts about technology integration prior to this class showed that she felt technology is a component of science, as she stated, "science and technology go hand in hand" (S13, Pre, 1/17/2012). After the course, her thoughts appeared to have stayed the same: "I think technology integration is an inevitable part of education. It will eventually become part of education" (S13, Post, 5/8/2012). Additionally, in terms of how she plans to integrate it into science teaching her response from pre to post stayed the same; she indicated using "SMART boards, computers, Elmo, projectors" (S13, Post, 5/8/2012). In response to a question on whether the course changed her perceptions about technology, student 13 said, "yes, my perception about technology has changed because I can see how it can be an educational resource" (S13, Post, 5/8/2012). However, in describing her attitude/comfort toward technology in a science classroom her feeling regarding technology changed. Her response in the pre survey demonstrated that she was very comfortable with technology integration but in her post-survey she stated, "I am not comfortable using technology because of my lack of knowledge but I would like to incorporate into my classroom with more training" (S13, Post, 5/8/2012). This shift in her attitude suggests that although she thought initially she had a thorough understanding of technology integration in science and the technological tools available for teaching science, her ideas were challenged throughout the course as by end she felt uncomfortable and that she required more training.

This same shift is evident in her activities reflections. In the first reflection she stated, "I think the interactive websites are useful but there are so many other forms of technology that can be used related to the teaching of science" (S13, R1, 2/9/2012). However, in her final reflection, she stated,

> I never knew that simulations could be so appropriate for elementary students. There was way too much for a student to get through but the simulations allowed the students to truly manipulate the elements. I need to learn and explore other simulations and games that I can use to make the content simple and understanding for my students. (S13, R5, 3/23/2012)

The lesson plan student 13 created also showed her hesitancy to delve completely into integrating technology in her teaching. Assuming that she began with a positive attitude toward technology in science teaching, we would expect that she would be open to and be able to apply a wide array of technological tool in her teaching comfortably. However, that was not the case, as she only employed a "Sid the Science Kid" video from PBS.org to teach balance and motion to her first grade P2 students. This limited exploration of technological tool incorporation demonstrates her questioning her comfort and ability levels, as well as her knowledge of technology integration.

Implications and Conclusions

The data from this research project indicate that participants, after receiving modeling and explicit instruction, were able to better define and apply technology in the science classroom. The participating preservice teachers improved in their understanding of technology as a tool to facilitate learning in a constructivist approach, though all of them still have room to grow in this area. The improvements were evident in participants' post-surveys, reflections, and lesson plans showing a positive attitude toward and inclusion of technology integration. The findings suggest that knowledge and beliefs can influence preservice teachers' intent to use technology in the classroom, especially as evidenced by their lesson plans. Optimism for using technology developed along with knowledge and competency, leading to an increased self-efficacy in technology integration (Cullen and Greene 2011).

Students can benefit if teachers integrate technology in elementary science teaching (Pan and Carroll 2002; Watson 2007). Therefore, it would be in the best interest of our students to change our method and promote science learning with technology. This study can aid the educational community to better understand preservice teachers' beliefs associated with technology integration. The use of explicit modeling of technology in science methods courses can aid to develop preservice teachers' comfort with technology integration in science teaching. Additionally, allowing preservice teachers to reflect on their teaching practice can prepare them to evaluate the appropriate and effective use of technology in science. Finally, future research would be to conduct follow up studies to see if and how preservice teachers actually utilized the technology they integrated in their science lesson plans.

This suggestion coincides with the recommendation that teachers and policy makers design educational programs that encompass various technology use in K-12 classrooms to enhance student learning (e.g., Abbitt 2011; Anderson and Maninger 2007). The studies presented in the literature review provide empirical evidence that designing student-centered pedagogies that use technology is effective and that student performance improves by allowing students to think and explore while creating their own learning environments (Adams 2011; Hite 2005; Hughes 2008; Lee et al. 2010; Matzen and Edmunds 2007; O'Bannon and Judge 2004; Oblinger and Oblinger 2005; Watson 2007). Given that 85 % of American teenagers are Internet users (Rice and Dolgin 2008), a disinclination to fully accept technology as an effective tool in the US classroom could contribute to continued low performance of our students on nationally ranked assessments (Watson 2007). Promoting science learning with technology would yield the best value in educational experience for our students.

The research presented here helps us comprehend the mind-set of preservice elementary teachers concerning technology integration in science. Technology integration in the science methods course provides a window for teachers to explore and increase technological content knowledge and advances, which increases their confidence with technology use in a science classroom. Furthermore, technology-enriched science activities provide the opportunity to change their perception about technology integration through the science methods course. Nevertheless, research is always an uphill climb, as we must still determine to what extent preservice teachers actually implement technology-enhanced lessons in their classrooms once they have completed their teacher education programs.

Appendix: Preservice Teachers Technology Integration Survey

Demographic

Gender: male _____ female _____

Race/ethnicity

_____American Indian/Native American

_____Asian

_____Black/African American

_____Hispanic/Latino

_____White/Caucasian

_____Pacific Islander

_____Other

1. How do you define technology? Give examples of technology and its uses in everyday life?
2. Explain how you have utilized technology in your everyday life?
3. What are your thoughts regarding technology integration in science?
4. If you used technology before, how did you plan to integrate it into a classroom setting?
5. Do you feel technology is beneficial to enhance society and beneficial when used to boost student learning in science?
6. Do you plan to integrated technology into your future classrooms? Explain
7. Will integration of technology into the classroom address a more diverse student population more effectively? Why or why not?
8. Do you think technology can better meet the needs of special needs students? How so?
9. Overall, how would you describe your attitude/comfort toward technology integration into a science classroom? Explain

The following two questions were added for the post-survey

10. Has this course changed your perceptions about technology? Has this course changed your perceptions about technology relating to science? Explain
11. Has this course altered your beliefs toward technology usage whether for personal use or use in a science classroom? Explain

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