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Examining Preservice Elementary Teachers' Technology Self-Efficacy: Impact of Mobile Technology-Based Physics Curriculum

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While iPads and other mobile devices are gaining popularity in educational settings, challenges associated with teachers' use of technology continue to hold true. Preparing preservice teachers within teacher preparation programs to gain experience learning and teaching science using mobile technologies is critical for them to develop positive beliefs and self-efficacy for future technology integration. The purpose of this study was to investigate changes in preservice elementary teachers' technology self-efficacy during their participation in a specialized science content course that utilized a mobile technology-based physics curriculum, Exploring Physics. The Exploring Physics curriculum is available as a hybrid online-offline application running on multiple platforms (iOS, Android, PC/Mac). Participants included 34 preservice elementary teachers who participated in pre- and post-implementation of a technology self-efficacy survey. Data sources also included two focus-group and individual interviews with six participants, weekly classroom observations, and artifacts. Results showed significant positive changes in participants' technology self-efficacy regarding the use of mobile technologies in science teaching. Factors that supported participants' technology self-efficacy included: (a) firsthand experiences with iPads, (b) enhanced science content understandings, (c) high interactivity and engagement, and (c) instructor modeling the use of technology. Findings have implications for preservice teacher preparation for technology integration in science teaching.

Mobile devices such as iPads, tablets and smartphones have become part of everyday life for many individuals in developed nations (Pegrum, Howitt, & Striepe, 2013; Zhang, 2015). With the explosion of mobile devices, more children are becoming addicted to interactive media and game play at an early age (Couse & Chen, 2010). At the same time, interest has been growing toward implementing 1:1 computing in schools to equip students with personal mobile devices (Looi et al., 2011).

Although using mobile technology is the most recent trend in educational contexts from grade school to college settings (Wilson, Goodman, Bradbury & Gross, 2013), the literature suggests that inclusion of mobile technologies in science teaching is limited (Ertmer & Orrenbriet-Leftwich, 2010; Hew & Brush, 2007). Challenges associated with teachers' use of mobile technologies in science teaching include lack of training during preservice teacher preparation, scarcity of appropriate activities and curriculum to teach science using mobile technologies (Crook, Sharma, Wilson, & Muller, 2013; Pegrum et al., 2013; Wilson, et al., 2013), and personal abilities such as lack of confidence to use technology (Wang, Ertmer & Newby, 2004).

More recently, several calls have been made to train preservice teachers within teacher preparation courses to cope with increasing demands of integrating technology in classrooms (US Department of Education, 2010; Project Tomorrow, 2010). Science educators have continuously argued that preservice teachers should be exposed to similar technologies within their teacher preparation courses for them to feel confident using similar technology in their own teaching (O'Bannon & Thomas, 2015; Rehmat & Bailey, 2014). Despite the calls, most preservice teacher preparation programs either fail to provide the type of preparation needed for technology integration or do not explicitly focus on technology integration at all levels of teacher preparation (Banas & York, 2014; Hermans, Tondeur, van Braak, & Valcke, 2008). Consequently, lack of experiences with technology integration adversely affects preservice teachers' technology self-efficacy, which plays an important role in decisions regarding the use of technology in future classrooms (Anderson & Maninger, 2007; Anderson, Groulx & Maninger, 2011). Researchers have found that preservice teachers' beliefs about technology integration influence their frequency and level of technology use in their student teaching (Bell, Maeng, & Binns, 2013; Wang et al., 2004).

Extant literature consists of studies examining preservice teachers' technology self-efficacy within the context of science methods or educational technology courses (Anderson et al., 2011; Wang et al., 2004); studies on preservice teachers' technology self-efficacy related to the use of mobile technologies is sparse. A vast majority of studies focus on investigating teacher beliefs on technology in a general sense.

More so, there is a dearth of empirical evidence on ways in which learning science using *mobile* technologies within science content courses influence preservice teachers' technology self-efficacy in relation to integrating mobile technologies into their own teaching. What type of science learning experiences using mobile technologies could impact technology self-efficacy beliefs? How do these experiences help preservice teachers' make explicit connections between the use of mobile technologies in science teaching and learning?

Our contention was that providing science learning experiences through mobile technologies would help foster a positive change in preservice teachers' technology self-efficacy. Science courses are an important part of teacher training; thus, our study is unique because it explores preservice teachers' perceptions of teaching science using mobile technologies while engaged in learning science through mobile devices. Additionally, we conducted an in-depth investigation on factors supporting preservice teachers' technology self-efficacy beliefs.

Focus of this Study and Research Questions

In this study, preservice elementary teachers were engaged in learning science through an innovative iPad-based physics curriculum called Exploring Physics (www.exploringphysics.com) in a semester-long science content course. We explored changes in preservice teachers' technology self-efficacy beliefs as they experienced learning science using Exploring Physics curriculum on iPads. Specific research questions that guided this study were as follows:

1. How does the Exploring Physics curriculum influence preservice elementary teachers' technology self-efficacy related to the use of mobile technologies in their future science teaching?
2. What factors associated with the use of Exploring Physics curriculum within a science content course contribute to preservice elementary teachers' technology self-efficacy?

Theoretical Framework and Background Literature

Self-Efficacy for Technology Integration

This study is informed by the self-efficacy construct proposed by Bandura (1977) as a judgment of individuals' capabilities to perform necessary actions that they believe could lead to desired results. Teacher self-efficacy has been linked to teacher behavior and attitudes (Dembo & Gibson, 1985; Mulholand & Wallace, 1996) and student learning outcomes and achievement (Bandura, 1982; Tosun, 2000; Tschannen-Moran, Hoy, & Hoy, 1998).

More recently, studies in the area have shown strong connections between teachers' self-efficacy to be a predictor of future teaching practices related to technology integration (Anderson & Maninger, 2007; Anderson et al., 2011; Lumpe, & Chambers, 2001). Evidence suggests that preservice teachers with higher levels of technology self-efficacy are more confident about integrating technology in their future classrooms (Abbitt & Klett, 2007).

