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The Effect of Design Teams on Preservice Teachers' Technology Integration

Laurene Johnson
Syracuse University

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Abstract

This study examined the effect of a specific instructional approach called design teams on preservice teachers' attitudes toward technology, their technology skills, and their Technological Pedagogical Content Knowledge (TPACK). In a design teams approach, participants work in collaborative teams to design solutions to solve real-world problems. This quasi-experimental study explored the efficacy of an educational technology course implemented with a design teams approach compared to the same course that utilized a standard instructional approach. The sample included 53 preservice teachers from one university majoring in either Early Childhood Inclusive or Elementary Inclusive Education. Preservice teachers in the treatment condition worked in design teams to plan technology integrated lessons to solve authentic instructional problems. In the comparison condition, preservice teachers completed instructor-designed assignments in class and planned a technology integrated lesson independently. In comparing the participating preservice teachers' attitudes toward technology, skills, and TPACK, it was found that there were significant differences between the two groups on TPACK when measured with evidence from lesson plans. There were no significant differences when survey data on attitudes toward technology, technology skills, and TPACK were compared; further exploration indicated that both groups significantly improved on these measures over the course of the semester. These results suggested that the design teams approach was appropriate for use in preservice teacher technology education, but additional research is necessary to determine in which contexts and with what specific learning outcomes it is most effective.

THE EFFECT OF DESIGN TEAMS ON PRESERVICE TEACHERS' TECHNOLOGY INTEGRATION

By

Laurene D. Johnson
B.S. Vanderbilt University, 1992
M.Ed. City University, 1997

DISSERTATION

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Chapter 1: Introduction

In the approximately 30 years since technology first appeared in schools it has become an integral part of the educational experience as classrooms, libraries, and even school offices have transitioned to more technological solutions to everyday tasks. Technology has a role in almost all aspects of school functioning—communicating, teaching, learning, and ultimately preparing students to be productive members of the future workforce. Where technology was once a scarce commodity in most schools, almost every school in the United States now has Internet access, and approximately one computer for every three students (National Center for Education Statistics, 2010). While there have been heavy investments by federal, state, and local governments over the past 15 years on improving the technology infrastructure, access to technological tools, and educators' technology skills in K-12 schools in order to promote the ubiquitous use of these tools in educational settings (Lawless & Pellegrino, 2007; U.S. Department of Education, 2007, 2009, 2010), technology has never been incorporated into the regular instructional practices of all teachers (Cuban, 2001; Mueller, Wood, Willoughby, Ross, & Specht, 2008; Project Tomorrow, 2011).

Our teachers are responsible for preparing our students for what is an increasingly technological world. Teachers who are unable to use technology to enhance student learning will potentially leave students unprepared to function in our technological society. While K-12 students generally accept the prominent role of technology in their everyday lives, they must be taught to function effectively in an environment where they are constantly barraged with information (Oblinger, 2008). Our rapidly changing world, and constantly evolving technological tools, will require a workforce that is technologically literate in a way that gives them the capacity to apply their current skills to future innovations (J. S. Brown & Adler, 2008).

To be prepared for their future, students must be taught to collaborate, make decisions, think critically, and multi-task in order to safely and effectively use the tools that give them the power to communicate with almost anyone in the world (International Society for Technology in Education, 2000; Lorenzo & Dziuban, 2006; Stokes, 2010).

Our understanding of how to use technology tools in instructional settings to promote these higher levels of technology literacy is still developing. While many efforts to explore the use of technology tools in education has focused solely on the quantity of technology being used in classrooms, the potential impact of the quality of technology use for instructional purposes by teachers has recently been gaining attention (Hall, 2010; Lei, 2010). Even with identical technological tools, individual teachers achieve different learning outcomes for their students as a result of the varying instructional approaches and implementation methods, emphasizing the importance of the teacher's role in the effectiveness of technology use for enhancing both teaching and student learning (Means, 2010).

As schools move toward technological solutions for everyday teaching tasks, for both instructional and economic reasons, teachers who are able to utilize these technologies in ways that benefit students will likely be in high demand (J. S. Brown & Adler, 2008; Means, 2010; Murphy & Regenstein, 2012; Nagel, 2012). Virtual schools, hybrid instruction that combines online and traditional instruction, "flipped classrooms" where students receive traditional lecture-based instruction electronically outside of class time and conduct experiments and collaborative activities during the school day, and electronic textbooks—all require that teachers be able to adapt their instruction to take advantage of technological innovations (Koller, 2011; Nagel, 2012; Project Tomorrow, 2010, 2011; Tucker, 2012; Young, 2011). Technology has become a permanent fixture in education, and the ability to integrate technology tools seamlessly into instruction to facilitate learning has become a permanent part of the definition of good teaching (Dede, 2005; Ertmer & Ottenbreit-Leftwich, 2010; Pierson, 2001).

All teachers therefore, including those new to the profession, should be ready to integrate technology into instruction to improve student learning. Unfortunately, many teachers report feeling unprepared to fulfill this expectation. Means (2010) states that, “Although many teachers certainly are using today’s technologies in innovative ways, they remain the exception rather than the rule” (p. 285). Surveys of teachers and students suggest that, while technology use in classrooms has increased over the past 10 years, use of technology in classrooms is neither ubiquitous nor taking advantage of the unique affordances that technology tools offer to promote student learning (Ertmer & Ottenbreit-Leftwich, 2010; Graham, Tripp, & Wentworth, 2009; Gray, Thomas, & Lewis, 2010; Jonassen, 2006; Steeves, 2012). While it has been suggested that it was predominantly “digital immigrant” teachers (Prensky, 2001) who struggled with technology integration, it is not only these more experienced teachers who felt inadequately prepared to use technology tools. New teachers have also consistently reported over time that they felt unprepared to use technology in the classroom to enhance student learning (Dawson & Norris, 2000; Evans & Gunter, 2004; Gray, et al., 2010).

In order to prepare tomorrow’s teachers to be effective integrators of technology, colleges and universities must provide preservice teachers—students currently enrolled in teacher preparation programs—education in using technology tools in the classroom to enhance learning (Dawson & Norris, 2000). Over the last two decades, technology integration preparation has received both attention and funding to improve preservice teachers’ readiness in this area (Lei, 2009), and 46 states developed technology standards requiring that all teachers who receive certification have the ability to effectively use technology tools in their instruction (Hightower, 2009). Many colleges and universities responded by including coursework in their teacher preparation programs to enhance preservice teachers’ abilities to use technology with students. This coursework often focused on enhancing preservice teachers’ positive attitudes toward technology use and building their technology skills (Dawson & Norris, 2000; Ward & Overall, 2011; Zhao, Pugh, Sheldon, & Byers, 2002), as these factors are seen as common barriers to teachers’ technology use (Ertmer, 1999).

While these factors do have an impact on teachers’ abilities to use technology with their students, teaching technology tools without a direct connection to the classroom context seems to have limited impact on preservice teachers’ ability to apply technological tools to teaching and learning scenarios (D. Brown & Warschauer, 2006; Mishra & Koehler, 2006). The exact combination of experiences, skills, and knowledge that will result in preservice teachers becoming effective technology integrators is exceedingly complex (Archambault & Barnett, 2010; Mishra & Koehler, 2006).

As a result, there has been a substantial focus on determining what knowledge preservice teachers need with respect to technology integration and the types of instruction that are most likely to produce preservice teachers who can effectively use technology with students. Much of this prior research has examined single instructional approaches, single outcomes, or used highly contextualized instruments that have limited generalizability to other teacher education programs (Kay, 2006). Research that explores multiple factors that impact teachers’ technology integration abilities and compares approaches is essential to developing a better understanding of what instruction is potentially most effective in educating future teachers to be effective integrators of technology (Hofer, Grandgenett, Harris, & Richardson, 2010; Kay, 2006).

In addition, the importance of exploring these factors in realistic instructional contexts has been emphasized by many experts in the field (Koehler & Mishra, 2005a; Shulman, 1986; Zhao, et al., 2002). While conducting research *in situ* inevitably results in confounding variables that are difficult to control, researchers reinforce that studying realistic contexts is essential in order to adequately account for the demands, complexities, and overall messiness that is inherent in real-world educational environments (Shulman, 1986; Zhao, et al., 2002). Research that intends to inform educational practice in terms of preservice teacher education must occur in these contexts, and not in isolation, in order to provide sufficient guidance to add to the knowledge base regarding what instructional approaches and techniques will ultimately be effective in teacher preparation programs (Koehler, Mishra, Yahya, & Yadav, 2004; Polly, Mims, Shepherd, & Inan, 2010)

This research sought to explore the efficacy of a specific instructional approach within the context of an existing program for preservice teachers in order to contribute to the literature base on the types of technology integration instruction that show promise in producing preservice teachers who have the skills and knowledge needed to be successful integrators of technology. In order to accomplish this, this research compared the efficacy of two different instructional approaches implemented with two different groups of preservice teachers at one university. The comparison group received instruction which included the basic components suggested in the literature for preservice technology education—practice with technology skills, exposure to exemplary models of technology integrated into instruction to support student learning, practice designing instruction that integrates technology to enhance learning, opportunities to reflect on their experiences, and an emphasis on positive attitudes toward technology (Adamy & Boulmetis, 2005; Alayyar, Fisser, & Voogt, 2010; Hur, Cullen, & Brush, 2010; Kay, 2007; Koehler & Mishra, 2005b; Pope, Hare, & Howard, 2002; Williams, Foulger, & Wetzel, 2009). This was accomplished in this version of the course through (a) practice using technology tools, (b) model lessons to provide examples of effective technology integration for classroom contexts, (c) creation of technology-based instructional materials, and (d) reflection and feedback.

The treatment group received instruction which included a design teams approach. Preservice teachers worked in teams to design technology-based solutions that solved real-world instructional problems (Alayyar, et al., 2010; Koehler & Mishra, 2005b). The teams worked collaboratively, following carefully sequenced and ritualized activities, to explore the problem and ultimately create artifacts that represented potential solutions to the problem (Kolodner, et al., 2003).

Both versions of the course were implemented within the context of an existing teacher education program. This provided a realistic backdrop in which to examine how the instructional approaches impacted preservice teachers who were simultaneously experiencing other educational methods instruction within their teacher preparation program, similar to that which occurs at universities nationwide.

The potential benefits of design teams approaches are that, through the collaboration and design of artifacts to solve real-world instructional problems, preservice teachers develop a better understanding of how to use technology in instruction to enhance learning, thus potentially increasing their abilities to integrate technology into instruction in their curriculum content and pedagogy in the classroom (Alayyar, 2011; Koehler & Mishra, 2005a). The unique features of the design teams approach, therefore, could have compelling effects on the factors that impact preservice teachers' ability to integrate technology in their teaching (Alayyar, 2011; Koehler & Mishra, 2005a; Shin, et al., 2009).

Based on the extensive literature on the essential skills and knowledge for technology integrating teachers, three factors were identified as the desired outcomes in this research: attitudes toward technology, technology skills, and knowledge specific to teaching and technology integration. While the literature presents a variety of definitions of technology integration knowledge (Zhao, Kendall, & Tan, 2003), the Technological Pedagogical Content Knowledge (TPACK) framework was proposed to represent the interactions between a teacher's various types of knowledge that are necessary for technology integration (Mishra & Koehler, 2006; Pierson, 2001). TPACK can, therefore, serve as a theoretical framework to guide what both preservice and inservice teachers need to know in order to effectively integrate technology into teaching (Koehler & Mishra, 2009).

In this quasi-experimental research, pre- and post-surveys were administered to preservice teachers in both the comparison and treatment groups to measure these desired outcomes. Lesson plans written as part of the course requirements were also assessed for evidence of preservice teachers' TPACK. The scores on all instruments were compared to determine if the design teams approach resulted in increased attitudes toward technology, technology skills, and TPACK in preservice teachers.

Figure 1 presents the theoretical framework on which this study was based. The entire theoretical framework depicts how the existing research in the field suggests that the traditional components of preservice teacher technology integration education (shown on the left), combined with the inclusion of the design teams approach as described in the literature, should result in increased attitudes toward technology, technology skills, and TPACK (Adamy &

Boulmetis, 2005; Alayyar, et al., 2010; Kay, 2007; Koehler & Mishra, 2005b; Williams, et al., 2009). This research study focused on testing the center section of the theoretical model, to determine whether the addition of the design teams approach to the existing instruction produced significant changes in the intermediate outcomes of attitudes, skills, and TPACK. This research sought to answer the following question: What effect does the integration of a design teams approach into an existing technology integration course have on preservice teachers' attitudes toward technology, technology skills, and TPACK?

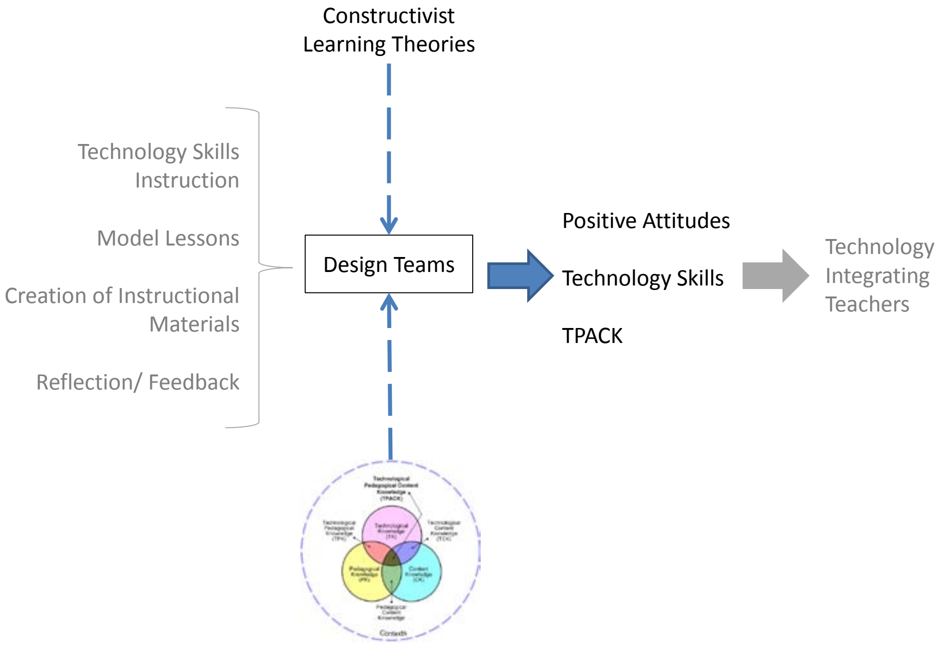


Figure 1. Theoretical Framework

This research contributes to the body of literature on how the instructional approaches used with preservice teachers in technology integration education courses impact their technology integration skills and knowledge by exploring these issues in context using a quasi-experimental research design, measuring multiple outcomes, and comparing the effectiveness of multiple instructional approaches (Hofer, et al., 2010; Kay, 2006). Understanding which instructional approaches are more effective than others is necessary for improving preservice teacher technology integration education in order to result in practicing teachers who are effective technology integrators. Teachers who are effective technology integrators will be better prepared for the technology-rich teaching contexts that await them in today’s schools, and better able to prepare their students to be contributing members in an increasingly technological society.

Chapter 2: Literature Review

The purpose of this dissertation was to determine the effect of the design teams approach, when compared to a standard instructional approach, on factors that impact preservice teachers' technology integration practices. This literature review will provide support for the underlying claim of this study: that the design teams approach has the potential to positively influence preservice teachers' attitudes toward technology, technology skills, and Technological Pedagogical Content Knowledge (TPACK).