In summary, Bandura's concept of self-efficacy has been established as a predictor of teachers' use of technology in classrooms (Anderson & Maninger, 2007; Banas & York, 2014). For the purposes of this study, self-efficacy for technology integration has been conceptualized as teacher beliefs in their capabilities to incorporate technology successfully in a way that promotes student learning. Researchers suggest that teachers with high technology self-efficacy are more likely to put forth efforts to incorporate technology into their teaching, create learning opportunities that use technology, and may "persist longer on technology-related tasks" (Anderson et al., 2011; Ertmer et al., 2003, p. 14).

Studies have also found that preservice teachers' self-efficacy for technology integration influence their motivation and intentions to use technology (Niederhauser & Stoddart, 2001, Pope, Hare & Howard, 2005; Teo, 2009), actual use of technology in student teaching (Chen, 2010), and technology adoption (Haight, 2011). Anderson et al., (2011) found that preservice teachers' self-efficacy for technology integration was a predictor of their intentions to use a variety of software as well as frequency of use in their future classrooms.

In another study, Rehmat and Bailey (2014) explored preservice teachers' beliefs about technology integration in a science methods course. They found that technology-enriched science lessons greatly influenced preservice teachers' attitudes toward technology and technology integration in their science lessons. In the following sections, only empirical research related to mobile technologies in teacher education are included.

Mobile Technologies in Education

Over the past decade, there has been growing interest in exploring benefits and constraints associated with utilizing mobile technologies in K-12 education (Zacharia, Lazaridou, & Avraamidou, 2016). The term *mobile learning* is often associated with learning via mobile technologies within an educational context.

Pegrum et al. (2013) summarized mobile learning as learning through digital mobile devices such as smartphones, iPhones, iPods, and iPads, and personal digital assistants (PDAs). These devices offer more mobility and portability than laptops and tablets (Pilgrim, Bledsoe & Reily, 2012; Traxler, 2009). At the time mobile devices were invented (early 2009), they were distinguished from other portable devices (laptops, tablets) on the basis of size and weight (Pegrum et al., 2013) one could argue that similar low-weight options are now available today.

According to Kinash (2011), mobile learning "allows students at all levels to have resources available to them at all times" (p. 56). Others have also noted the advantages of mobile devices, which enables learning to take place *anytime* and *anywhere* (Brand & Kinash, 2010; Franklin, 2011).

Availability and accessibility via mobile devices opens up opportunities for scientific inquiry in formal and informal contexts (Pegrumet al., 2013). Furthermore, mobile learning allow learners to investigate real life outside their laboratory in a variety of contexts, such as working in field sites, parks, museums, or their own garden at home (Looi et al., 2014). Additionally, the merits of mobile learning have been linked to student learning by promoting socialization and networking among learners (Koole, 2009; Looi et al., 2014); increased student collaboration (Falloon, 2015; Pilgrim et al., 2012), and increased communication between learners and instructor (Rossing, Miller, Cecil, & Stamper, 2012).

Studies have also shown that use of mobile devices enhance K-12 students' science conceptual understandings. Zacharia et al. (2016) found that students using mobile devices had higher gains in science conceptual test (on flowers and its parts) than did the students who learned the content via traditional methods. In another study, mobile technology-assisted learning helped young students' personalized learning on a variety of topics such as the life cycles of the butterfly (Song, Wong, & Looi, 2012). Although mobile technologies offer innovative learning environments, not all classroom teachers are comfortable with using mobile technologies explicitly in their instruction (Zacharia et al., 2016), evidence that preservice teachers need to develop a solid knowledge base on using mobile technologies for science teaching (Looi et al., 2011).

Mobile Learning in Preservice Teacher Education

While iPads and other mobile technologies have grown in popularity in K-12 education, an increasing emphasis has been placed on preparing preservice teachers to be able to respond to these technological demands (Brown, Englehardt, & Mathers, 2016; Pegrum et al., 2013). A large body of literature focuses on preservice teachers' views on technology in a general sense, but these studies do not focus on understanding views on the use of mobile technologies. O'Bannon and Thomas (2015) investigated 245 preservice teachers' perceptions on the use of mobile phones in classrooms and the mobile phone features that they perceived as beneficial for learning. Nearly half of the preservice teachers surveyed had positive views of the use of mobile phones in classrooms and viewed accessibility to the Internet and the use of educational apps as positive features of mobile phones.

Studies have also found that preservice teachers' use of mobile technologies during field experiences affect their perceptions of using similar technologies in their future science teaching (Brown, Englehardt, & Mathers, 2016). Brown et al. also found that, while preservice teachers talked about iPads as an effective tool for science teaching, they also believed them to distract from student learning.

Mourlam and Montgomery (2015) explored preservice elementary teachers' beliefs on technology as they used iPads in their coursework and field experiences. They found that preservice teachers' beliefs about technology integration played an important role in their willingness to incorporate iPads into their instruction.

Methodology

Research Design

This study utilized multiple methods of data collection, and analysis was designed to investigate changes in preservice teachers' technology self-efficacy during a specialized physics content course. According to Plano, Clark, and Creswell (2008), using multiple methods has advantages over a single-method approach and provides a better and more complete understanding of the phenomena being investigated. In this study, quantitative methods were used to examine changes in participants' technology self-efficacy, and qualitative methods were used to examine the underlying factors that supported changes in technology self-efficacy.

Research Context and Participants

The study was conducted in a specialized physics content course designed for early childhood and elementary education majors at a large public university. This course is referred to as a *specialized* content course because it offered a rich blend of science content knowledge using pedagogical models that prepare preservice teachers for their future science teaching (Crowther & Bonnstetter, 1997).