For the purpose of this research, the *design teams approach* will be defined as an instructional approach in which educators work in teams over time to create instructional technology products that solve real-world pedagogical problems (Alayyar, 2011; Koehler & Mishra, 2005a). While other authors in the field have used a variety of terms to describe instruction which includes design teams, such as Learning By Design (Kolodner, et al., 2003) and Learning Technology by Design (Koehler & Mishra, 2005a), in this research the term *design teams approach* will be used to refer to the overall instructional approach and the term *design teams* will be used to refer to the collaborative groups of preservice teachers.

This literature review will discuss this approach and its potential impact on preservice teachers' technology integration education in detail in order to justify both the logic and importance of this particular study within this field. This will be accomplished by first looking at the current state of technology use in schools and preservice teacher technology integration education to proffer that new instructional approaches are necessary to help better prepare preservice teachers to be effective technology integrators. Next, recent examples of preservice teacher technology integration instruction will be discussed in order to situate this study in a broader context in terms of what instructional approaches and resulting learning outcomes have been previously implemented and studied. The research regarding the factors that impact teachers' technology integration will be discussed to provide details on specific outcomes for preservice teacher technology integration instruction. Three of these outcomes (positive attitudes toward technology, technological skills, and TPACK) will be defined, the existing research on these factors synthesized, and justification provided for their selection as key factors affecting preservice teachers' technology integration.

Finally, the appropriateness of a design teams approach for addressing these outcomes will be explored. The origins and applications of the design teams approach in general, and specifically with preservice teachers in the context of technology integration instruction, will be presented to assist the reader in gaining an understanding of the potential benefits of this approach in this context. The literature specifically on the components and structures of design teams will be synthesized, and a proposed sequence of components presented based on the implementations of design teams approaches in the literature. The potential benefits of learning in design teams in general, and specifically how the components of the design teams approach are uniquely appropriate for improving attitudes toward technology, technology skills, and TPACK in preservice teachers will be presented. Ultimately, the theoretical framework presented in the introduction guides both the research and the literature review. This review begins, therefore, with an overview of technology availability and technology use by teachers and students past and present in schools in the United States.

The State of Technology Use in Schools

Over 10 years ago researchers indicated that, despite technology being available in schools and classrooms, the potential of technology for enhancing teaching and learning was not being reached due primarily to inadequate use of technology tools by classroom teachers

(Abrami, 2001; Cuban, 2001). In the ensuing years, researchers have continued to find inconsistent use of technology tools by teachers in schools (Cuban, 2012; Mueller, et al., 2008; Sutherland, et al., 2004; Vannatta & Fordham, 2004; Wozney, Venkatesh, & Abrami, 2006). While technology use in schools has gradually increased over this time period, teachers who use technology effectively are still the exception (Means, 2010; Steeves, 2012). According to Vockley (2008), the two major obstacles to maximizing technology's impact on education are (a) the perception that technology is already being used effectively in schools, while in reality it is still used sparingly in most classrooms; and (b) that technology is still being used in schools to teach technology skills to students, rather than as a powerful tool for enhancing learning.

While early research on technology in education focused on access to technology tools in schools (Ertmer, 1999), current research suggests that adequate technology resources are now available in U.S. schools ("Ed-tech stats," 2010; Gray, et al., 2010). For example, 98% of elementary teachers reported having at least one computer available in their classroom every day, and 92% of classroom computers had Internet access (Gray, et al., 2010). Despite this almost ubiquitous access, research conducted in classrooms suggests that teachers are not making use of these powerful technology resources. Pitler (2011) found that of over 60,000 lessons observed in 34 states, 63% still contained no technology use at all, and students used no technology in 73% of the observed lessons. Technology that is used in classrooms continues to be primarily for traditional, teacher-led instruction and teacher productivity tasks (Cuban, 2012; Ertmer & Ottenbreit-Leftwich, 2010; Graham, et al., 2009). The most commonly reported uses of technology by elementary students were for practicing basic skills and conducting research, rather than for more complex tasks. Elementary teachers reported primarily using technology to complete basic administrative tasks, such as word processing, researching with Internet browsers, and record keeping (i.e. electronic gradbooks; Gray, et al., 2010). While teacher technology use has steadily increased over the past 10 years, research suggests that many teachers are still not taking advantage of the power of technology tools for teaching and learning in their classrooms (Pitler, 2011).

It is not surprising, therefore, that only 39% of elementary and secondary students indicated that school met their technological expectations, and 86% say they use more technology outside of school than inside (CDW-G, 2011). When technology is used to support traditional forms of instruction, teachers are not taking advantage of the unique affordances the tools offer to enhance and support student learning (Ertmer & Ottenbreit-Leftwich, 2010; Koehler & Mishra, 2003). When teachers use technology in ways that encourage collaborating, decision-making, critical thinking, and interactivity, students gain both subject-area knowledge and the type of technology fluency that will likely be necessary in the future workplace (J. S. Brown & Adler, 2008; Cuban, 2012; Graham, et al., 2009; Penuel, 2006).

Despite these potential advantages of effective technology use, only 44% of elementary teachers reported using technology often in their classrooms during instructional time, and only 39% of teachers with less than three years of teaching experience indicated using technology often during instruction (Gray, et al., 2010). Steeves’ (2012) research attempted to explain the limited use by the least experienced teachers, suggesting that they were not prepared to use technology, primarily because they did not feel they were capable of using technology effectively to promote student learning. This research indicates that new teachers are entering the workforce without the skills needed to effectively use technology tools in their teaching (Gray, et al., 2010; Steeves, 2012), thus shifting the focus to the technology integration instruction which occurs in teacher preparation programs.

While education of preservice teachers in technology integration has long been viewed as an essential element in improving technology integration in classrooms, the research over time has suggested that preservice teachers have not been adequately prepared to take advantage of the power of technology for enhancing student learning (National Council for Accreditation of Teacher Education, 1997; Whetstone & Carr-Chellman, 2001). As early as 1999, a Milken Exchange study found that the technology courses being offered to preservice teachers were not resulting in new teachers who were prepared to integrate technology (Moursund & Bielefeldt, 1999). Since this study, research has continued to suggest that despite efforts to improve these technology courses, preservice teachers continued to feel unprepared to be effective technology integrators (D. Brown & Warschauer, 2006; Dawson & Norris, 2000; Evans & Gunter, 2004). With less than half of new teachers indicating that their undergraduate education adequately prepared them to use technology in educational settings, today's preservice teacher education programs are still falling short of the goal of preparing teachers who are ready and able to integrate technology effectively to improve student learning (Gray, et al., 2010).

Teaching Technology Integration

Since technology began appearing in schools, many teacher preparation programs recognized the need to provide experiences and coursework intended to improve preservice teachers' ability to integrate technology into instruction (Kay, 2006; Strudler & Wetzel, 1999; U.S. Department of Education, 2010). Early efforts to include technology in teacher education programs often focused solely on building preservice teachers' technology skills in isolation (National Council for Accreditation of Teacher Education, 1997; Zhao, et al., 2002). Research on these courses recognized that providing only technology skills instruction was insufficient as teachers were able to use technology for personal tasks but unable to apply these skills to teaching situations (Moursund & Bielefeldt, 1999; Sandholtz, Ringstaff, & Dwyer, 1997).

More recent efforts, for example projects funded through the federal Preparing Tomorrow's Teachers to use Technology (PT3) program, attempted to link technology instruction to both preservice teachers' educational methods courses and their field experiences in classrooms in an attempt to connect technology instruction to other teacher preparation coursework (Dawson & Norris, 2000; Kay, 2006; Pope, et al., 2002; Wentworth, 2006). The research on these programs often suggested improvements on isolated factors, such as preservice teachers' technology skills or attitudes (Kay, 2006). A mismatch persisted, however, between what was taught in teacher education programs and what teachers actually needed to integrate technology in classrooms (Hew & Brush, 2007; Pope, et al., 2002). As technology was still perceived by some education faculty as secondary to the main purpose of teacher preparation, preservice teachers were often left with new skills and knowledge about teaching and learning that were seemingly unrelated to their new technology competencies (D. Brown & Warschauer, 2006; Brush & Saye, 2009; Dawson, 2006; Dawson & Norris, 2000; Ottenbreit-Leftwich, Glazewski, & Newby, 2010; Zhao, et al., 2003). As a result, many preservice teachers completed their teacher preparation programs feeling inadequately prepared to integrate technology into instruction to enhance learning (Dawson & Norris, 2000; Evans & Gunter, 2004; Grunwald Associates LLC, 2010). The research on these programs provided substantial guidance for the developing field of preservice teacher technology education. The continued presence of inadequately prepared novice teachers, however, suggests that researchers have not yet discovered the technology integration instruction that will provide all preservice teachers with the knowledge and skills they need to be successful technology integrators (Brush & Saye, 2009; Hargrave & Hsu, 2000; Kay, 2006).

A review of the literature provides substantial insight into the prevailing knowledge regarding essential components of effective preservice teacher technology education instruction. Technology integration instruction should (a) enhance positive attitudes toward technology, (b) emphasize technology skills, (c) expose preservice teachers to exemplary models of technology integrated into instruction to support student learning, (d) provide preservice teachers with practice in designing instruction that integrates technology to enhance learning, and (e) provide opportunities to reflect on their experiences (Adamy & Boulmetis, 2005; Alayyar, et al., 2010; Hur, et al., 2010; Koehler & Mishra, 2005b; Williams, et al., 2009). In order to help preservice teachers “connect technology to the process of teaching and learning” (Lambert, Gong, & Cuper, 2008, p. 387), instruction should provide authentic tasks that are directly related to classroom teaching and learning and use a combination of instructional approaches that focus on technology integration skills and transfer to the classroom context (D. Brown & Warschauer, 2006; Kay, 2006; Lambert & Gong, 2010). While a variety of instructional approaches have been documented in the literature, the answers as to what combination of instructional approaches are most appropriate and effective in increasing preservice teachers’ abilities to integrate technology in their teaching are still lacking (Kay, 2006). The literature can provide insight into the instructional approaches that have been used in previous research, their potential effectiveness in promoting technology integration knowledge and skills with preservice teachers, and the potential weaknesses of these approaches which should be addressed in future efforts to develop and research similar courses.

Lessons from the literature. The literature suggested that technology integration coursework for preservice teachers in recent years has placed an emphasis on promoting preservice teachers' technology integration skills through situated, classroom-based learning experiences (Chen & Chan, 2011; Graham, et al., 2009; Hur, et al., 2010). For example, Hur, Cullen, & Brush (2010) developed guidelines for their course design efforts suggesting that preservice teachers need (a) concrete experiences with technology integration; (b) opportunities for reflection to help them construct knowledge; (c) assistance in applying technology to real-world classroom situations; (d) support from a community of learners; and (e) to develop TPACK through using their technology knowledge in relation to their developing teaching and content knowledge. Hur and her team (2010) accomplished this in three phases:

1. Preparation, which focused on preservice teachers building classroom-appropriate, foundational technology skills;
2. Exploration, during which preservice teachers were exposed to technologies applied to specific subject areas, then collaboratively reflected on these applications to build their TPACK understandings; and
3. Implementation of technology-enhanced lessons by preservice teachers with students in classrooms.

Qualitative analysis of interview data from eight preservice teachers suggested that they gained confidence in their ability to plan for and use technological tools in the classroom (Hur, et al., 2010).

Kinuthia, Brantley-Diaz, and Clark (2010) emphasized the role of reflective knowledge and community knowledge in enhancing preservice teachers' understandings of technology, content, and pedagogy through a case-based learning methodology. The cases used in their instructional technology course for preservice mathematics teachers provided a common starting point and vicarious classroom experiences for the otherwise inexperienced preservice teachers. Unlike classroom placements where technology use can vary widely based upon the skills of the host teacher (Dawson, 2006; Dawson & Norris, 2000), cases provided consistent contexts for problem-solving. Cases supplemented course activities, which included learning technology skills, completing written reflections, writing technology-based lesson plans including classroom-appropriate resources and artifacts, and submitting an electronic portfolio to document learning. Through group discussions of the individual cases, preservice teachers were able to consider alternative technologies and pedagogies for the lessons presented in the cases, and reflected upon their own plans and experiences, and received feedback from their peers. Qualitative analysis of various data sources from eight preservice teachers suggested the course experiences increased their confidence in their technology integration skills and knowledge, and increased awareness of issues impacting technology integration in classrooms. No effect was found related to mathematics teaching skills, however, which were one focus of the approach.

Lambert & Gong (2010) reconceived their technology course for preservice teachers to move away from the original focus on technology skills development and shift toward a more instructional focus. They modified the course to include “subject-related, classroom tasks; principles of teaching and learning;” (p. 59) content knowledge; technical skills; and a focus on the ability to explain reasons for including specific technological tools in instruction. Preservice teachers created classroom-appropriate technology products that matched the stated purpose for each class session. A one sample, pre-/post- analysis found that preservice teachers’ experienced improved attitudes toward technology integration, increased confidence in their technology integration abilities, and increased technology skills.

Ward & Overall (2011) included a two-credit technology integration course in a series of classes that students took as a cohort. In the technology integration course, preservice teachers learned technology skills while instructors modeled the necessary classroom management and pedagogy necessary for successful technology integration. Preservice teachers were also required to implement a technology-enhanced lesson in placement classrooms specifically by creating a website (called a WebQuest) that included comprehensive directions and resources used by students during lesson implementation. Qualitative analysis of survey data found increased classroom-related technology skills and technology integration skills. A comparison group from another university showed similar statistically significant gains, with slightly smaller effect sizes than the treatment group. Statistical analyses to test for differences in the two groups were not reported.

These studies exemplify some of the limitations of recent research in this field. Many researchers create and study their own instructional approach that is unique to their preservice teacher education program, thus providing limited guidance for preservice teacher education more generally (Donovan, Green, & Hansen, 2011; Koh & Divaharan, 2011; Lubin & Ge, 2012). The lack of equivalent comparison groups in the studies provides evidence of individual approaches that have potentially positive effects with particular samples of preservice teachers, but no comparison of approaches to determine if certain instructional approaches are potentially more effective than others. These comparisons are necessary to evaluate the effectiveness of the variety of approaches in technology integration education for preservice teachers (Kay, 2006; Lambert & Gong, 2010; Ward & Overall, 2011).

These examples all found evidence of positive effects on factors that impact preservice teachers' technology integration abilities, and have many similar components in their instructional approaches. The approaches tended to include (a) collaboration; (b) reflection; (c) problem-solving; (d) building of foundational technology skills; and (e) use of authentic teaching situations, often in the form of lesson planning. These common components provide substantial guidance as to what types of instruction have the potential to be effective in this realm. These approaches were also all grounded in constructivist and collaborative learning theories, suggesting that approaches with this theoretical basis have potential for improving factors that impact technology integration in preservice teachers. Each group of researchers also explored several factors that affect technology integration, which is evident in their inclusion of multiple measures and dependent variables. As technology integration is complex, and there are multiple factors that impact preservice teachers' technology integration abilities, exploring multiple outcomes has become standard practice in research in this field (Kay, 2006). As with much of the research in this field, exactly which outcomes are explored has evolved over time.