Major goals of the course included the following: (a) enhancing preservice teachers' science content knowledge on physical science topics relevant for their future teaching, such as electricity, magnetism, and force and motion and (b) modeling of appropriate instructional strategies, including technology use, which preservice teachers are expected to utilize in their future teaching. The class met three times a week on alternate days, including two class sessions for 1 hour and 50 minutes and a Friday session for 50 minutes. The fourth author, Douglas Steinhoff, was the assigned instructor for the course.

The participants included 34 preservice elementary teachers, all 19-21 years old. Most of the participants were females (32) except for two males. Each preservice teacher was given an iPad at the beginning of the semester to use during class and to take home as well. Along with having a 1:1 exposure to iPads, there were ample opportunities for participants to learn science via hands-on inquiry-based investigations, PhET (http://phet.colorado.edu) simulations and other web-based software, collaborative team work, and group discussions in small and large groups. A subsample consisting of six participants was selected for individual interviews. This subsample was selected after the initial administration of the technology science teaching efficacy survey. We selected participants whose scores were within the low and high quartiles in order to maximize potential variability in terms of technology self-efficacy.

Additionally, two focus-group interviews were conducted with four additional participants, separate from the participants interviewed. The focus-group participants were selected based on their willingness and availability for interviews. Each individual participant participated on both pre and post interviews. Thus, all six participants completed the individual pre and post interviews, and the same four additional participants completed the pre and post focus-group interview.

The Exploring Physics Curriculum

The curriculum Exploring Physics (http://www.exploringphysics.com/) is available as a hybrid online-offline iPad application ("app" hereafter), running on multiple platforms (iOS, Andriod, and PC/Mac). The app utilizes interactive inquiry- and modeling-based pedagogical approaches to promote deeper understanding of physical science topics aligned with K-12 curricula.

The unique design features include the following:

- High interactivity and student engagement: The app features eight units on topics such as electricity, force and motion, and energy. Each unit has labs including a prelab discussion for students to make predictions, followed by a series of hands-on investigations, a postlab discussion, and practice problems. Students can enter their information into the app as text, drawings, equations, and graphs (see Figure 1). Furthermore, the hybrid online-offline access allowed students to work anywhere without an Internet connection. While a reliable Internet connection is needed to download the e-books or any updates related to the app, no Internet is needed to enter or save the work.
- Model-building tools for deeper conceptual understanding: The app features model-building tools including drawing, graphing, adding text, data tables, and equations for problem-solving. The information is stored within the app, which students can access anytime and anywhere to submit their homework assignments and receive feedback and grades electronically.
- Scaffolds for guided inquiry: Various resources are available within the app as quick reference tips and reading pages that serve as a guide for students. The app also features built-in animations and simulations and movies on problem-solving to assist students while engaged in learning.
- Teacher guide: It also has a support system for teachers available as teacher guides (see Figure 2), for instance, expert movies on how to setup a lab or an experiment, alignment with *Next Generation Science Standards* (NGSS Lead States, 2013) and *Common Core State Standards for Mathematics* (Common Core State Standards Initiative, 2010), resources on pedagogy used, and common misconceptions associated with the topic.