Critical Factors of Technology Integration

There is extensive research on both factors that enhance teachers' technology integration and the barriers to technology integration in K-12 schools. Ertmer (1999) classified barriers to technology integration into two types. *First-order barriers* include those that are extrinsic to teachers, such as resource availability, time, and support. *Second-order barriers* consist of barriers that are internal to teachers, such as attitudes and beliefs about teaching and learning that may prevent them from utilizing technology successfully with students. Early efforts to integrate technology in schools focused on the elimination of the first-order barriers, assuming that integration would take place once adequate resources were available (Ertmer, 1999). While access to resources is certainly a fundamental first step, as access has become less of a factor, the focus of technology integration efforts has shifted to the second-order barriers. True integration of technology requires more than just access to the necessary tools; it requires changes to many aspects of teaching practice (Sandholtz, et al., 1997; Wozney, et al., 2006).

Considerable research on teacher technology integration has emphasized the impact of the second-order barriers, specifically a combination of positive attitudes toward the use of technology to enhance learning and technology skills (Kay, 2006; Penuel, 2006; G. Watson, 2006; Whetstone & Carr-Chellman, 2001). Each of these factors has been found in research to be a significant predictor of teachers' actual technology integration practices (Agyei & Voogt, 2011; Wozney, et al., 2006).

Attitudes toward technology. While removing any one barrier does not solve the technology integration problem, research has focused on the importance of a teacher's attitude toward technology use as a key variable in a teacher's decision to use technology with students (H. J. Becker, 1994; Ertmer & Bai, 2008; Inan & Lowther, 2010). Attitude is defined in the literature as "an informed disposition to respond" toward or away from an object (Koszalka, 2001, p. 96). Attitude includes four components: (a) cognition, including knowledge about something (like technology use in classrooms) and beliefs that it will be beneficial; (b) feelings, defined as an emotional response generally based on experience; (c) intent, which indicates that a person is ready to take action; and (d) the person's actual behavior (Koszalka, 2001; Zimbardo & Leippe, 1991). Armitage and Christian (2003) suggested that, while attitude can be difficult to measure, there was generally a strong correlation between attitudes and behavior, particularly between specific (rather than general) attitudes and corresponding behavior. Positive attitudes were predictive of productive behavior, while negative attitudes were affiliated with a lack of effort (Campbell & Williams, 1990).

With respect to technology use by teachers specifically, research supports that positive attitudes toward technology are a necessary prerequisite for effective technology integration by teachers in classrooms (Christensen & Knezek, 2000a; Ertmer & Bai, 2008; Hew & Brush, 2007; Milbrath & Kinzie, 2000). Even teachers who had the skills and knowledge necessary to use technology in the classroom were unlikely to do so without a positive attitude toward technology and its role in the learning process (Palak & Walls, 2009; Ropp, 1999).

Changing attitudes, however, can be a difficult process. Zimbardo and Leippe (1991) suggested that attitude change begins with a person's knowledge, attention, and understanding of a new idea, which can ultimately lead to both acceptance of the new idea and a change in behavior. Rogers (1995) agreed, indicating that knowledge about an innovation, its uses, and its value leads to a teacher developing attitudes that will affect his/her decision of whether to adopt the innovation. Instruction that combines (a) modeling or demonstration of behavior, ideally by a role model; (b) practice; and (c) reinforcement, has been shown to result in attitudinal change (Smith & Ragan, 2005).

Research has found that instruction in technology integration resulted in improvement in teachers' attitudes toward technology. A substantial amount of research has made a connection specifically between technology courses that provided training in technology skills and integration for preservice teachers and improved attitudes toward technology and its use with students (Abbott & Faris, 2000; Agyei & Voogt, 2011; Dawson & Norris, 2000; Ertmer & Bai, 2008; Milbrath & Kinzie, 2000). For example, Abbott and Farris (2000) found significant increases in preservice teachers' attitudes toward technology resulting from incorporating instructional strategies and meaningful projects that required the use of technology into their preservice literacy course. While there is much similar research to support that technology integration instruction can promote positive attitudes toward technology, and that these attitudes are a likely precursor to technology integration, positive attitudes alone were not enough to guarantee that teachers would successfully integrate technology (Ertmer & Bai, 2008; Rovai & Childress, 2002).

Technology skills. Teachers often cite a lack of technology skills as the reason they do not use technology with students (Hew & Brush, 2007; Project Tomorrow, 2011). In an early study on the characteristics of computer-using teachers, Becker (1994) found that exemplary computer-using educators had higher than average computer skills, often as a result of more time spent using computers both in formal training and informal sessions. In order to provide teachers with technology skills and additional time spent exploring various tools, many initial efforts to help inservice and preservice teachers integrate technology focused solely on the teaching of technology skills (Abbott & Faris, 2000; Polly, et al., 2010; Zhao, et al., 2002). This instruction tended to result in teachers with personal technology skills that were not necessarily transferable into the teaching and learning context (Dawson & Norris, 2000; Evans & Gunter, 2004; Zhao, et al., 2002).

While it is widely accepted that technology skills are necessary for technology integration, researchers have had difficulty defining exactly what technology skills are necessary for a teacher to be proficient enough with the tools to be a successful technology integrator (Zhao, et al., 2003). Early teacher technology standards attempted to create exhaustive lists of skills and knowledge related to the use of technology tools that teachers were expected to master (International Society for Technology in Education, 2000). Due to the ever-changing nature of technology tools, however, it was later recognized that technology proficiency is a moving target (Ertmer & Ottenbreit-Leftwich, 2010), as any definition of technology literacy is likely outdated by the time it reaches publication (Koehler & Mishra, 2009). The best definition would be to emphasize the particular skills that are relevant in a given context (Kay, 2007). Especially considering the wide variety of content areas and topics that early childhood and elementary school teachers are required to teach, defining a comprehensive skill set that will meet every preservice teacher's future needs would be impossible (Ertmer & Ottenbreit-Leftwich, 2010).

While a wide variety of technology skills were seen in research studies with preservice teachers, depending on the specific purposes of the research, a core of foundational technology skills seem to consistently appear in standards and research over time. These skills include basic operations, productivity tools (i.e. word processing, spreadsheets), communications, World Wide Web, and multimedia (Brush, Glazewski, & Hew, 2008; International Society for Technology in Education, 2000; Ottenbreit-Leftwich, et al., 2010; Palak & Walls, 2009; Zhao, et al., 2003). The research also suggests these were the skills most commonly taught in preservice teacher education programs and most commonly used in classrooms (Project Tomorrow, 2010; Thieman, 2008).

One solution used in technology integration education, therefore, was that of ensuring that preservice teachers have these foundational technology skills that give preservice teachers the ability to effectively use the tools that were most prevalent in classrooms (Thieman, 2008; Vannatta & Banister, 2008). Recent studies have indicated that a teacher having more advanced technical skills does not necessarily result in more effective technology use with students than more basic skills (Palak & Walls, 2009), as successful technology integrators possess a wide range of technology skills and competencies (Zhao, et al., 2002). Thus, providing preservice teachers with a baseline of technology skills that can be built upon throughout their teaching careers has been shown to help them become inservice teachers who have success with learning newer technologies by applying their existing foundational skills to new situations (Hofer & Swan, 2008; Jaipal & Figg, 2010; Koehler & Mishra, 2003).

Research on specific technology skills for teachers has waned in recent years, as researchers began to recognize that the technology skills necessary for integration into teaching and learning go beyond merely being able to operate the hardware and software (Koh & Divaharan, 2011). Even for a relatively technologically proficient teacher, neither attitudes nor technology skills work alone. A person's attitudes toward technology impacts their technology skills, and their skills affect their attitude (Hew & Brush, 2007). For example, Snoeyink and Ertmer (2001) found that teachers did not see the value of technology integration until they had basic technology skills. Thus, attitudes and skills must both be addressed in order to improve a teacher's ability to integrate technology into instruction (Christensen & Knezek, 2002). As a result of recognizing that there were multiple factors involved, research evolved away from studying attitudes and skills in isolation and toward teaching and researching the more complex topic of technology integration (Koh & Divaharan, 2011).

Beyond attitudes and skills. While both positive attitudes and technology skills are necessary components of any technology integrator's repertoire, they are not enough to guarantee success integrating technology into classroom learning activities. In order to be an effective technology integrator, teachers need to know how to apply their technology skills to teaching and learning within the classroom context (Cennamo, Ross, & Ertmer, 2010; Koehler, Mishra, Yahya, et al., 2004; Zhao, et al., 2002). Knowing how to operate the technology for personal tasks is not enough, as teachers need to feel confident in their ability to operate technology for the purpose of improving student learning (Evans & Gunter, 2004; Lambert, et al., 2008). Even teachers who are willing and able to operate the tools will not integrate technology if they lack the knowledge related specifically to how to use the tools to support teaching and learning activities (Hew & Brush, 2007; Mishra, Koehler, & Kereluik, 2009). This involves combining technology-related knowledge with other essential knowledge of teaching, including (a) pedagogy, which is knowledge of the methods of teaching and learning; and (b) content, meaning the subject matter that is being taught (Koehler & Mishra, 2005b; Shulman, 1986).

Technology Integration Models

Researchers have been exploring for many years exactly how technology skills and knowledge, content knowledge, and pedagogy should be combined in inservice teacher training and preservice teacher education to enhance teachers' abilities to use technology in powerful ways with their students (Lei, 2009; Schaffer & Richardson, 2004; Schmidt, et al., 2009). While researchers have attempted to create models that represent teachers' technology integration knowledge, many of these models treated technology as an isolated component (Zhao, et al., 2003). For example, the early efforts to represent what teachers needed to know in order to integrate technology resulted in technology standards for teachers at both the state and national levels (Barron, Kemker, Harmes, & Kalaydjian, 2003). These early standards looked primarily at technology skills competencies, and were ultimately determined to be inadequate representations of technology integration knowledge as they failed to treat technology as an integrated piece of a teacher's overall understandings about teaching and learning (Zhao, et al., 2002).

Later versions took a more integrated approach by expanding the focus to include the necessary conditions and personal characteristics of teachers that led to adoption of technology as a tool for teaching (H. J. Becker, 1994; Mueller, et al., 2008; Wozney, et al., 2006; Zhao & Cziko, 2001). For example, Zhao and Cziko (2001) looked at technology adoption from a

Perceptual Control Theory perspective. In their model, there were three necessary conditions in order for teachers to use technology: (a) belief that technology is more effective that what is currently being used; (b) belief that using technology will not disrupt more important goals the teacher would like to attain; and (c) belief that he/she has “sufficient ability” and resources (p. 6).

TPACK. While Zhao & Cziko (2001) provided guidance with respect to prerequisites for technology adoption, their model did not provide specific guidance regarding exactly what “sufficient ability” to integrate technology entailed. Technological Pedagogical Content Knowledge (TPACK; Mishra & Koehler, 2006; Pierson, 2001), however, provided a theoretical framework to guide what both preservice and inservice teachers needed to know in order to effectively integrate technology. Mishra and Koehler (2006) built upon Shulman’s (1986) well-known work with Pedagogical Content Knowledge (PCK). PCK provided a framework that explained how isolated pedagogical knowledge and content knowledge were not adequate for a teacher to successfully use pedagogy to teach content, but that a complex understanding of how the two types of knowledge worked together was necessary.

Pierson (2001), followed by Mishra and Koehler (2006), expanded upon the PCK framework, and argued that teaching technology, pedagogy, and content separately is not enough. The three must be blended in order for teachers to fully understand how to interpret subject matter and present it in a way that makes sense to the learners while utilizing technology as a teaching and learning tool. Within the context of TPACK, Technological Knowledge (TK) was defined as knowledge about all types of technologies. Content Knowledge (CK) referred to an understanding of the subject matter (e.g. language arts, mathematics) that will be taught, while Pedagogical Knowledge (PK) related to “methods and processes for teaching” (Schmidt, et al., 2009, p. 125). Technological Content Knowledge (TCK) is an “understanding of the manner in which technology and content influence and constrain one another” (Koehler & Mishra, 2009, p. 65). Preservice teachers must be able to match technologies to specific content understandings, which requires being well-versed in technological applications for curricular purposes (Koehler & Mishra, 2009; Pierson, 2001). Technological Pedagogical Knowledge (TPK) requires an understanding of how the use of technological tools impacts all facets of teaching and learning, including everything from the location of technological devices in the classroom space to the nuances of how students learn (Koehler & Mishra, 2009; Pierson, 2001).

TPACK was defined, therefore, as an “intuitive understanding” (p. 125) of how these three types of knowledge can be used together in the classroom to improve teaching and learning (Schmidt, et al., 2009). TPACK is not additive, in that it is different from its three individual components. Teachers who are effective technology integrators have a “deep, flexible, pragmatic, and nuanced understanding of teaching with technology” (Koehler & Mishra, 2009, p. 66). Teaching effectively with technology involves, therefore, an understanding of all three domains (technology, pedagogy, and content), and an understanding of the interrelationships of these three as they pertain to the teaching context (Koehler & Mishra, 2009).

Pierson (2001) suggested “technological-pedagogical-content-knowledge” (p. 427) as a way to more precisely define technology integration as it is practiced by those with expertise in this area. TPACK represents a departure from more technocentric representations of technology integration knowledge that began with operating the technology, then later attempted to apply these technologies to teaching and learning contexts (Harris, Mishra, & Koehler, 2009; Papert, 1990). TPACK, in contrast, emphasizes the connections between technology, pedagogy, and content, essentially bridging the gap between the essential components of teaching and technology tools (Harris, et al., 2009; Koehler, Mishra, Yahya, et al., 2004).

The TPACK framework as envisioned by Mishra and Koehler (2006) was initially applied in the context of inservice teacher professional development. The use of this framework, however, has recently been expanded into preservice teacher education as well. For example, Brush and Saye (2009) used case studies and authentic contexts with preservice social studies teachers in order to build their TPACK specifically related to social studies content. Hammond and Manfra (2009) described their application of a pedagogical framework (*giving-prompting-making*) as a means for helping preservice social studies teachers understand and develop TPACK; while Ozgun-Koca, Meagher, and Edwards (2009) looked at the effects of a technology-rich methods course on preservice teachers' knowledge of TPACK related to mathematics.

These studies provided potential instructional approaches for building TPACK with preservice teachers. However, data collection to actually measure the TPACK of preservice teachers was not included in these studies. Data that were collected were highly contextualized to the particular study. The effects, therefore, of these instructional approaches outside of each particular context were not explored. As evidence is lacking to recommend one particular instructional approach over another in terms of helping preservice teachers develop connections between their technology, pedagogy, and content knowledge, more research is needed in this area (Kay, 2006; Ozgun-Koca, et al., 2009).

The Potential of a Design Teams Approach

One instructional approach that has been proposed in the research for helping to provide connections for preservice teachers between the content taught in technology integration courses and their developing understandings of content and pedagogy learned in other coursework is a design teams approach (Alayyar, 2011; Koehler & Mishra, 2005b). In order to explore in detail the potential of this instructional approach in this context, this section will provide information on the origins and applications seen in the literature of a design teams approach. Research on the use of this approach with preservice teachers specifically in the context of technology integration education will be presented and synthesized to provide both context and a foundation for the current study. The literature will be used as the basis for establishing and defining the essential components of the implementation of a design teams approach. Finally, the components and features of a design teams approach will be analyzed specifically in terms of its potential impacts on preservice teachers' attitudes toward technology, technology skills, and TPACK.

Design teams were initially conceived by Kolodner and her colleagues (2003) as part of their Learning By Design™ (LBD) approach for the teaching of science. As envisioned by Koldner's team (2003), Learning By Design™ combines the methods of case-based reasoning (Kolodner, 1993) and problem-based learning (Barrows, 1985). In LBD, students worked in design teams to learn scientific concepts through a sequence of classroom activities designed to help them explore, collaborate, investigate, design, reflect, and revise based on feedback received from their classmates and the instructor. Structures and guidance provided by the instructor kept students focused on specific tasks and goals, scaffolded experiences to support students as they progressed through the learning process, coordinated design teams tasks and activities, and ensured that learning goals were met.

While a design teams approach was initially envisioned in K-12 science classrooms, the components of such an approach have also been applied to technology integration instruction. In this context, preservice teachers were presented with an instructional problem to solve, and worked in collaborative teams to design artifacts using technology tools to potentially solve the problem (Alayyar, et al., 2010; Fessakis, Tatsis, & Dimitracopoulou, 2008; Koehler & Mishra, 2005a). While this application of a design teams approach was very similar to that used by Kolodner and her colleagues, the learning focus in these teacher education settings was on developing teachers' knowledge of instructional technology and instructional theory, and enhancing their ability to apply this knowledge to classroom contexts (Fessakis, et al., 2008; Koehler & Mishra, 2005b).

Research suggests that collaborative approaches like design teams that embed instruction for preservice teachers in authentic teaching contexts are more effective in promoting learning than more traditional instructional approaches (Brush & Saye, 2009; Korthagen & Kessels, 1999). The combination of these rich contexts and structured experiences for collaboration and reflection have been shown to improve preservice teachers' understanding of the complexities of the teaching context, increased their abilities to anticipate and address potential problems that could occur during instruction, and ultimately result in improvement in preservice teachers' instructional skills (Kurtts & Levin, 2000; H.-L. Lu, 2010).

As developing sound instructional skills that can ultimately transferred to the classroom context is an essential component of effective preservice teacher education, using instructional approaches that enhance these abilities is essential (Howard, 2002; National Council for Accreditation of Teacher Education, 2010). Research indicates that embedding preservice teachers' learning in the classroom context highlights the value of the instructional methods under study by interconnecting the instructional methods with the eventual context in which they will be used (Gibbons, Nelson, & Richards, 2002; Hughes, 2005; Joyce & Showers, 2002). A design teams approach provides this contextualized learning environment by actively engaging participants in meaningful, classroom-based activities and collaboration focused on the building of instructional knowledge. This combination of active engagement, contextualized learning, and collaboration has been found to increase the likelihood that preservice teachers will be able to apply the knowledge gained in their teacher education program to new situations and contexts, including classroom teaching (Hacker & Niederhauser, 2000; Howard, 2002; Hughes, 2005).

While this indicates that a design teams approach is consistent with the research relating to the type of learning experiences necessary in teacher education settings, the effectiveness of the design teams approach in the specific context of preservice teacher technology integration education is just beginning to be explored. Determining how a design teams approach can provide meaningful technology integration experiences that are embedded in authentic classroom teaching contexts can inform efforts to design instruction that helps preservice teachers develop the necessary knowledge and skills to be successful technology integrators. The recent literature in this area provides substantial guidance in this direction.

Design Teams and Technology Integration Skills Development

In proposing their TPACK framework, Koehler and Mishra (2005a) suggested LBD (Kolodner, et al., 2003) as an appropriate approach for helping teachers develop their understandings of the seven TPACK components. In their Learning Technology by Design approach (Koehler, Mishra, & Yahya, 2007), teachers worked in collaborative groups, called design teams, "over extended periods of time" (p. 744) to "develop technological solutions to authentic problems" (p. 741). Teachers enhanced their understanding of the TPACK components through engaging in and solving real-world, ill-structured problems that provided context for learning about instructional technology (Koehler & Mishra, 2005b).

To support the assertion that Learning Technology by Design would be effective for developing TPACK in teachers, Koehler and his colleagues (2004) studied the effect of a design teams approach in a master's level educational technology course where teachers worked in teams with university faculty members to design online courses. These team interactions resulted in shifts in attitudes toward technology as educators experienced the value of technology tools in real-world, instructional settings. Teachers learned technology skills “implicitly” (p. 34) by learning about the technology necessary for solving a problem or meeting specific instructional or learning needs with the chosen solution. The ill-structured, open-ended problems grounded in real-life scenarios afforded by the Learning Technology by Design model helped the master’s students learn technology skills in context, as well as learning the specific skills that were needed for solving their instructional problem as they developed and tested “individual and collective understandings” (Koehler & Mishra, 2005b, p. 135). Working in design teams to plan and create instructional materials required team members to negotiate how technology, pedagogy, and content worked together in their proposed solutions, thus increasing their understandings of TPACK. As a result, teachers explored the interactions between technology, pedagogy, and content as they worked in their teams to apply the TPACK components in the context of designing artifacts for instructional purposes.

Their design teams approach showed promise with respect to increasing master’s students’ TPACK. However, the study focused on TPACK with inservice teachers who participated in a master’s level course that utilized a design teams approach, potentially limiting its generalizability to other groups and contexts. The researchers measured only gains in TPACK understandings, not including information about potential impacts on other factors that ultimately affect a teachers’ ability to integrate technology. This study helped further define and clarify the TPACK framework, provided information about how this knowledge developed in teachers, and lent support to the researchers’ hypothesis that design teams was an appropriate approach for building technology integration knowledge. While the instructional approach seemed effective in this context, additional research could help determine if this is more effective than other approaches for enhancing relevant learning in technology integration education contexts.

Other researchers have begun to test the effectiveness of a design teams approach in enhancing both TPACK and other factors affecting technology integration with other teacher populations, including preservice teachers. In their research in Kuwait, Alayyar and her team (2011; 2010) explored the effect of using a design teams approach in a technology integration course on preservice science teachers' attitudes toward technology, technology skills, and TPACK. The preservice teachers worked in design teams over a 12-week period to develop a technology-integrated lesson plan to solve an instructional problem posed by the instructor. Researchers found significant gains in some components of preservice teachers' attitudes toward technology, their basic technology skills, and their understanding of six of the seven TPACK domains (Alayyar, 2011).

Alayyar's (2011; 2010) research suggests that a design teams approach has potential for improving multiple factors that impact teachers' technology integration, including attitudes toward technology, technology skills, and TPACK. The findings lend further support to the hypothesis that a design teams approach is appropriate in the technology integration education context. As this is one study with one group of preservice science teachers outside of the United States, the results are promising but additional research would be needed to confirm these results and determine if they are generalizable to other contexts. Alayyar (2011), similar to Koehler and Mishra (2005b; 2004), only studied the design teams approach, so it did not provide further information with respect to the effectiveness when compared to other instructional approaches. The existing research on the design teams approach for technology integration education is encouraging, yet there is still substantial room for additional research to add to the growing knowledge base in this area.

Components and structures of a design teams approach. The literature, therefore, strongly suggests that preservice teachers' attitudes toward technology, technology skills, and their TPACK ultimately impact their potential as technology integrators. In addition, the use of a design teams approach in preservice teacher technology education has been shown to increase preservice teachers' attitudes toward technology, technology skills, and TPACK. The literature, however, is more limited in terms of guidance for the structure and organization of the implementation of a design teams approach in technology integration education in general, and with preservice teachers specifically. In order to further explore how a design teams approach can potentially be applied in a technology integration course with preservice teachers, the essential components and structures of such an approach must be identified. Descriptions of the implementations of design teams approaches in the literature were examined and are synthesized here to provide additional guidance to inform the implementation of this approach.

Researchers who have used design teams approaches agreed that they comprise two primary components: whole group activities and small group activities. While small group activities were focused on investigating, exploring, justifying decisions, and developing artifacts; whole group activities were for learning from each other's successes and failures, providing and receiving feedback, and refining participants' understandings of key concepts essential for problem solving (Koehler, Mishra, Hershey, et al., 2004; Kolodner, et al., 2003). The instructor, as in many cooperative learning models, has a facilitative role, providing (a) guidance for the collaborative process, (b) instruction on necessary content or skills, and (c) expert feedback and resources as needed (Johnson & Johnson, 2009; Kolodner, et al., 2003).

Learner supports. While these general instructor responsibilities were similar across design teams' implementations, design teams approaches have been used with various ages of students and with varying levels of learner support provided by the instructors. Kolodner and her colleagues (2002; 2003) worked with middle school students in their study, and instructors provided significant support to their students in the form of (a) skill and concept instruction, (b) handouts to guide thinking processes, (c) guiding questions to structure team interactions and reflections, and (d) meetings with small groups (design teams) and the entire class. Koehler and his team (2004) researched their design teams approach with inservice teachers who were enrolled in a master's in educational technology course. As a result of working with older students who had experience with the content being taught, the course instructors provided very little direct support for the design teams' processes. The course included required readings and discussions of these readings. Each design team included both master's students and a university professor who was the instructor of the course that the team was tasked with designing. Other than these basic structures and occasional assistance provided to individual teams by the instructor, the teams in this implementation were left to negotiate their own team processes.

In contrast, researchers who implemented a design teams approach with undergraduate students described providing a combination of (a) direct instruction on technological tools, (b) guiding questions to structure design teams' work and reflections, (c) online environments for team collaboration, (d) structured presentations by instructors on expectations and design principles, and (e) less structured team work sessions (Alayyar, 2011; Alayyar, et al., 2010; Fessakis, et al., 2008). The instructors in these implementations provided fewer learner supports than were seen with the middle school students (Kolodner, 2002), but more support than the more experienced teachers received in the master’s-level course (Koehler & Mishra, 2005b; Koehler, Mishra, Hershey, et al., 2004).

Course formats for design teams approaches. While the majority of design teams approaches noted in the literature were implemented in traditional classroom settings, online communication was often used to supplement face-to-face meetings. Technologies such as email, discussion boards, and blogs have been used as forms of communication for design teams (Fessakis, et al., 2008; Koehler & Mishra, 2003). While many components of a collaborative learning environment are best accomplished in person (Johnson & Johnson, 1994), carefully selected technology tools can provide an effective means of communication among team members when face-to-face meetings are not possible (Single & Single, 2005).

One tool that shows promise for facilitating the various types of interactions involved in implementing a design teams approach is web conferencing. In years past, the terms *computer* and *web conferencing* were commonly used to refer to text-based online communication. As technology has advanced, however, the term *web conferencing*, also called virtual meetings or webinars, is generally accepted to refer to synchronous, online communications that include multiple tools, such as audio and video, online polling of participants, document and application sharing, text chat, and virtual whiteboards for collaborative activities (Hartley, 2006; Skylar, 2009). Web conferencing marries a variety of applications to provide a complete set of tools that can be used to facilitate both synchronous and asynchronous instruction and communication (Hartley, 2006).

While reduced learning outcomes related to completing course activities via web conferencing is a potential concern, research has found that university-level students who participated in learning via a web conferencing environment were as successful as those in both more traditional online and face-to-face environments (Coffey, 2009; Skylar, 2009). Students indicated a preference for synchronous online learning versus asynchronous environments, student satisfaction increased when using synchronous tools compared to providing asynchronous resources, and web conferencing specifically reduced students' feelings of isolation in online classes (Beattie, Spooner, & Jordan, 2002; Offir, Lev, & Bezalel, 2008; Reushle & Loch, 2008).

Challenges faced in conducting collaborative, team-based activities via computer-mediated communications include the difficulty of establishing the relationships needed for effective team interactions in an online environment (Ensher, Heum, & Blanchard, 2003). In addition, access to the appropriate tools needed to effectively run this relatively technologically advanced application represented an important component in successful online peer support initiatives (Single & Single, 2005). This would suggest that a blended approach, providing both face-to-face and online interaction, would take advantage of the unique features of the web conferencing environment while still providing the relationship-building that is best established in face-to-face meetings. In addition, ensuring access to the online tools, either via personal technology or loaned equipment, would be necessary for the success of a blended implementation of a design teams approach.

A summary of the existing studies and the structures and formats of the design team approaches in each is provided in Table 1.

Table 1

Summary of Relevant Research Using Design Teams Approaches

Research	Context	Length	Format	Design Teams' Supports
Kolodner, et al., 2003	Middle school science class	8 weeks	Face-to-face	• Whole group instruction • Handouts/Graphic organizers to guide team activities • Instructor-led team meetings • Multiple structured activities for all steps in model • "Ritualized and sequenced activities" (p. 495)
Koehler & Mishra, 2005b	Masters' in educational technology course	Semester	Face-to-face with asynchronous online communication (email, discussion boards)	• Instructor-provided readings and discussions • Mini-lessons on technology topics (20-30 minutes) • Assigned teams • Independently functioning teams with little instructor support
Fessakis, et al., 2008	University math education course	5 weeks	Online (blogs)	• Instructor-provided readings and interactive technology tools • Guidance on general steps in process • Some required assignments
Alayyar, et al., 2010	Preservice science education course	12 weeks	Face-to-face	• Lessons on multimedia technology tools and classroom uses • Guidance on general steps in process • Some required assignments • Coaching by content, technology, and pedagogy specialists

Components of the approach. As the literature suggested collaboration was essential in a design teams approach, the collaborative interactions in the design teams must be productive and successful in order for a design teams approach to result in the intended learning outcomes for preservice teachers. Johnson and Johnson (1994) provided guidance for teachers implementing collaborative environments through their cooperative learning model, which they described as requiring both a common group goal and individual accountability. They indicated that, regardless of the size of the group or the focus of the interaction, successful cooperative groups had five characteristics:

1. Positive interdependence, meaning each group member had a unique contribution such that all members' efforts were required for the group to be successful;
2. Promotive, face-to-face interaction, meaning group members encouraged and assisted each other;
3. Both individual accountability and personal responsibility toward achieving group goals;
4. Use of interpersonal and small group skills, including communication skills and the ability to resolve conflicts; and
5. Regular reflection on the group's functioning and effectiveness (p. 2).

In addition to providing the conditions to promote successful collaborative interactions, the design teams approach should include specific elements designed to guide participants through both the design process and, ultimately, the learning process (Johnson & Johnson, 2009; Kolodner, et al., 2003; Risko, Vukelich, & Roskos, 2009). While the research on the use of design teams approaches in education includes settings from eighth grade to preservice and inservice teachers and university faculty (Alayyar, et al., 2010; Fessakis, et al., 2008; Koehler & Mishra, 2005a; Koehler, Mishra, Hershey, et al., 2004; Kolodner, et al., 2003), the major elements of the overall approach were primarily the same across these examples:

1. Presentation of a design challenge
2. Whole group instruction on essential content

3. Brainstorming potential solutions, refining ideas, and developing potential solutions or artifacts
4. Sharing solutions and testing of artifacts
5. Feedback from the whole class and within teams, and team and personal reflection
6. Focus on implementation through refining, redesigning, and testing
7. Sharing with the whole class, and team and personal reflections

Iteration was essential in the implementation process: These steps were repeated as necessary until the teams developed an artifact that they considered to be their final product. In terms of work with preservice and inservice teachers, this artifact was often the learning materials that could be implemented with students (Fessakis, et al., 2008; Koehler & Mishra, 2005b; Kolodner, et al., 2003).