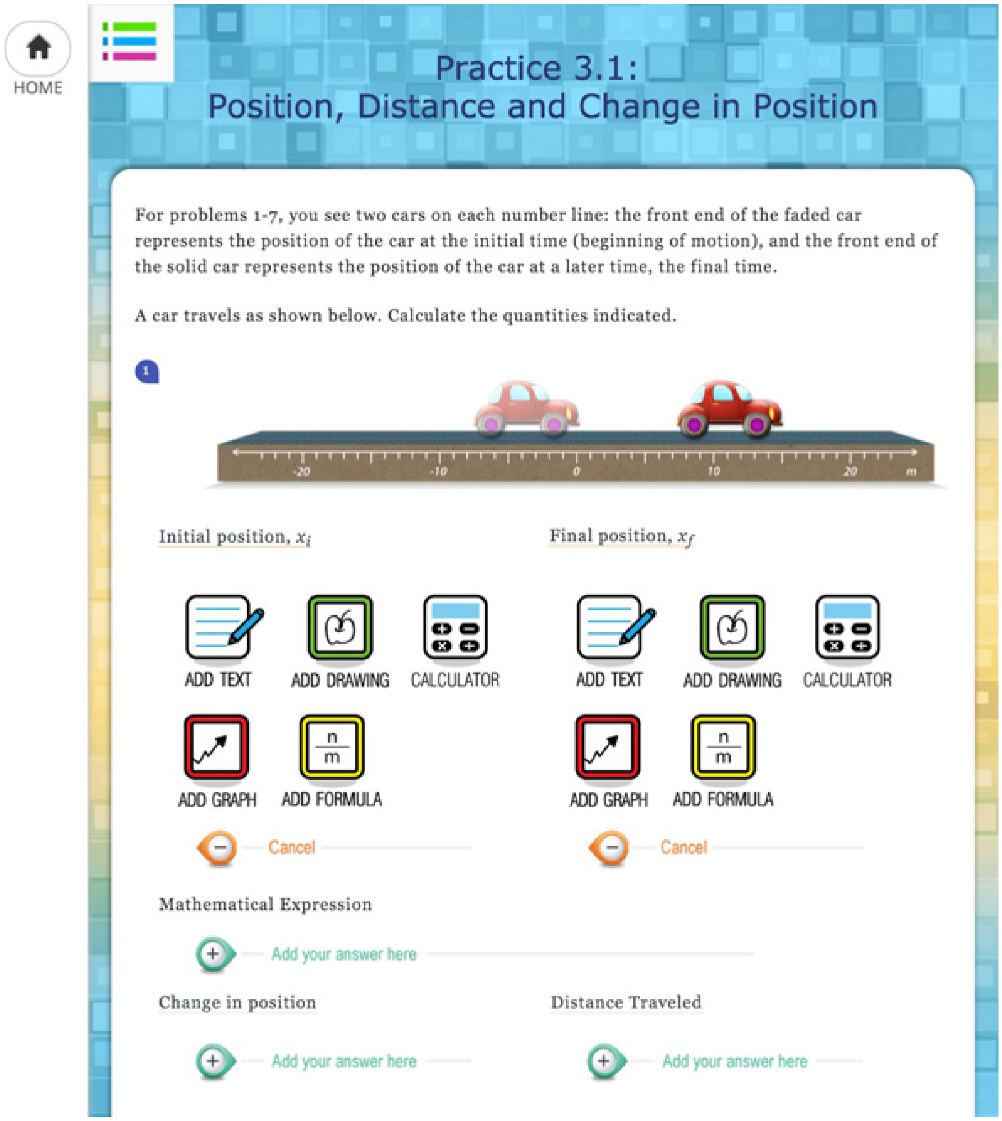

Figure 1. *A screenshot of model-building tools.*

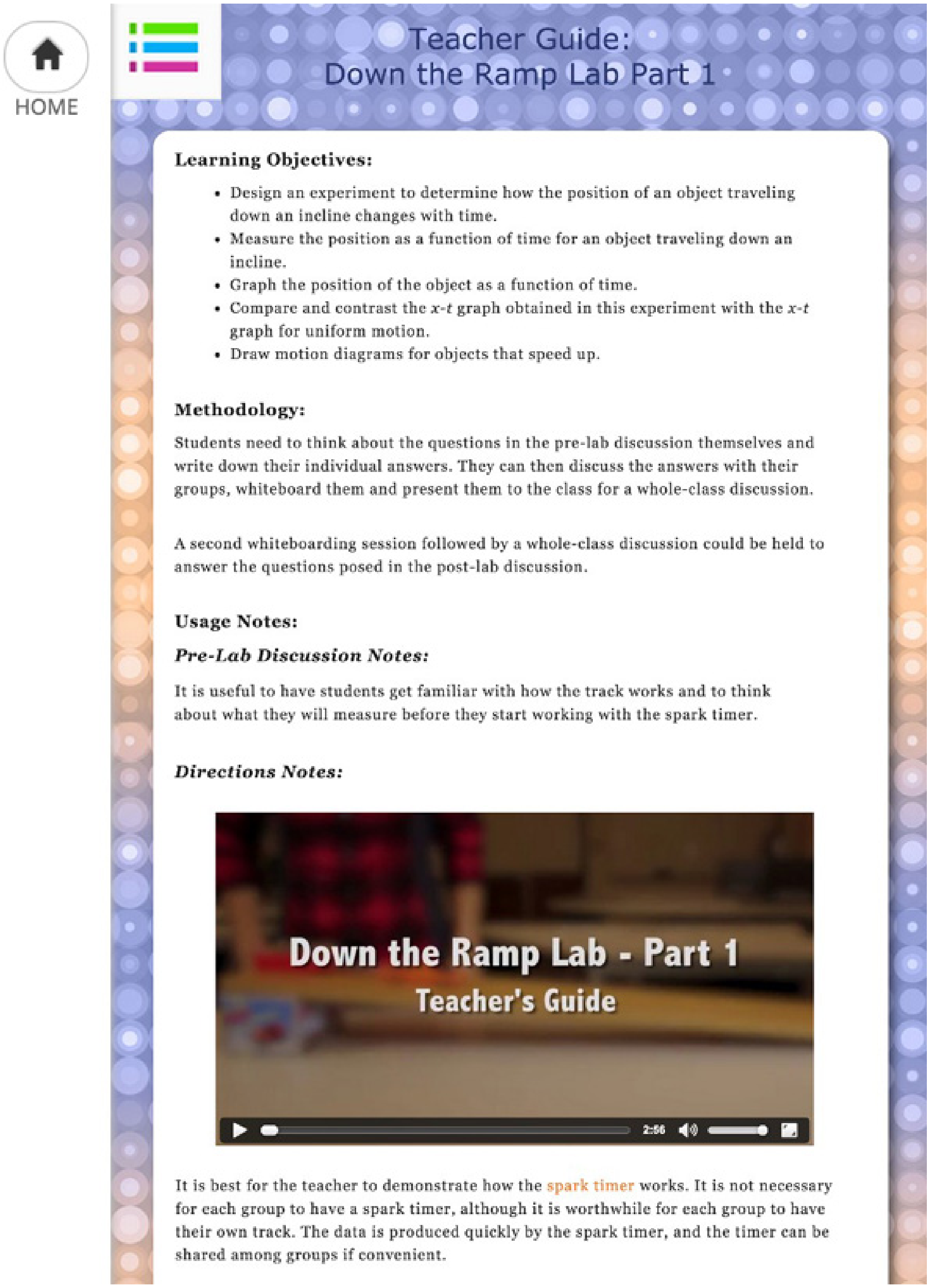

Figure 2. *A screenshot from the teacher guide.*

Data Collection

Data collection was conducted in two phases: (a) a quantitative phase and (b) a qualitative phase. Informed consent forms were distributed, followed by the administration of the Technology Science Teaching Efficacy (TSTE) survey to all participants who provided consent. The TSTE was implemented as a pretest at the beginning of the semester and as a posttest at the end of the semester. The survey consists of 20 items on a 5-point Likert scale to collect data on participants' confidence in incorporating various mobile technologies in their future science teaching; for example, "I feel confident in my ability to continually find better ways to teach science using mobile technologies."

The survey questions were adapted from the self-efficacy instrument by Bleicher (2004) and the Wang et al., (2004) scale on self-efficacy beliefs for technology integration, with a focus on mobile-technologies (see Appendix A for all survey items). The survey measures one component, technology science teaching self-efficacy for integrating mobile technologies, thus is one-dimensional in nature. The standard deviation statistics for the individual test items are available as Appendix B.

Scores on the TSTE scale can vary between 20 and 100. Higher scores corresponds to higher technology self-efficacy with the emphasis on mobile technologies. Cronbach's alpha was used to calculate the reliability. Pretest reliability was 0.82 and the posttest reliability was 0.87 for this sample of participants.

Qualitative sources of data collection included semistructured interviews with individual participants, focus-group interviews, and weekly classroom observations and artifacts. Artifacts included instructors' lesson plans, additional handouts given in class, and online and paper-copy home assignments. The first interview focused on understanding participants' general views on using mobile technologies in science teaching and whether they used technology in their prior high school or college science courses. The purpose of the second interview was to determine whether participants' views and perceptions on using mobile technologies in their own science teaching changed and the factors that supported any such changes. The purpose of focus-group interviews were to encourage rich discussions and sharing ideas among the participants regarding their views on learning and teaching science via iPads. All interviews were audio-recorded and transcribed.

Data Analysis

Data analysis included two distinct phases: (a) quantitative analysis using statistical measures and (b) qualitative analysis using grounded theory techniques. For the quantitative analysis, the repeated measures ANOVA and posthoc paired sample t-tests with Bonferroni adjustment were calculated using IBM SPSS 22.0. The paired sample t-tests were used. Time represented the within-subjects factor to determine the changes in technology science teaching efficacy from the pre- to posttest. The null hypothesis was that no significant differences exist in the participants' technology science teaching self-efficacy at a given time (pre- and posttest). The estimates of effect size were calculated by using Cohen's d.

The grounded theory approach (Strauss & Corbin, 1988) was used to analyze the qualitative data. Grounded theory techniques were well suited for the data analysis, as they allowed themes to emerge from the data. The interview data were analyzed through open coding for generating initial codes that emerged from the data. These initial codes were then grouped to generate categories using the process of axial coding. An example of a coding scheme is shown in Table 1. Categories and subcategories were each revisited to draw meaningful links among them.

Two interviews were randomly chosen and were coded by another researcher (an expert in qualitative analysis), which allowed cross-checking of the categories. After rounds of discussion and mutual agreement between the first author (primary researcher) and the other researcher (an expert in the field), the coding scheme was established. All the other interviews were then coded by the primary researcher. Further, theoretical comparisons were employed in which data were continuously reviewed to compare incident to incident within and across categories. The theoretical comparisons were also made based on prior knowledge and the existing literature.

Table 1
An Example of the Coding Scheme

Category	Description	Example
Positive views on technology	Participant indicated willingness to incorporate technology in future science teaching	I can see myself using technology to teach science in the classroom. Especially with younger kids, they're seeing more and more technology as they're growing up, so I could see technology benefiting their learning styles (Participant 2, 2nd interview).
Increased confidence	Participant indicated changes in confidence to teach using mobile technology	Having my own iPad and doing it myself at home has made me more confident (Participant 3, 2nd interview).
Firsthand experience	Participant indicated experiences of learning science through iPads on a daily basis	Just being hands-on with the iPad and getting to know the features. I have gotten a feel of it so I would be able to incorporate it in my teaching (Participant 2, 2nd interview).
Enhanced science content understandings	Participant indicated deeper understanding of the science concepts learning through the app	It's easy to see it and like it was a simulation of how electrons were transferred. Like we did that John Travolta thing that was funny but it made you understand the point, where you couldn't have done that on a piece of paper (Participant 2, 2nd interview).
High interactivity and engagement	Participant indicated model-building tools were highly interactive and engaging	Being able to Whiteboard, and draw as well as type and do graphs. It was a lot quicker and easier than doing it on paper (Participant 4, 2nd interview).
Instructor modeling	Participant mentioned that the course instructor's use of technology were successful models	Watching him use the Smart Board and how he uses the S mart Board kind of gives me ideas on what I could do with it in my classroom with the kids that I have. The iPads and the Smart Board kind of together are good (Participant 6, 2nd interview).

Results

In this section, the findings for the first research question are discussed followed by the findings of the second research question. The first research question aimed to explore changes in preservice elementary teachers' technology self-efficacy. The results presented for the first research question include evidences from both quantitative and qualitative analysis. The second research question aimed to identify the factors that supported changes in participants' technology self-efficacy. The excerpts from participants' interviews are reported such that the individual and the data source (first or second interview) are evident. For example, 1P-2nd refers to the second interview with the first participant. The focus-group (FG) interviews are represented in a similar fashion, referring to the first or the second focus-group interview, for example, FG-1st represents the first focus-group interview.

Research Question 1

The data from surveys were tested for normality of distribution of scores. The data were acceptable in terms of skewness ($< +/-2.0$) and kurtosis ($< +/-2.0$). Pre- and posttest means along with paired *t*-test results and measures of effect size were calculated. The mean technology science teaching self-efficacy score increased from pretest ($M = 76.69$, SE $= 1.89$) posttest ($M = 83.21$, SE $= 1.62$). The paired sample *t*-test showed a significant increase from pre-post scores ($t = 12.373$, $p < .01$). Using Cohen's *d* as estimates of the effect size and the suggested norms (Cohen, 1988), a moderate effect size ($d = 0.64$) was found for the changes in technology self-efficacy.

The interview responses supported quantitative results that showed significant gains in participants' technology self-efficacy beliefs. The evidence of changes in technology self-efficacy were demonstrated by ways in which participants expressed their (a positive views on mobile technologies in science teaching and (b) increased confidence in using such technologies in their own teaching.

Positive Views on Using Mobile Technology in Science Teaching. At the beginning of the semester, participants were asked about their general views on incorporating mobile technologies in science teaching. A majority of participants shared benefits associated with iPads when used in older grade levels and were convinced that iPads should not be used in early education settings. For instance, one participant said, "I flip-flop back and forth on the idea of iPads because kindergartners I feel like would really struggle. Older grades like, fourth and fifth grade, I think they could get it more" (1P-1st).

Several others expressed hesitation to include technologies in their teaching because of their lack of prior experiences of learning science using technology or the lack of knowledge of how technologies can be incorporated effectively in science teaching. As one participant said, "In my high school there was no technology in our classrooms at all, just a whiteboard, worksheets and a book. I honestly don't like using technology, I rather have a worksheet rather than doing something on a computer" (2P-1st). Another participant shared "I would probably have to learn a lot more about the technologies especially for science education" (3P-1st).