In order to successfully participate in a design teams approach, participants needed instruction and guidance with respect to the collaboration and communication skills that were necessary for the teams to be successful (Amador, Miles, & Peters, 2006; Johnson & Johnson, 1994; Risko, et al., 2009). With preservice teachers, as they were inexperienced both in teaching and in providing constructive feedback about instruction, additional structure and guidance was needed to help them learn how to give constructive, professional feedback to their peers (Kurtts & Levin, 2000; Neubert & McAllister, 1993). This instruction and support involved (a) clearly stating the instructional goals of the design teams approach, (b) assigning or having students assign roles to team members, (c) providing guiding questions to structure activities and team communications, (d) practicing the use of the design teams' processes, (e) supplying instructions or organizing frameworks to structure design teams' interactions, and (f) providing ample opportunity for debriefing design teams' functioning in order to facilitate successful group processes (Amador, et al., 2006; Derry, Hmelo-Silver, & Nagarajan, 2006; Fessakis, et al., 2008; Koehler, Mishra, Hershey, et al., 2004; Kolodner, et al., 2003; Kurtts & Levin, 2000; Risko, et al., 2009).

In the literature, implementations consisted of two primary class structures: design teams (small groups of 3 or 4 people) and community (the whole class). Each of these structures had specific functions within the process, as described here (Alayyar, 2011; Kolodner, et al., 2003).

Community (whole class). While the implementations of design teams approaches in the literature varied, there were consistently three primary functions for the community: (a) setting expectations and goals, (b) poster sessions, and (c) testing and feedback (Alayyar, et al., 2010; Koehler, Mishra, Hershey, et al., 2004; Kolodner, et al., 2003).

- Setting expectations and goals was accomplished early in the implementation, typically on the first day of design teams' work. During this process, the instructor communicated the purpose of design teams, the basic tasks involved, and the goals for the design teams' work.
- Poster sessions were forums for design teams to share their draft artifacts or solutions, explain their reasoning for choosing these particular options with the entire class, and receive feedback from class members that could be used to inform the team's future design decisions. During poster sessions, all design teams displayed their artifacts in their existing form and explained them to the community members. Community members provided verbal or written feedback to each team.
- Testing and feedback provided detailed information to the design teams about the functioning of their artifacts. Community members had the opportunity to test the current version of each team's proposed solution. Teams took detailed notes during the testing

and used the information and feedback received during the process to plan subsequent modifications.

Design teams (small groups). There were six primary functions for the design teams: (a) clarifying the problem or task, (b) assigning team members' roles, (c) brainstorming, (d) creating artifacts, (e) practicing, and (f) debriefing (Alayyar, et al., 2010; Koehler, Mishra, Hershey, et al., 2004; Kolodner, et al., 2003).

- Clarifying the problem or task involved each team discussing their understanding of the task, seeking clarification as needed, and conducting additional research or gathering of examples necessary for the entire team to understand the problem prior to beginning work on designing a solution to the problem.
- Assigning team members' roles involved selecting one member from each team to focus on a specific role during all team activities. The specific roles to be assigned were established by either the teams or by the instructor. These roles guided students during all group interactions, ensuring unique contributions and tasks for each team member.
- Brainstorming occurred at the beginning of the design process as team members thought about and recorded all possible solutions to the design problem. Teams brainstormed as many solutions as possible, along with a justification for why each was a workable solution. These brainstormed solutions were eventually narrowed down to a few of the most promising solutions. These promising solutions, and the justifications for why they were the most promising options, were then shared with the community during the poster sessions.

- Creating artifacts included drafting, modifying, revising, and finalizing artifacts that were chosen by the teams as the most promising solutions to the design problem. The actual form of the artifacts varied depending on the specific design problem.
- In implementations involving teaching contexts, practicing entailed sharing the proposed final artifacts with the design team members prior to implementing the final solution. In contexts where each team member created a different part of the teams' solution, practice involved combining these individual contributions into one complete, final artifact. When the process focused on team members creating their unique solutions, this involved each team member practicing the implementation of the solution with their design team as the audience. Practice sessions provided additional feedback to students and teams so minor adjustments or revisions could be made prior to selection or implementation of the final solution.
- Debriefing involved each design team reflecting upon and evaluating their team functioning in order to provide both positive reinforcement and constructive criticism regarding the teams' processes and progress. Debriefing activities were intended to improve the functioning of the design teams and occurred at the end of every design team session to inform future activities.

Sequencing of components. Each of these community and design teams' functions represented an essential component in the implementation of the design teams' approach. These components were organized and sequenced by the instructors to provide the scaffolding and iteration necessary for learning to take place (Kolodner, 2002). According to Jonassen (1999), scaffolding "provides temporary frameworks to support learning and student performance beyond the learners' capacities" (p. 235). The design teams approach provided scaffolding through (a) breaking the problem-solving process down into a sequence of small steps, (b) providing the shared expertise of all team members and the instructor when needed, (c) dividing resources and tasks among team members, and (d) helping participants develop their own knowledge base by interpreting their experiences through their interactions with each other (Gardiner, 2011; Kariuki & Duran, 2004; B. Watson, 1995). The entire process promoted "sustained inquiry and revision of ideas" (Koehler & Mishra, 2005a, p. 95) which preservice teachers needed to build the understandings necessary to apply their new knowledge in real-world situations. The steps in the design teams approach built upon each other, fostering the types of relationships and thinking processes required for authentic problem solving, thus the appropriate sequencing of the components is essential in ultimately promoting learning (Hawkes & Romiszowski, 2001; Koehler, Mishra, Hershey, et al., 2004). The iterative sequence of the components presented above, synthesized from the approaches presented in the literature, is included in Figure 2.

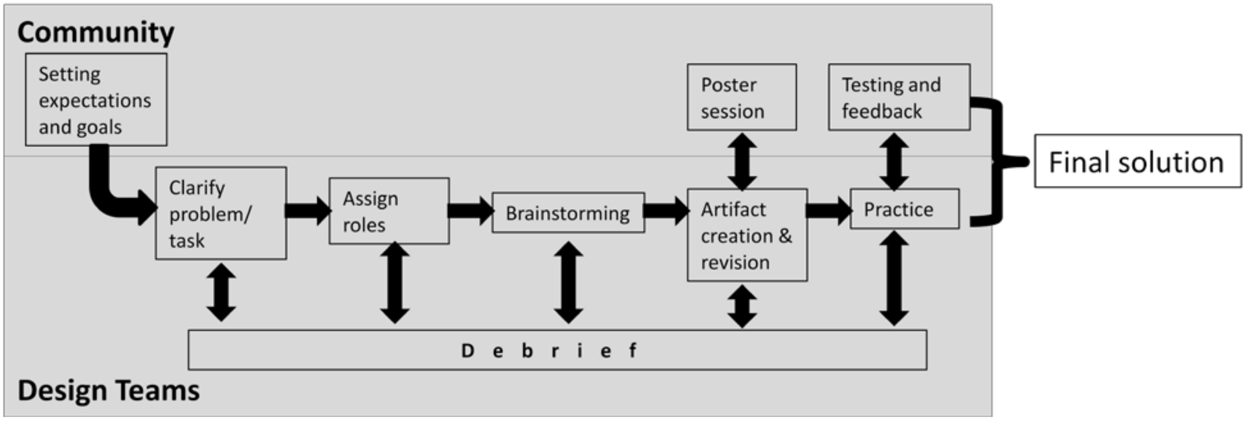


Figure 2. Sequence of components in the design teams approach.

Benefits of learning through a design teams approach. While there are many instructional approaches used in preservice teacher technology integration education which are based on similar theoretical foundations, a design teams approach is particularly well-suited to this context. The components of this approach, as well as the collaborative nature of the process, result in the types of learning experiences necessary for helping preservice teachers develop the skills and knowledge to be successful technology integrators (Alayyar, 2011; Koehler & Mishra, 2005b).

Benefits of collaboration. The design teams approach is grounded in learning theories that emphasize collaboration as an essential component in the learning process, such as social constructivism (Vygotsky, 1978), generative learning (Grabowski, 2004), constructionism (Harel & Papert, 1990; Papert, 1991), and constructivist learning (Jonassen, 1999). These theories suggest that learning is constructed through interactions with the environment, other learners, and learning communities. Approaches such as Learning By Design™ (Kolodner, et al., 2003) and Koehler and Mishra's Learning Technology by Design (2005a), were grounded in these socially-based learning theories.

Instructional approaches based on these theories have been successful in enhancing learning with various audiences (Fessakis, et al., 2008; Kolodner, et al., 2003). Research has suggested that participants in socially-based learning environments had a better understanding of content, were able to generate more ideas and potential solutions to problems, and were better able to apply their learning to new situations, when compared to students working individually or in competitive learning environments (Johnson & Johnson, 1994). These types of understandings and abilities are necessary for preservice teachers to become successful integrators of technology (Hur, et al., 2010). Research with inservice and preservice teachers has also supported the importance of collaborative approaches in increasing teachers' attitudes toward technology and their knowledge of technology, pedagogy, and content specifically (Briscoe & Peters, 1997; Koszalka, 2001; Lawless & Pellegrino, 2007). Teachers working in teams to design technology-based lessons enhanced their TPACK skills (Jang & Chen, 2010; Koehler & Mishra, 2005b) through the provision of a forum for practice, reflection, and collegial support inherent in structured collaborative interactions (Kurtts & Levin, 2000; Lim & Khine, 2006; Snoeyink & Ertmer, 2001).

Collaboration has particular importance in preservice teacher technology integration contexts (Hur, et al., 2010) When tasks are complex, the existence of collaborative groups allowed students to “pool their expertise” (Kolodner, et al., 2003, p. 505). This made the collective knowledge of the group, rather than only individuals’ knowledge and understandings, accessible to everyone in completing tasks (Kolodner, et al., 2003). In technology integration education contexts, where preservice teachers have a variety of expertise with respect to technology, pedagogy, and content, this group knowledge had particular advantages in terms of planning for and using technology in teaching and learning applications (Dawson, 2006; Hur, et al., 2010; Vannatta & Banister, 2008). Being able to access the collective knowledge of the group to solve problems facilitated preservice teachers’ shift from student to practitioner as they communicated, collaborated, and revised while designing instruction; increasing the quality of both the products created and the resulting learning (Harris & Hofer, 2011; Koehler, Mishra, Hershey, et al., 2004).

Improving attitudes, skills, and TPACK. While the collaboration inherent in the design teams approach has substantial advantages in this context, this approach offers additional benefits in terms of increasing preservice teachers’ attitudes toward technology, technology skills, and TPACK. The design teams approach provides instruction that includes the components necessary to result in attitudinal change, including (a) increasing preservice teachers’ knowledge of technology integration, (b) models of technology integration, (c) practice, and (d) reinforcement (Smith & Ragan, 2005; Zimbardo & Leippe, 1991). As design teams work collaboratively to solve real-world problems, they explore an array of potential solutions. Each solution integrates different technology tools into instruction to promote learning, thus providing opportunities for increasing preservice teachers' knowledge of technology integration ideas and concepts (Koehler, Mishra, Hershey, et al., 2004).

Through the preparation of potential and final solutions, as well as the community sharing activities, preservice teachers are exposed to a variety of models of technology integration, including those of the members of their own team and those of their classmates (Alayyar, 2011; Hur, et al., 2010). As preservice teachers develop technology-integrated lessons and resources with their design teams, they have the opportunity to practice designing these learning experiences and creating the materials necessary for implementation. In addition, as preservice teachers present their potential solutions and justify their decisions for using particular tools and instructional strategies to address specific learning outcomes, their teammates and community members provide reinforcement for innovative and effective technology integration solutions (Alayyar, 2011; Koehler & Mishra, 2005a; Williams, et al., 2009). This combination of experiences, which are inherent in the design teams approach, have the potential to promote attitudinal change with respect to the use of technology for teaching and learning.

A design teams approach also potentially provides a unique and effective environment for learning technology skills. While in standard technology integration instruction, preservice teachers learn predetermined technology skills independently through tasks designed by instructors, in a design teams approach they learn skills collaboratively in context as they attempt to solve instructional problems (Koehler & Mishra, 2005a; Lubin & Ge, 2012). Kay (2007) found that collaborative and authentic tasks like these were the most effective context for learning technology skills. When preservice teachers work collaboratively, they benefit from the technological expertise of their instructor, their teammates, and members of other teams. This allows them to learn technology skills from multiple sources, potentially increasing the complexity and quantity of the learned skills beyond what may be possible in more traditional forms of instruction (Alayyar, 2011; Kay, 2007; Lubin & Ge, 2012). Research has found that this availability of collaborative expertise increased preservice teachers' willingness to experiment with more challenging tasks and push themselves beyond their technological comfort zone. As this occurs, they learn how to complete these tasks, and become more confident in their ability to do so (King, 1997; Williams, et al., 2009).

Koehler and Mishra (2003) found similar benefits, in that design team members learned both basic technical skills and classroom-specific technology skills from each other as they brainstormed potential solutions, justified their decisions, and created instructional materials using technology. As individuals and teams revised their potential solutions as a result of the feedback and testing components of the approach, they learned new technology skills as they explored how to improve their solutions. This provided preservice teachers with the opportunity to learn the skills within a classroom-appropriate context, potentially increasing their ability to use and apply these skills in their future teaching (Howard, 2002; Kariuki & Duran, 2004; Kay, 2007).

The components of the design teams approach provide ideal experiences for supporting preservice teachers' development of TPACK. Koehler, Mishra, Hershey, and Peruski (2004) found that the initial brainstorming process in their design teams approach functioned to both uncover potential ideas for future steps in the artifact creation process and solidify the relationships among the team members. This experience provided an avenue for teachers to explore alternative ideas for solving the instructional problem through selection of technology tools aligned with the selected content—a necessary component of TPACK development (Kinuthia, et al., 2010; Koehler & Mishra, 2005a). As teams began evaluating the brainstormed options and discussing the strengths and weaknesses of each, team conversations centered around technology, content, and pedagogy, and the interactions among these three concepts, in determining the best possible solution (Koehler, Mishra, Hershey, et al., 2004). During poster sessions, feedback from their peers promoted reflection and revision of solutions, causing teachers to analyze the appropriateness of their solution in terms of content, pedagogy, and technology in order to improve their final product (Koehler & Mishra, 2003).

According to Koehler and Mishra (2005a), TPACK developed in situations like these that required teachers to negotiate the connections between technology, pedagogy, and content. Teachers wrestled with the sometimes conflicting forces of specific content, pedagogical imperatives, and the affordances and limitations of technological tools. As they did this, their understanding of the unique relationships between these three components of technology integration developed. "Design projects lend themselves to sustained inquiry and revision of ideas" (p. 95). These understandings are necessary in developing teachers who can apply their knowledge to a variety of real-world scenarios (Koehler & Mishra, 2005a); and can develop a vision of how technology integration will look in their classroom (Kariuki & Duran, 2004).

The design teams may begin as a class requirement, but they can develop into a long-term support system, an outlet for reflection and discussion, and an opportunity for those with weaker skills and knowledge to collaborate and capitalize on the expertise of the entire group, all of which have been shown to increase TPACK in preservice and inservice teachers (Alayyar, 2011; Amador, et al., 2006; H. J. Becker, 1994; Koehler & Mishra, 2005b; Koehler, et al., 2007;

Pierson, 2001). The design teams approach provides a collaborative problem-solving environment for preservice teachers that is similar to the planning and teaching environments they will eventually encounter as practicing teachers (Kemery, 2000; Lubin & Ge, 2012; Schultz, 2003). These realistic instructional planning experiences encourage critical thinking, and allow preservice teachers to engage in professional dialogue as they negotiate how technology, pedagogy, and content interact and work together to promote student learning (Harris & Hofer, 2011; Jegede, 2002; Koehler, Mishra, Hershey, et al., 2004; Le Cornu, 2005). The emphasis on peer sharing, iteration, and justification of instructional decisions in a design teams approach requires preservice teachers to constantly question and reevaluate the relationships between the TPACK components, as well as providing opportunities to learn vicariously from their classmates' successes and mistakes (Koh & Divaharan, 2011).

The authentic experiences provided through a design teams approach that allow preservice teachers to practice the process of matching technology tools to content and pedagogy, require a constant and sustained consideration of these three components and how they work together. Such consideration is necessary for developing the type of integrated understandings that help preservice teachers make the transition from student to practitioner (Alayyar, 2011; Koehler & Mishra, 2005a).

Summary

While technology integration in classrooms has steadily increased since the first computers appeared in schools years ago, technology tools are still not being used to their potential for enhancing teaching and learning. One reason is that many preservice teachers graduate from teacher education programs still feeling unprepared to effectively use technology in their teaching. While many universities have offered or required technology integration coursework for those majoring in education, and much research exists on a variety of instructional approaches for technology integration education, it is still unclear exactly what approaches are most effective for helping preservice teachers become capable of integrating technology to enhance students' learning. In order to prepare preservice teachers to effectively integrate technology, these programs need to focus on improving multiple factors that affect preservice teachers' abilities to integrate technology, including attitudes toward technology, technology skills, and Technological Pedagogical Content Knowledge. Research suggests that all three of these are necessary for preservice teachers to become effective technology integrators.

One instructional approach that has shown promise in increasing all three of these factors in preservice teachers is the design teams approach. The structured collaboration and design tasks inherent in this approach provide unique advantages that make it especially well-suited for preservice teacher technology integration education contexts. In order to build upon the existing literature on design teams approach in this context, this study focused on comparing instructional approaches in order to determine which types of instruction may be most effective for enhancing preservice teachers' abilities to effectively integrate technology.

This research explored the impact of the design teams approach in an existing technology integration course for preservice teachers on attitudes toward technology, their technology skills, and TPACK. Based on this review of the literature, the researcher hypothesized that preservice teachers participating in the course implementation that included the design teams approach would show significantly greater increases in their positive attitudes toward technology, their technology skills, and their TPACK than a group of preservice teachers who participated in the same course using a standard instructional approach.

Chapter 3: Research Methods

The purpose of this quasi-experimental study was to explore the impact that a design teams approach would have on increasing preservice teachers' attitudes toward technology, technology skills, and TPACK. This was accomplished by implementing two versions of a technology integration course for preservice early childhood and elementary teachers at a medium-sized university in the northeast region of the United States.

Background Information

As inadequate use of technology by teachers in schools is often linked to inadequate preparation of teachers in colleges and universities (Brush & Saye, 2009), like many of the teacher education programs described in the literature, this university required students majoring in either early childhood or elementary education to take three credits of coursework to assist them in learning to integrate technology into their teaching. Three one-credit courses were developed to provide preservice teachers with the knowledge, skills, and experiences that early childhood and elementary school teachers needed in order to successfully incorporate technologies into their teaching. The courses provided students with opportunities to build upon their existing technology skills, develop strategies for improving teaching and student learning using technology tools, and develop and use instructional resources that support student learning (Lei, Lu, & Gilliard-Cook, 2010). There were four graduate students, all supervised by the same faculty member, who served as the instructors for these courses each semester.

The course that was the focus of this research was the second in the three-course series. The first course introduced preservice teachers to the concept of technology integration, the use of basic technologies, and provided classroom-appropriate, hands-on activities using these technologies. The second course focused on exposing students to emerging technologies and provided preservice teachers with their first opportunity to integrate technology into teaching by requiring them to write and implement a technology-infused lesson in their field placement (Lei, et al., 2010).

The course consisted of six 2 hr 15 min sessions during the semester: three during the first 3 weeks of the semester, 2 in the middle of the semester, and 1 during the final week of the semester. The preservice teachers spent six weeks in field placement classrooms, three weeks at a time, during the semester that they were enrolled in this course. The class met only during the weeks that they were not at their field placement schools. The class took place in two classrooms on the university campus. One room was a typical classroom setting with tables and chairs for preservice teachers, and a computer workstation with projector and screen for the instructor. This classroom was used for providing lecture-based instruction, conducting class discussions, and other non-technology based activities. The other room was a computer lab containing 17 student workstations, 1 teacher workstation, 2 projectors, 1 screen, 1 interactive whiteboard, and 1 networked printer available for use by all workstations in the lab. The computer lab was used for technology-based instructional activities and for preservice teachers to create electronic products.

Preservice teachers at this university completed their education courses as a cohort, meaning that they took their education coursework each semester in a “block” with others who were at the same place in the program. The course under study was part of the second block taken by preservice teachers in their education coursework. The Block II sequence included six courses in addition to the technology course: Primary Grades Math Methods, Social Studies Methods, Inclusive Education Seminar, Differentiation for Inclusive Education, Creative Movement, and a three-credit practicum field experience in local kindergarten to Grade 3 classrooms. In this phase of the certification program, program faculty preferred that all preservice teachers were assigned to field placements in Grades 1-3 classrooms. Due to availability however, some preservice teachers who were majoring in early childhood education were assigned to kindergarten classrooms (K. Oscarlece, personal communication, August 1, 2012). With respect to field placements, each preservice teacher was assigned a host teacher. This was the classroom teacher with whom the preservice teacher worked at the school. The host teachers were regular classroom teachers who supervised and mentored the preservice teachers as they assisted with classroom duties, including some teaching responsibilities.

Most preservice teachers at this university enrolled in Block II during either the spring semester of their sophomore year or the fall semester of their junior year. Preservice teachers were assigned to cohorts by school of education staff during their freshman year. Cohort assignments were based on a variety of factors, including prior university performance, liberal arts concentration or major, education major, and participation in other university programs (such as travel abroad). All preservice teachers who entered Block II had taken approximately the same education coursework prior to entering Block II, though some students in the fall cohorts had taken one additional three-credit educational course prior to entering Block II (M. Sarno, personal communication, May 31, 2012). Due to the number of preservice teachers in each cohort, and the number of computer workstations available, preservice teachers were divided into two sections for the technology integration course but took all other block courses as one cohort group. In total, four sections of the course were included in this research: two in the fall semester and two in the spring semester.

Sampling and Participants

The participants in this study were a convenience sample of 53 preservice teachers enrolled in a required, one-credit, undergraduate, technology integration course during the fall and spring semesters in the 2011-2012 school year. At this university, all students majoring in early childhood and elementary education completed a program which resulted in certification in both the primary area of study and special education. All participants in this study, therefore, had a special education focus in addition to their early childhood or elementary education major. Preservice teachers enrolled in these courses were sophomores, juniors, or seniors majoring in either inclusive early childhood or inclusive elementary and special education. The 31 students enrolled in the two Fall 2011 semester sections served as the comparison group (receiving the standard instruction), while the 22 students enrolled in the two Spring 2012 semester sections served as the treatment group (receiving the design teams approach). All preservice teachers participating in this study had successfully completed the first technology integration course prior to enrolling in this course. Administering the treatment all in one semester was designed to isolate the effects of the treatment by reducing potential diffusion of the treatment to the comparison group.

Instrumentation

In this study, five instruments were used to measure the three outcome variables: *attitudes toward technology*, *technology skills*, and *TPACK*. The instruments were selected based on several criteria. These instruments have been used in other similar studies on preservice teacher technology integration to measure similar constructs. They are generally considered in the field as reliable and valid measures of these constructs with preservice teachers (Agyei & Voogt, 2011; Alayyar, 2011; Christensen & Knezek, 2002; Morales, Knezek, & Christensen, 2008; Schmidt, et al., 2009). These instruments were also designed and have been used in prior research to measure change resulting from technology-integration-focused interventions, similar to how they were utilized in this research (Alayyar, 2011; Christensen & Knezek, 2002; Koh &

Frick, 2009; Lambert, et al., 2008; L. Lu, Johnson, Tolley, Gilliard-Cook, & Lei, 2011; Shin, et al., 2009; Ward & Overall, 2011), suggesting that they were adequate measures of the constructs under study in this context.

Multiple instruments were included to measure both technology skills and TPACK in order to provide sensitive and complete measures of these outcome variables. The construct *technology skills*, for the purposes of this research, was defined as having two components: basic technology skills and classroom-specific technology skills (Snoeyink & Ertmer, 2001; Zhao, et al., 2003). Two instruments were used in order to measure both of these components of the technology skills construct. One of the instruments used to measure TPACK also included six questions related to “technology knowledge.” This construct relates to preservice teachers’ perceptions of their general knowledge of and interest in technology, but the survey items did not include questions about the specific technology skills that were the focus of this particular research. The two instruments used in this study to measure technology skills included more detailed questions about preservice teachers’ abilities to perform specific tasks with technology that provided a better measure of technology skills as defined by this research.

Two measures were also used to assess TPACK in this study. As researchers have suggested measuring both perception-based and performance-based evidence of TPACK, this study included both a survey of preservice teachers’ perceptions of their TPACK and a lesson plan rubric to measure evidence of their TPACK in their instructional materials (Harris, Hofer, & Grandgenett, 2010; Schmidt, et al., 2009). The researcher contacted the authors of all of the instruments via email and received permission to use the instruments for this research.

Basic demographic data, including seven questions on the pre-surveys and two questions on the post-surveys, were also collected to better describe the characteristics of the sample and to ensure that the comparison and treatment groups were not significantly different on any key demographic variables prior to taking the course under study. For ease of administration, these demographic questions were included at the beginning of the Survey of Teachers' Knowledge of Teaching and Technology, which is included here as Appendix D.

Measuring attitudes toward technology. The Teachers' Attitudes Toward Computers Questionnaire (TAC) version 5.1 (Christensen & Knezek, 2000a) was administered in this study to measure preservice teachers' attitudes toward technology (see Appendix A). The instrument consisted of 88 items using a 5-point Likert scale and 7 items using a 7-point semantic differential scale to measure 9 subscales related to teachers' attitudes toward computer use both personally and with students. The instrument included a final question that asked respondents to rate their "Stage of Technology Adoption" on a scale from 1 to 6. This instrument was originally created by combining multiple existing instruments into one measure, and has been seen in other research to be sensitive to changes in attitudes toward technology resulting from instructional interventions (Alayyar, 2011; Koh & Frick, 2009; Ward & Overall, 2011). It has been used extensively in research and found to be valid and reliable with inservice and preservice teachers, with Cronbach's alpha values ranging from .84 to .97 for the 9 subscales (Agyei & Voogt, 2011; Christensen & Knezek, 2002; Lambert, et al., 2008).

Measuring technology skills. The Technology in Education Competency Survey (TECS; Christensen & Knezek, 2000b, 2001) was administered to measure technology skills related specifically to teaching contexts (see Appendix B). The instrument consists of 9 items using a 5-point Likert scale to measure classroom-specific technology competencies like respondent's ability to create technology-based instructional materials for use with students. The instrument was developed and has been used in research to measure changes in preservice teachers' classroom-specific technology skills (Alayyar, 2011; Christensen & Knezek, 2001). Use of the instrument results in a total score calculated by computing the mean of the nine responses. This instrument has been used in research with both inservice and preservice teachers, with Cronbach's alpha values ranging from .89 to .92 (Agyei & Voogt, 2011; Christensen & Knezek, 2000b).

The Technology Proficiency Self-Assessment (TPSA; Ropp, 1999) was administered as a measure of foundational technology skills relevant to a classroom setting (see Appendix C). The TPSA included 20 items using a 5-point Likert scale to measure technology skills including applications, communications, World Wide Web, and technology integration. The resulting responses can be separated into four subscale scores to provide details on specific aspects of technology skills or the mean of all 20 items can be calculated for a total score (Ropp, 1999). The instrument has been frequently used in research to measure basic technology skills in educators (Ropp, 1999; Ward & Overall, 2011). It has been validated with both inservice and preservice teachers, with Cronbach's alpha values ranging from .93-.95 (Alayyar, et al., 2010; Gençtürk, Gökçek, & Günes, 2010; Morales, et al., 2008; Ropp, 1999). It has also been found in recent studies to be sensitive to changes in preservice teachers' basic technology skills over time (Alayyar, 2011; Koh & Frick, 2009; Ward & Overall, 2011). All items were used as originally published, though examples of specific names of software or websites that appeared in the original instrument were updated to reflect current technology. For this study, this instrument was intended to provide an overall picture of preservice teachers' foundational technology skills, so the total score was used in the analyses.

Measuring TPACK. TPACK consists of seven components: *Technology Knowledge* (TK), *Content Knowledge* (CK), *Pedagogical Knowledge* (PK), *Pedagogical Content Knowledge*

(PCK), *Technological Content Knowledge* (TCK), *Technological Pedagogical Knowledge* (TPK), and *Technological Pedagogical Content Knowledge* (TPACK; Schmidt, et al., 2009). With respect to this instrument, the term “content” refers to the four core subject areas typically taught by early childhood and elementary school teachers (literacy, mathematics, social studies, and science). The survey that was used for this study was designed to specifically measure these seven TPACK components. As the literature suggested that increases in one component of the framework do not necessarily result in growth in all components of TPACK (Angeli & Valanides, 2009), each component must be considered, and measured, separately.

A Survey of Teachers’ Knowledge of Teaching and Technology (TPACK Survey; Schmidt, et al., 2009) was used to measure preservice teachers’ TPACK for this study (see Appendix D). The survey consisted of 47 self-report items using a 5-point Likert scale to measure preservice teachers’ perceptions of their knowledge of the 7 components of TPACK. This survey also included eight Likert-scaled questions that inquired about preservice teachers’ perception of the technology use of their education professors, and three questions requiring preservice teachers to indicate the approximate percentage of education professors, other professors, and cooperating teachers who effectively integrated technology in their teaching. Administration of the instrument resulted in seven subscale scores. The instrument does not include a total score calculation (Schmidt, et al., 2009). Schmidt and her colleagues (2009) developed the instrument based on reviews of existing instruments designed to measure similar constructs and relevant literature on the TPACK framework. Items were developed by the researchers, content validity analyzed by experts in the field, then items were revised based on this analysis. This survey was validated on 124 preservice teachers (Schmidt, et al., 2009) and used in a study of 23 elementary inservice teachers (Shin, et al., 2009). Other researchers have found this measure to be sensitive to changes in preservice teachers' TPACK resulting from instructional interventions (Alayyar, 2011; L. Lu, et al., 2011). Cronbach's alpha values with preservice teachers ranged from .75 to .92 for each of the seven subscales. Cronbach's alpha values with inservice teachers ranged from .40 to .98.

In addition to measuring preservice teachers' perceptions of their TPACK with the TPACK Survey, the Technology Integration Assessment Rubric (TPACK Rubric; Harris, Hofer, & Grandgenett, 2010) was used to assess evidence of TPACK in preservice teachers' lesson plans (see Appendix E). As other research has suggested using multiple measures of TPACK due to differences between preservice teachers' perceptions of their TPACK and evidence of TPACK present in instructional materials, both perceptions and evidence were measured to obtain a more complete picture of preservice teachers' TPACK (Hofer, et al., 2010; Schrader & Lawless, 2004). The TPACK Rubric instrument consisted of four criteria: Curriculum Goals & Technologies, Instructional Strategies & Technologies, Technology Selection(s), and "Fit," which were intended to measure TCK, TPK, and TPACK. Each lesson plan received a score ranging from 1 to 4 for each criteria and an overall score that is the sum of these 4 scores. These overall scores, therefore, ranged from 4 to 16. Harris and her colleagues (2010) designed the rubric with input from technology-using teachers and administrators. The rubric was reviewed by TPACK experts for both construct and face validity. Pilot testing, during which experienced teachers used the rubric to score preservice teachers' lesson plans, was conducted and revisions were made to the rubric based on the pilot test results. Interrater, test-retest, and internal consistency reliability were all adequate. Interrater reliability for all rows on the rubric ranged from 86-94%, and the overall percent agreement for test-retest was 87%. Cronbach's alpha for the instrument was .91 (Harris, Hofer, & Grandgenett, 2010).