At the end of the semester, participants were asked again about their views on technology integration in elementary science teaching. There were noticeable positive shifts in participants' views on technology integration as they talked about the benefits of using mobile technologies in elementary science teaching. As one participant said, "At the beginning I would have said paper, just because that's what I'm used to, but after learning how to use it [iPads], I like it a lot" (3P-2nd).

Most participants believed that elementary students would find learning via iPads to be fun and interesting because they are more familiar with using mobile technologies every day. Participants also realized the importance of becoming familiar with the technology because of the growth in the use of technology in teaching. The following excerpts from the second focus-group interview illustrate this tendency:

> I myself am an elementary-ed teacher, so I'll be teaching all kinds of subjects, but I can see myself using technology to teach science in the classroom. Especially with younger kids, they're seeing more and more technology as they're growing up, so I could see technology benefiting their learning styles things like diagrams on the computer or something. (Participant 3, FG-2nd)

> I agree. And since we are going to be using them [iPads], like whenever we're teachers, and technology will have bigger things, so it's nice to get the experience with it now rather than our first year of teaching. (Participant 4, FG-2nd)

Increased Confidence in Integration of Mobile Technologies. In addition to positive views about technology integration, the participants expressed increased confidence in incorporating mobile technologies because of successful experiences of learning science themselves using such technologies. As one participant said, "Having my own iPad and doing it myself at home has made me more confident. I have just gotten the feel of it, and I would be able to incorporate it in using it [in future science teaching]" (3P-2nd).

Many participants felt that having the experience of working on iPads and the Exploring Physics app everyday was helpful and prepared them for their future technology use. As one participant mentioned that she used "iPads every day during class and for homework, which is a lot of exposure" and that it helped in "learning and getting comfortable with using the app and doing different things with the iPads, thus more ideas to use in the classroom" (2E-2).

Research Question 2

Four major categories contributed toward participants' improved technology self-efficacy for science teaching: (a) firsthand experiences with iPads, (b) enhanced science content understandings, (c) high interactivity and engagement, and (d) instructor modeling the use of technology.

Firsthand Experiences With iPads. Participants appreciated having firsthand experiences learning science through iPads and mentioned several affordances of the device that helped them see benefits for incorporating iPads in their own future science teaching. Many participants who initially felt anxious to learn science through iPads at the beginning of the semester said that their perceptions on mobile-technology had changed because of continuous engagement with iPads and the Exploring Physics app on a daily basis. Many participants believed that this prolonged engagement with iPads helped them become more comfortable working with iPads and afforded them ideas to use them in their science teaching. The following excerpts from the focus-group interview reflect this tendency:

> Just being hands-on with the iPad and getting to know the features – like video camera on there for my project, the timer, and Internet. I have gotten a feel of it, so I would be able to incorporate it in my teaching. I would be able to do that again. (2P-2nd)

> I've never used iPads before this class like this [i.e., using iPads every class period], and definitely never the app, so I didn't know a whole lot going into it, like what it would be like, but more of learning and getting comfortable with using the app and doing different things with the iPads that I could use in the classroom in the future. (3P-2nd)

Realizing that the use of iPads is highly emphasized nowadays in schools, many credited their firsthand iPad experiences with preparing them for their future science teaching. Many participants who were not familiar with how to incorporate iPads effectively into science learning were now more familiar with using and learning themselves, as one participant mentioned:

> I think it kind of made it more of reality, like I've never actually gotten the experience to teach with iPads before, and this made it actually real that you can do it, it's possible and you probably are going to need to do it in the future. (5P-2nd)

Enhanced Science Content Understandings. Another major contributor toward participants' technology self-efficacy beliefs was their enhanced science content understandings via iPad-based Exploring Physics curriculum. Participants frequently mentioned that the app was designed in ways that engaged them in deeper understanding of the concepts at their own pace. They also mentioned that the contents within the app were designed for them to learn in ways they are expected to teach.

For instance, one participant mentioned, "I know a lot more than I did before. This was my first physics class I've ever taken. I thought it was taught in a way that it was a lot easier to understand" (6P-2nd). Another participant said that witnessing and using a variety of technologies to learn content promoted deeper understandings of concepts: "It's easier to learn it when he [the course instructor] uses different examples for everything and different mediums, like Smart Board, computers, and iPads. We're using all these different things to understand concepts more deeply" (3P-2nd).

Participants particularly mentioned that the app was useful in understanding abstract concepts through a visual simulation and that they saw value in teaching this way for their future students to be able to understand abstract concepts as well. For instance, one participant shared her experience of working with a simulation on static electricity and flow of charges:

> I think that for certain assignments that you couldn't do on a piece of paper, you can do with a virtual simulation. Like, we did that John Travolta thing that was funny but it made you understand the point, where you couldn't have done that on a piece of paper. It's easy to see it, and like, it was a simulation of how electrons were transferred or something like that so we could actually see it. (2P-2)

High Interactivity and Engagement. Participants in the iPad group mentioned that the Exploring Physics app was highly interactive and engaging for them, and they saw value in teaching this way. They appreciated a wide range of experiences provided by the app, such as model-building tools, built-in videos and simulations, expert movies on problem solving, and quick reference tools and resources. Several students felt that drawing, writing text, and using the whiteboard feature on the app increased efficiency and saved time, as one participant said, "Being able to Whiteboard, and draw as well as type and do graphs. It was a lot quicker and easier than doing it on paper" (4P-2nd).