Table 2 provides an overview of the instruments, the variables being measured, and the subscales when applicable.

Table 2

Overview of Instruments

Instrument	Collection	Construct	Subscales	Number of Items
TAC	Pre/Post	Attitudes	Interest	10
			Comfort	9
			Accommodation	11
			Interaction	10
			Concern	10
			Utility	10
			Perception	7
			Absorption	10
			Significance	10
TECS	Pre/Post	Technology Skills	None	9
TPSA	Pre/Post	Technology Skills	None	20
TPACK Survey	Pre/Post	TPACK	TK	6
			CK	12
			PK	7
			PCK	4
			TCK	4
			TPK	9
			TPACK	4
TPACK Rubric	Post	TPACK	None	4

Procedures

One instructor taught all four sections of the course involved in this research study. Each group, comparison and treatment, received the same instruction as other preservice teachers in that group, regardless of which section they were enrolled in. The same instructional materials were used, identical resources were provided, and identical course sites were available on the university's course management system.

Role of the researchers. The primary researcher served dual roles in this study, of researcher and course instructor. This researcher is a former elementary classroom teacher certified to teach elementary grades K-6 and grades K-12 technology, and has extensive training in and experience implementing collaborative learning environments with both children and adults. She has a bachelor's degree in early childhood and elementary education, a master's degree in educational technology, and was working toward a Ph.D. in instructional design at the time this research was completed. It is recognized that, while qualified to implement both versions of the course, serving as both researcher and instructor potentially weakens the knowledge claims made as a result of this research. To minimize this impact, data were collected at the end of the course on preservice teachers' perceptions of the quality of the course instruction, in order to increase research validity by comparing the preservice teachers' perceptions in both groups. This instrument consisted of six questions which assessed the instructor's (1) knowledge, (2) preparation, (3) presentation skills, (4) encouragement of participation, (5) enthusiasm, and (6) whether the student would recommend the instructor.

Two additional researchers, both of whom were instructors for the first course in this series, conducted the consent interviews for this study, to eliminate any coercion that potential participants may have felt had their instructor conducted these interviews. One of these additional researchers also conducted the manipulation checks and served as a second lesson plan rater.

At the time this study began, the primary researcher had been an instructor for the series of technology integration courses at this university for three semesters: two semesters teaching the first course, and one semester teaching the second course. As a result, this researcher had taught 21 of the 31 members of the comparison group in the first course, and had been a substitute instructor for one day of the first course for an additional 7 members of the comparison group. The instructor, therefore, had a prior relationship with these preservice teachers. None of the members of the treatment group had this researcher as their instructor for the first course in the series, and all met the instructor on the first day of the course under study.

Manipulation check. One of the team of course instructors performed a manipulation check to ensure that the two instructional approaches were implemented as intended each semester. Manipulation checks consisted of four observations each semester. The observer took notes using a laptop during the class on all teaching events that took place. After class, these notes were used to calculate the number of minutes that were spent in each type of instructional activity (Cameron, Connor, & Morrison, 2005). The activities were classified by type based on the descriptions of both the standard instruction and the design teams approach provided in this document. In addition, the observer assigned a global rating for each class that represented whether the instruction comprised primarily a standard or primarily a design teams approach. This observer also rated the instructor on 4 of the variables related to quality of the instruction, using a 5-point Likert scale. These were the same items completed by the preservice teachers to rate the quality of course instruction. The Manipulation Check Recording Sheet is included as Appendix F.

Instrument administration. All surveys were administered to the preservice teachers using an online survey administration tool. Surveys were password protected and formatted such that all questions on the surveys required a response. Links to the surveys were posted on each class' course management site. Preservice teachers received points toward their course grade for completing the surveys by the due date stated in the course syllabus. Email reminders were sent one day prior to the due date to preservice teachers who had not completed the surveys. Preservice teachers completed the four survey instruments as a pre-assessment during the first week of class, then completed them again as a post-assessment within one week of the final class session. Email addresses were collected on each survey in order to accurately assign the course points and to match pre- and post-surveys for each participant. After pre- and post-surveys were matched, each preservice teacher was randomly assigned a unique identifier and email addresses were removed prior to data analysis. The six questions related to the quality of the course instruction were only administered at the end of the course. These questions were taken directly from the course evaluation. Responses to these questions were anonymous.

The TPACK Rubric was completed by the course instructor and the second rater to analyze the lesson plans which were submitted electronically through the course management site as the final project for the course. Lesson plans were first coded with the randomly assigned unique identifiers. Any other content that could potentially identify the preservice teachers or their group membership was removed. Lesson plans were then converted to portable document format (PDF) files, saved with the unique identifiers as the file names, and copied to two flash drives. All lesson plans, treatment and comparison, were included in one document folder without any indication of group membership. Lesson plans were reviewed electronically during the scoring process.

The second rater was trained by the researcher in the use of the rubric during two 2-hour sessions. In the first session, the raters reviewed the rubric and pertinent definitions, then collaboratively scored one sample lesson plan. During the week following this session, the raters read and scored five sample lesson plans independently. In the second session, both raters shared their scores for the five sample lesson plans and results were discussed to ensure consistency and common understanding of the rubric categories. During the two months following the second session, all 53 participating preservice teachers' lesson plans were scored by both raters independently. The two raters then met to discuss the ratings and revise if necessary to ensure that rubric guidelines were being applied consistently by both raters to all lesson plans. This lesson plan scoring process occurred during the summer following the spring course implementation.

Description of course implementation. For both groups, each of the six class sessions focused on a specific technology topic or tool, and all activities for that day involved that technology. These topics were Day 1—Technology Enhanced Assessment, Day 2—Web 2.0 for Student Collaboration, Day 3—Podcasting for Storytelling, Day 4—Computer and Web Accessibility, Day 5—Technology for Teaching Math and Social Studies, Day 6—Course Project Presentations. The components of the instruction were included for a particular purpose related to addressing the constructs under study, aligned with the essential components for preservice technology education as indicated in the literature (Adamy & Boulmetis, 2005; Alayyar, et al., 2010; Hur, et al., 2010; Kay, 2007; Koehler & Mishra, 2005b; Pope, et al., 2002; Williams, et al., 2009). While some components of the instruction were included to address specific constructs, such as improving attitudes or technology skills, most instruction was integrated to combine activities that would improve attitudes, technology skills, and the seven components of TPACK.

Days 1 through 5. The instruction described in Table 3 was the same across the two implementations: comparison and treatment. The approximate amount of time spent on each instructional activity is included in parentheses.

Table 3

Description of Common Course Instruction

Day 1. These activities provided preservice teachers with information and resources on using technology tools for student assessment in the classroom.

Instruction	Description	Technology Tools	Purpose
Lecture	Introduction to Bloom's original and revised taxonomies (10 minutes) (Anderson & Krathwohl, 2001; Bloom, 1956)	• Electronic presentation	• Introduce new content • Emphasize positive attitudes
Discussion/ Activity	Practice in pairs and teams using Bloom's taxonomy to write lesson outcomes, activities, and assessments for a New York State Social Studies Curriculum Standard (45 minutes)	• Word processing template • Course management site	• Exposure to models of effective technology integration • Practice designing instruction • Reflection
Lecture	Introduction to rubrics lecture/group brainstorm (7 minutes)	• Electronic presentation • Interactive whiteboard	• Introduce new content • Practice technology skills
Review example rubrics	Analysis of example rubric (10 minutes)	• Interactive whiteboard • Online rubric creation tool	• Exposure to models of technology integration

Technology skills instruction included (a) a brief demonstration of where to locate templates and web links on the course management site, (b) instruction on logging in for printing purposes, and (c) a demonstration of the basic steps for creating an electronic rubric using the online tool.

Day 2. These activities provided preservice teachers with information and resources on collaboration using Web 2.0 technologies and uses for instructional purposes.

Instruction	**Description**	**Technology Tools**	**Purpose**
Lecture	Examples of Web 2.0 technologies (5 minutes)	• Electronic presentation	• Introduce new content • Emphasize positive attitudes
Discussion/ Activity	Completed survey to assess Web 2.0 literacy, then worked in pairs to learn about a Web 2.0 technology, summarize it on the class wiki, and provide feedback for their peers on the wiki (20 minutes)	• Spreadsheet • Wiki • Online videos	• Introduce new content • Practice technology skills • Exposure to models of effective technology integration • Reflection
Model lesson	Participated in third grade social studies lesson by working in pairs to learn about an assigned African country and completing a wiki page comparing life in Africa to life in the U.S. (45 minutes)	• Wiki • Websites	• Practice technology skills • Exposure to models of technology integration

Technology skills instruction included demonstrations of how to (a) access the wiki, (b) access the survey on the wiki site, (c) launch the videos, (d) edit a wiki page to type a summary, (e) connect headphones to the computer, (f) access the website to research their country, and (g) insert an image into the wiki.

Day 3. These activities provided preservice teachers with information and resources about podcasts and their uses in instruction.

Instruction	Description	Technology Tools	Purpose
Lecture	Introduction to podcasting, including relevant vocabulary, characteristics, and examples (10 minutes)	• Electronic presentation • Podcast example	• Introduce new content • Emphasize positive attitudes
Discussion/ Activity	Previewed education-related podcasts with partner, noting purpose, audience, intended learning outcomes, and curriculum content (25 minutes)	• Word processing template • Podcasts • Course management site	• Introduce new content • Practice technology skills • Exposure to models of effective technology integration • Reflection
Model lesson	Participated in first grade social studies lesson by working in pairs to storyboard and create a podcast describing a community worker's job (30 minutes)	• Concept mapping software • Podcast creation website	• Practice technology skills • Exposure to models of technology integration

Technology skills instruction included (a) an overview of the technology tools, (b) a demonstration of downloading the concept map template from the course management site, (c) a demonstration of how to add symbols in the concept mapping software, and (d) a demonstration of how to add pictures and audio in the podcast.

Day 4. These activities provided preservice teachers with information and resources on assistive technology tools that can be used in the classroom to benefit students. This was the first class after preservice teachers returned from their field placements, so some class discussions focused on discussing their upcoming technology-integrated lesson plans.

Instruction	**Description**	**Technology Tools**	**Purpose**
Discussion	Shared technology use seen in placement classrooms, the technology tools available in the schools, and any concerns with respect to implementing a technology-enhanced lesson in their field placement classroom (15 minutes)	• Electronic presentation	• Exposure to models of technology integration • Emphasize positive attitudes
Lecture	Video clip discussing technology challenges faced by people with disabilities and demonstration of the use of assistive technologies (5 minutes)	• Online video	• Introduce new content • Emphasize positive attitudes
Discussion/ Activity	Participated in four technology-based centers which addressed assistive technologies including screen readers, an adaptive keyboard, adaptive features in word processing software, and the computer operating system's accessibility features (70 minutes)	• Word processing • Screen reader simulation • Adaptive keyboard • PC operating system • Websites	• Introduce new content • Practice technology skills • Exposure to effective models of technology integration • Reflection

Technology skills instruction included the written directions for each center, which taught preservice teachers how to use (a) formatting tools in word processing for accessibility purposes, (b) accessibility features in the computer operating system, (c) a screen reader simulation, and (d) the adaptive keyboard. Technical assistance was also provided to individuals or groups as needed during centers.

Day 5: These activities provided preservice teachers with information and resources to assist them in writing their lesson plans.

Instruction	Description	Technology Tools	Purpose
Discussion	Shared ideas for modifying existing lesson ideas for their own lesson plans (20 minutes)	• None	• Exposure to models of technology integration • Emphasize positive attitudes
Activity & Model lesson	Participated in four centers which included a model social studies lesson using the interactive whiteboard, a prerecorded web conference of a first grade teacher giving examples of technology use for mathematics instruction, a variety of classroom-focused websites to potentially use in their own lesson plans, and a meeting with the instructor to review the lesson plan requirements (80 minutes)	• Interactive whiteboard • Web conference recording • Websites • Course management software • Word processing	• Practice technology skills • Exposure to effective models of technology integration • Practice designing instruction • Reflection

Technology skills instruction included detailed written directions provided at three of the centers to help students use the interactive whiteboard, access the web conference, and access the web links on the course management site.

On Days 1-4, after the completion of this instruction, the preservice teachers began either their mini-project (comparison group) or their design teams task (treatment group). On Day 5, preservice teachers were given the opportunity to ask questions and explore resources for use in their lesson (comparison) or completed a design teams task (treatment).

Day 6. Each preservice teacher did a presentation of the lesson that he or she had written and implemented in the field placement classroom. These presentations included (a) an overview of the lesson; (b) a statement of state curriculum and technology standards addressed; (c) the teacher preparations needed to implement the lesson; (d) a description of how technology facilitated implementation of the instructional strategies, (e) details of how student learning was assessed; (f) examples of student work or other proof of lesson implementation; and (g) a reflection on the effectiveness of the instructional strategy and technology. Due to the number of preservice teachers in the comparison group courses and the time available, they were divided into two groups and presented their lesson to half of the class. In the treatment group courses, preservice teachers presented to their entire class.

Other course components. In addition to the activities listed here, each class included some general feedback about previously submitted assignments, reminders about future assignments, and opportunities for students to ask questions. Unless specifically giving a presentation or directions, the instructor served as a facilitator during class activities for both groups, circulating the room providing assistance and answering questions as needed. While the instructor occasionally provided technology troubleshooting support, the school help desk was sometimes called upon to solve technological issues that arose during class. Each preservice teacher also wrote and submitted two written reflections. These required reflecting on the how the technology integration ideas seen in class could be used in classrooms with students. Details about how these reflections differed for the two groups are included in the descriptions of each condition.

Preservice teachers in both groups also completed a final project for the course which required them to integrate technology into one mathematics or social studies lesson in their field placement. The goal of this final project was to give the preservice teachers practical experience using technology in instruction. The project consisted of three parts:

1. A technology audit to gather information at the placement school on technology tools that were available for them to use in their lesson,
2. A written lesson plan and accompanying instructional materials, and

3. An implementation of the lesson with students in their placement classrooms and presentation to their classmates.

The preservice teachers used a lesson plan template specific to either mathematics or social studies. These templates were provided by the instructors of the methods courses, so that the lesson plan format would be consistent for all Block II courses. As the comparison and treatment groups had different methods' instructors, the format of the mathematics templates varied slightly, though the main content was the same. The technology components of the lesson plan templates were the same for both groups. The social studies lesson plan template for both groups is included as Appendix G. The math lesson plan template for the comparison group is included as Appendix H, and the treatment group math template as Appendix I.