Another participant said that the mobile-technologies provide "opportunity of 1 to 1 ratio with students with iPad in their hands to explore further or if they do not understand they can each look up a Youtube video" (3P-2nd). Other participants also mentioned about how the organization of information within the app helped them learn, and they realized that learning science through the app could assist their future students as well. The following excerpts from the focus-group interview reflect this tendency:

> It would be a lot easier to teach with the app, because everything is like step-by-step instructions, like those videos, the videos are helpful. So I guess I can teach it or explain it to people. (1P-2nd)

> I usually just "add drawing," then wrote it. I like to write, it helps me learn better. You have the option to add text or add drawing [using model-building tools on the app], so I would always add drawing to do the equation on there. For teaching purposes it would be smarter to fill out and plan it. I makes you think more into the project. (3P-2nd)

Instructor Modeling the Use of Technology. Several participants made statements about the course instructor's use of technology that showed them successful models of technology integration in science teaching. Further, the course instructor's positive approach toward technology seemed to positively impact participants' confidence to incorporate technology into their science teaching. The following conversation from the focus-group interview highlights this tendency:

> Being good at teaching us the app and the iPad help me feel confident to do it if I were to go on to teaching in the next year or something, because I know that he could do it. It's not too hard. He's kind of influential at it because he is such a good teacher, and it helps that he has confidence. (4P-2nd)

> I agree, and also watching him use the Smart Board and how he uses the Smart Board kind of gives me ideas on what I could do with it in my classroom with the kids that I have. The iPads and the Smart Board kind of together are good. (6P-2nd)

Many participants commented that this was their first experience seeing a science instructor who was enthusiastic about integrating technologies in science teaching, and that made a positive impact on them. They also mentioned feeling more connected to their instructor and that the possession of "iPads opened up another line of communication," as they could email their instructor anytime (5P-2nd).

Discussion and Implications

The primary goals for this study were to examine changes in preservice teachers' technology self-efficacy during their participation in a specialized science content course that utilized an iPad-based curriculum for science teaching. The results of this study provided evidence that learning science via iPads and the Exploring Physics curriculum app helped increase preservice elementary teachers' self-efficacy for integrating mobile-technologies in their future science teaching. Both quantitative and qualitative evidence suggest that preservice teachers showed positive changes in their views, perceptions, and confidence to integrate mobile technologies into their future science teaching.

These findings concur with previous studies that suggest exposing preservice teachers to effective models of technology integration within their teacher preparation courses (Rehmat & Bailey, 2014). The finding regarding the significant positive changes in participants' technology self-efficacy is particularly important, given that past studies have pointed out that preservice teachers are do not feel prepared to use iPads or other mobile technologies in their science teaching.

The inclusion of iPads is not a common practice during preservice teacher preparation programs. More so, preservice teachers are not often exposed to science via explicit use of iPads or mobile technology-based science curriculums. Given the need for the inclusion of research-based, mobile technology-integrated science curriculum, this study has made an important contribution to the field suggesting that science content courses that use technology-enriched science lessons can aid development of preservice teachers' technology self-efficacy.

One unique aspect of the course was integration of iPads in ways for preservice teachers to learn science content, which also provided firsthand experiences in which they witnessed effective models of teaching science using technology. Working through the Exploring Physics app allowed them to see benefits of using mobile technologies in science teaching, which positively contributed toward their technology self-efficacy.

Unlike traditional methods, the use of iPads and other mobile devices promotes self-directed learning by widening preservice teachers' prospects to use various in-built features and functions and educational apps, as well as having the option of online search while engaged in learning (O'Bannon & Thomas, 2015; Rehmat & Bailey, 2014). In the case of this study, the Exploring Physics app features, including quick reference tips related to particular concepts, expert videos and movies on problem solving, and reading pages on relevant topics, helped preservice teachers learn science at their own pace. In addition, model-building tools, such as drawing, texting, and graphing, within the app engaged them in ways that promoted deeper learning of content. This increase in science content understandings helped them identify potential benefits of using iPads and the app in their own teaching.

Additionally, preservice teachers particularly found the hybrid offline-online access of the Exploring Physics app helpful for their science learning. Once the e-books within the app were downloaded, preservice teachers were able to work offline, enter, or save their homework and other assignments.

Although working on Exploring Physics did not require an Internet connection (unless downloading more e-books or accessing web-based resources), not all educational apps may be designed to work without a reliable Internet connection. Therefore, science teacher educators should discuss the challenges preservice teachers should anticipate while working with various technologies or at a school districts that may not have a reliable Internet support (in some rural areas). The discussion may include challenges associated with availability of internet, technological support, and equipment at their future school site (Chen, 2010). Furthermore, additional training on technology integration in science teaching should be continued within science methods courses, which are typically offered after the science content coursework is completed. Such training would better prepare preservice teachers to tackle challenges in future technology integration.

The course instructor modeling the use of iPads and other technologies, such as a Smart Board and PhET simulations, made a significant impact on preservice teachers' views and perceptions of technology integration in science teaching. This finding is particularly important, given that the explicit use of mobile technologies is not always common within traditional science content courses. Considering technology self-efficacy beliefs is a crucial factor for successful technology integration. Science course instructors should place greater emphasis on modeling effective pedagogies related to technology integration.

Modeling of effective pedagogies should include engaging preservice teachers in a variety of technologies, in addition to mobile technologies, such as a Smart Board, Promethean board, computer simulations, probeware, digital imaging and movies, clickers, concept-mapping tools ,and so on (Guzey & Roehrig, 2009). Having exposure to multiple examples of technology integration during science content courses would provide a useful and relevant context for preservice teachers to integrate technology in their future science teaching (Chen, 2010; Dexter & Rieder, 2003).

As in the case of this study, not all participants reported being familiar with using mobile devices for academic purposes, even though many reported using such devices for personal or entertainment purposes. Other studies have also noted that, while preservice teachers may be comfortable using iPads and iPhones for their personal use, they may not feel prepared to use iPads for educational purposes (Brown et al., 2016). This unfamiliarity was a major cause of confusion or frustration among participants who were more familiar with traditional modes of learning. However, using mobile-based curriculum explicitly for learning science content increases the possibility that preservice teachers will understand the affordances of mobile technologies in learning and teaching science (Looi et al., 2011). Once the initial hurdle to use technology was overcome, participants saw benefits of teaching with technology.

This study has major implications for preservice teacher preparation. First, it shows that mobile technologies such as iPads and mobile-based student-centered curricula have the potential to facilitate learning; more science courses should be designed to facilitate such an environment. Evidently, such an environment will result in increases in technology science self-efficacy beliefs (Wang et al., 2004), as in the case of this study.

Second, managing and facilitating such an environment is challenging and requires rigorous training for course instructors. Every technology has its own tradeoffs (Wilson et al., 2013), so instructors should be aware of and hold discussions with preservice teachers to prepare them for unanticipated challenges in future teaching.

Third, developing mobile-technology driven science content course could be challenging. Students may well experience frustrations and anxiety in the initial weeks of learning in this new environment. In this study, nearly half of the students had no prior experience using iPads for learning, even though every participant reported being familiar with using iPhones and iPads for their personal use. Instructors should continue to provide scaffolding needed for students to value learning science using mobile-technology. Examples of scaffolding include, but are not limited to, continuous modeling of mobile-based technologies throughout the preservice science content and methods coursework, opportunities to plan, design, practice and implement science lessons using pedagogical approaches that incorporate use of mobile-technologies, providing support and mentoring during their field experiences on use of mobile technologies, and providing opportunities for preservice teachers to reflect, revise, and reteach science lessons using mobile technologies in formal and informal environments. Training on technology integration should also be available for course instructors, mentors, and school teachers through workshops, so they are trained to provide feedback and support to preservice teachers (Dexter & Reidel, 2003).

Fourth, science instruction should not solely depend on using mobile-technologies nor should traditional-style learning be replaced; however, careful planning and administration of technology-based curriculum such as Exploring Physics are effective tools for science instruction. Research on integrating mobile-technologies for preservice coursework is an exciting and new area, and the discussion should continue on exploring ways to engage and prepare preservice teachers in learning and teaching via mobile technologies.

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Appendix A
Technology Science Teaching Efficacy Beliefs Survey

(Adapted from Bleicher, 2004; Wang et al., 2014)

Purpose: The purpose of this survey is to determine your beliefs and perceptions on using mobile technologies in your science teaching. Mobile technologies refer to using mobile devices such as laptops, iPads, tablets, iPods, and smart phones to support teaching and learning in elementary science classrooms.

Please circle your choices for each statement on the sheet that best matches the degree to which you agree with each statement below.

5 = STRONGLY AGREE
4 = AGREE
3 = UNCERTAIN
2 = DISAGREE
1 = STRONGLY DISAGREE

		SA	A	UN	D	SD
1.	I feel confident that I understand mobile technologies well enough to maximize their use in my classroom.	**5**	**4**	**3**	**2**	**1**
2.	I feel confident that I have the skills necessary to use mobile technologies for instruction.	**5**	**4**	**3**	**2**	**1**
3.	I feel confident that I can successfully teach relevant science content with appropriate use of mobile technology.	**5**	**4**	**3**	**2**	**1**
4.	I feel confident in my ability to continually find better ways to teach science using mobile technologies.	**5**	**4**	**3**	**2**	**1**
5.	I feel confident that I can help students when they have difficulty with using mobile devices during science instruction.	**5**	**4**	**3**	**2**	**1**
6.	I feel confident that I can effectively monitor students' use of mobile devices during science instruction in my classroom.	**5**	**4**	**3**	**2**	**1**
7.	I will generally teach science effectively using mobile technology.	**5**	**4**	**3**	**2**	**1**
8.	I feel confident that I can motivate my students to participate in science lessons using mobile technology.	**5**	**4**	**3**	**2**	**1**
9.	I feel confident that I can mentor students in appropriate uses of mobile-technology to learn science.	**5**	**4**	**3**	**2**	**1**

		SA	A	UN	D	SD
10.	I feel confident that I can consistently use mobile technology in effective ways to teach science.	**5**	**4**	**3**	**2**	**1**
11.	I know the steps necessary to teach science concepts effectively using mobile technology.	**5**	**4**	**3**	**2**	**1**
12.	I feel confident that I can regularly incorporate mobile technologies for my science classes.	**5**	**4**	**3**	**2**	**1**
13.	I feel confident about assigning, grading and providing feedback on science projects using mobile technologies.	**5**	**4**	**3**	**2**	**1**
14.	I feel confident about selecting appropriate technology resources, software and products to improve science instruction.	**5**	**4**	**3**	**2**	**1**
15.	I feel comfortable using mobile-technologies in my science teaching.	**5**	**4**	**3**	**2**	**1**
16.	I will be responsive to students' needs during teaching science using mobile-technology.	**5**	**4**	**3**	**2**	**1**
17.	When teaching science using mobile-technologies, I will usually welcome student questions.	**5**	**4**	**3**	**2**	**1**
18.	I feel confident that as time goes by, my ability to address my students' needs for learning science using mobile-technologies will continue to improve.	**5**	**4**	**3**	**2**	**1**
19.	I feel confident that I can develop creative ways to teach science using mobile technology.	**5**	**4**	**3**	**2**	**1**
20.	I will typically be able to answer students' science questions while they engage in learning science through mobile-technologies.	**5**	**4**	**3**	**2**	**1**

Appendix B
Item Statistics

Item	Mean	Std Deviation	N
1	4.1176	.72883	34
2	4.2059	.64099	34
3	4.0588	.69375	34
4	4.0294	.83431	34
5	4.2647	.70962	34
6	4.0294	.75820	34
7	3.6765	.84282	34
8	4.5000	.56408	34
9	4.1765	.62622	34
10	3.9412	.88561	34
11	3.9412	.95159	34
12	4.0882	.83003	34
13	4.1765	.75761	34
14	3.7941	.88006	34
15	4.0588	.73613	34
16	4.5000	.50752	34
17	4.6471	.54397	34
18	4.6765	.47486	34
19	4.0588	.91920	34
20	4.2647	.70962	34