Comparison condition. With the comparison group, the course was implemented as it had been in previous semesters, consisting of the components described previously as Days 1 through 5 (lectures, class discussions, and model technology-integrated lessons), mini-projects (often completed with a partner), and the final project lesson plan. Preservice teachers in the comparison group worked on the lesson plans independently, outside of class time. Some guidance was provided to preservice teachers in terms of formatting of the assignment, but lesson plan content was written outside of class. Preservice teachers implemented their lesson plans during the second half of their field placements. On Day 6, they presented their lesson and shared their reflections on their lesson effectiveness with their classmates. All of these class activities, and specifically the mini-projects, were structured to provide the preservice teachers with opportunities to develop and reflect on their TPACK (L. Lu, et al., 2011). The activities unique to the comparison condition are described here.

Mini-projects. In order to provide practice designing technological resources for instructional tasks, the comparison group completed mini-projects during the first four class meetings. Each mini-project was a stand-alone assignment which required preservice teachers to create a classroom-appropriate technology artifact based on a scenario provided by the instructor. Preservice teachers were given the option of completing each mini-project with a partner or independently. The instructor provided a hard copy assignment sheet for the mini-projects to each person in class. The assignment sheets explained the real-world scenario on which the assignment was based, the required components for the assignment, the assessment criteria, and (for Mini-projects 1, 2, and 3) provided step-by-step directions for operating the technology in order to assist preservice teachers in completing the task. These assignment sheets were also available on the class' course management site. Each preservice teacher was required to submit his or her completed mini-project assignment through the online course management system. The mini-projects were as follows:

Mini-project 1: Learning scenario and electronic rubric. Preservice teachers created an electronic rubric using a rubric creation website. Beginning with selecting one of the learning outcomes from their Bloom's taxonomy activity (see description of Day 1), they used word processing to type a description of this learning scenario in a short paragraph. This scenario included a description of (a) their hypothetical students (such as grade level and necessary prior knowledge), (b) the subject and topic being taught, (c) the grade level specific state standard(s), (d) the desired learning outcomes, (e) the learning activity, and (f) the product(s) of the learning activity. Preservice teachers created a rubric using the online rubric-creation tool templates to assess the students' learning as described in their learning scenario. The learning scenario and the rubric were submitted for grading purposes.

Mini-project 2: Wiki. Preservice teachers created a wiki using an online website creation tool. They first selected a state social studies standard for second or third grade, wrote learning outcomes for this standard, then created a wiki that could potentially be used as a learning activity with students. The wiki contained a description of the proposed activity including (a) the selected curriculum standard and learning outcomes, (b) directions for students, (c) potential resources for students, (d) a student page template, and (e) an opportunity for student interaction on the site. The link to the wiki home page was submitted for grading purposes.

Mini-project 3: Podcast episode. Preservice teachers created one podcast episode using an online podcasting tool. They first selected a math or social studies curriculum standard; and created a short podcast that could be used in a lesson with students to address that standard. The podcast needed to contain a minimum of a title slide, the curriculum content as stated by the curriculum standard, and a concluding slide. The link to the completed podcast episode was submitted for grading purposes.

Mini-project 4: Matching assistive technologies to student needs. Preservice teachers used their new and existing knowledge of assistive technologies to determine three assistive technologies that could be used by a student in their placement classroom to help his or her learning or performance. Preservice teachers selected a target student from their placement classroom who they thought might benefit from the use of assistive technologies. Using a PDF template provided on the course management site, they each typed a brief description of their target student’s strengths and weaknesses, three specific ideas for assistive technologies that may benefit that student, and a justification for why those technologies would be helpful in potentially improving the student’s learning. As preservice teachers were all placed in different classrooms, they completed this mini-project independently. The completed templates were submitted for grading purposes.

Reflections. Preservice teachers each completed two individual, written reflections. The purpose of these assignments was for preservice teachers to apply what they had learned in class to real-world, teaching scenarios. These reflections were submitted after Days 3 and 5.

Independent lesson planning. Preservice teachers in the comparison group planned and wrote their final project lesson plan outside of class time. The instructor provided time in class for individual questions about the lesson plan, but did not assist with lesson planning or writing. No supports were provided for lesson planning other than class activities and discussions previously described.

Treatment condition. The treatment group received the instruction as was provided to the comparison group, described previously as Days 1 through 5 (lectures, class discussions, and model technology-integrated lessons). The mini-projects were shortened and incorporated into the design teams tasks, in order to provide practice with these technological tools while allowing adequate time for work in design teams. The design teams tasks provided preservice teachers with practice designing technology-integrated instruction. Information from prior studies using the design teams approach was used to inform the implementation in this context. A more detailed description follows.

Design teams approach (intervention). Prior research with respect to peer support approaches with preservice teachers indicated that teaching the steps and procedures of the approach prior to requiring students to use it for supporting their instructional planning was an essential part of the instruction (Kurtts & Levin, 2000; Risko, et al., 2009). For example, Kurtts and Levin (2000) included two phases in their collaborative planning process. The first phase allowed preservice teachers to learn and practice the procedures of their collaborative planning model using scenarios assigned by the instructor. Their research suggested that class participants found this practice to be beneficial as they moved into the second phase of the project, collaborative planning for lessons that they would implement in classrooms. This practice familiarized preservice teachers with the collaborative process, allowing them to focus on lesson planning (rather than the steps in the process) in the second phase. Other research on collaborative approaches has suggested that practicing both the procedures of the process being used and the necessary group interactions was a necessary precursor to productive learning experiences resulting from collaborative group projects (Johnson & Johnson, 2009; Risko, et al., 2009).

To provide this necessary instruction on the process itself, the implementation of the design teams approach for this study included two cycles. The first cycle taught the components and process of the design teams approach that was used in class within the context of technology integration, while the second cycle applied this approach to lesson planning. Cycle I focused on establishing effective group interactions and learning the processes of the design teams approach. In this cycle, all teams were assigned the same curriculum standard and designed a technology-based activity to help second grade students meet the standard. This allowed the preservice teachers to practice the components of the design teams approach with controlled content. Cycle II focused on using these previously learned components and processes of design teams to collaborate on designing each preservice teacher’s final project lesson plan. In this cycle, the design teams began working on technology-enhanced learning activities for their own lessons. The teams worked together to help each member design a technology-enhanced lesson plan to be implemented with students in his or her field placement classroom. While each design team potentially produced artifacts that were used by multiple team members, all preservice teachers were required to write and implement their own lesson plan.

The components of the design teams approach for this research were chosen based on the relevant literature on the topic while accommodating some of the unique features of this context, including a limited amount of class time and the limited teaching experiences of the preservice teachers. The components in the design teams approach, therefore, were intentionally organized and ordered to scaffold the preservice teachers through both learning how to navigate the design teams approach and design their technology-integrated lesson plans.

Consistent with the literature, the implementation of the design teams approach for this research included two primary class structures: design teams (small groups of 3 or 4 people) and community (whole class) (Alayyar, 2011; Kolodner, et al., 2003). The components of the design teams approach specifically as applied in this research are described here.

Community (whole class). There were three primary functions for the community: (a) setting expectations & goals, (b) poster sessions, and (c) testing and feedback (Alayyar, et al., 2010; Koehler, Mishra, Hershey, et al., 2004; Kolodner, et al., 2003).

- Setting expectations and goals: On Day 1 of the course, the instructor communicated the basic tasks and goals for the design teams through an electronic presentation to the entire class. Additional information regarding the purpose and ultimate goal of the design teams approach for the course was provided on Day 2, also through an oral presentation supported by an electronic presentation.
- Poster sessions: Each design team shared their lesson ideas, solutions, and reasoning for their selections with the entire class. During poster sessions, all design teams displayed their artifacts in their existing form and explained and demonstrated their functioning to

their classmates. The instructor and class members provided verbal or written feedback to each team.

- Testing and feedback: Each design team was visited by some of their classmates; who attempted to complete the instructional activities as directed and provided detailed information to the design team about the functioning of their artifacts. For example, if a team's artifact included written directions for operating a particular piece of software, their visiting classmates attempted to follow the directions and provided feedback to the team to inform revisions of their artifacts.

Design teams (small groups). The six primary functions for the design teams were (a) selecting curriculum standards, (b) assigning team members' roles, (c) brainstorming, (d) artifact creation, (e) practice, and (f) debriefing (Alayyar, et al., 2010; Koehler, Mishra, Hershey, et al., 2004; Kolodner, et al., 2003).

- Selecting curriculum standards: Design teams were assigned or selected a state or local school district curriculum standard that was the focus of the instruction being designed. For Cycle I, one standard was assigned to all teams by the instructor. For Cycle II, preservice teachers selected their standard based on information they received from their host teacher. Designing instruction to meet this standard represented the design problem.
- Assigning team members' roles: Each design team assigned roles such that each team included a Technology Specialist, a Content Specialist, a Pedagogy Specialist, and a team leader, for each cycle. These roles were chosen for this research as they represent the essential components of the TPACK model, and were used in a prior study of the design teams approach (Alayyar, 2011). For teams with only three members, one person had two roles: team leader plus either Technology, Pedagogy, or Content Specialist. These roles

guided the preservice teachers as they worked on designing their artifacts to think about all three components of technology integration and provided each team member with a unique contribution to the team's efforts.

- Brainstorming: At the beginning of each cycle, team members worked together to think about possible solutions to the design problem. Teams brainstormed as many solutions as possible, along with a justification for why each would potentially work to help students attain the desired learning outcome. During each subsequent team meeting, the original list of brainstormed solutions was narrowed down until only a few of the most promising solutions remained. These promising solutions were then shared with the community during the poster sessions.
- Artifact creation: This involved drafting, selecting, revising, finalizing, and justifying the selection of artifacts which would potentially become the instructional materials used with students during lesson implementation. Teams created artifacts for multiple promising solutions during each cycle. These promising solutions were shared, tested, evaluated, revised, and potentially discarded until they eventually became drafts of the final solution. Artifacts included items such as lesson plan outlines, student handouts, student templates, and presentation materials.
- Practice: Preservice teachers shared their final instructional plans and artifacts with the members of their design team prior to implementing lessons with students. The practice session provided additional feedback to each preservice teacher so minor adjustments could be made to their lessons and materials prior to lesson implementation.
- Debriefing: At the end of every design teams task, each team reflected upon and evaluated the functioning of their design team. The debriefing activities were intended to

improve the functioning and effectiveness of the design teams. The following questions guided the debriefing process:

- How did you feel about your team process today?
- What worked? What didn't work?
- What will you do the same next time?
- What will you do differently next time? (Derry, et al., 2006; Kolodner, 2002).

Table 4 describes the two design teams cycles and the corresponding activities. Details on the specific implementation of the activities included in the table are described in the text that follows.

Table 4

Plan for Implementation of Design Teams Approach

Cycle	Class Number	Meeting Type	Activities
I	1	Class	• Establish design teams • Set expectations and goals • Communicate curriculum standard • Assign roles for Cycle I • Debrief process
	2	Class	• Brainstorming • Artifact creation (promising solutions) • Poster session • Debrief process
	3	Class	• Artifact creation (draft of final) • Testing and feedback • Artifact creation (revision) • Submit final team artifacts • Debrief process
II	In Field	Web conference	• Select curriculum standards and potential resources • Assign roles for Cycle II • Brainstorming • Debrief process
	4	Class	• Artifact creation (promising solutions) • Poster session • Debrief process
	5	Class	• Artifact creation (draft of final) • Testing and feedback • Artifact creation (revision) • Debrief process
	In Field	Web conference	• Artifact creation (revision) • Feedback • Practice • Debrief process
	6	Class	• Community sharing and reflection • Submit final artifacts

Following the initial instructional activities described previously, the treatment group completed design teams tasks for the first five class sessions. The instructor provided a hard copy assignment sheet to each person in class for each design teams task. The assignment sheets explained the required components for the task, the assessment criteria, and (for tasks 1, 2, and 3) provided step-by-step directions for operating that day's newly introduced technology tool in order to complete one portion of the task. These assignment sheets were also available on the class' course management site. Each preservice teacher was required to submit their completed design teams task documents through the online course management system. The instruction and tasks were as follows:

On the first day of class, the instructor introduced preservice teachers to the design teams approach, including a basic description, goals for the design teams in this course, definitions of the three components of TPACK (technology, pedagogy, and content), and expectations (5 minutes). The instructor then presented the instructional problem that all design teams would solve during the first three classes (Cycle I): *You must teach a technology-integrated lesson to second grade students focusing on the following curriculum standard: Urban, suburban, and rural communities differ from place to place. You must develop a brief technology-integrated lesson plan, including teaching materials, to help students meet a learning outcome associated with this standard.* After the introduction, preservice teachers relocated to sit with their teams and began their first task.

Preservice teachers were assigned to their design teams by the instructor. Teams of 3 or 4 people were formed considering two factors: the grade level of the preservice teachers' field placements and their year in school as listed on the course roster provided by the university. Teams were composed of preservice teachers with matching grade level placements whenever possible. This was intended to facilitate the lesson planning process, as those placed in the same grade level would have similar curriculum standards and student developmental abilities. Though all of the preservice teachers participating in this course were at the same place in their education program, they were classified by the university based on credits and ranged from sophomore to senior in university classification. While this was not believed to be an issue with respect to the success of the design teams, attempts were made to distribute the individuals with different classifications throughout the design teams when possible.

Design teams task 1: Preliminary lesson plan outline and rubric. Preservice teachers created a preliminary lesson plan outline and electronic rubric using the rubric creation website, similar to the comparison group's Mini-project 1. The design teams task was different from Mini-project 1 in that (a) preservice teachers completed this task in their design teams; (b) all teams used the same curriculum standard assigned by the instructor; (c) the learning scenario was expanded to include multiple potential learning outcomes rather than only one; and (d) this task was completed as the first step in solving the instructional problem. The word processing document created by the teams was called a "lesson plan outline" as it served as the starting point for the next two design teams tasks. Other requirements were the same as Mini-project 1. The preliminary lesson plan outline and the rubric were submitted for grading purposes.

Design teams task 2: Promising solutions and wikis. Expanding on the lesson plan outline from task 1, design teams brainstormed all potential solutions for solving the instructional problem. Preservice teachers were provided with the following questions, which were taken from the final lesson plan templates, to guide their brainstorming: (a) How will I teach this? (b) How will I share information? (c) How will students engage in the learning? (d) What technology or technologies can be used to facilitate or enhance student learning?

After brainstorming, each team identified the three most promising solutions and justified their selections. One of the solutions was required to be a wiki created with an online website creation tool to support students' collaborative learning. The other two solutions could use technologies of the team's choosing. The team members then drafted artifacts for all three solutions, including a draft wiki site, other instructional materials, student activities, and assessments. After all teams had draft artifacts, a poster session took place. Teams used the feedback from this session to adjust their solutions as necessary. As teams completed their task, one preservice teacher from each team used written directions provided by the instructor to create a web conferencing room for their design team to be used in future tasks. The revised lesson plan outline and instructional materials for all three promising solutions were submitted for grading purposes.

Design teams task 3: Testing, final solutions, and podcasts. Each design team finalized their artifacts through revision, testing, and agreeing on their final chosen solution for solving the instructional problem. Preservice teachers began by selecting two solutions for solving the instructional problem: (1) a podcast created with an online podcast creation tool, and (2) the most promising solution from Design teams task 2, using technologies of their choosing. Teams created or modified their plans and instructional materials, then artifact testing took place. After receiving community feedback from the testing, the teams finalized their instructional solution, revised their artifacts, and justified their decision in terms of technology, pedagogy, and content. Teams submitted all instructional materials that would be necessary to complete the lesson with students and their final lesson plan outline (including learning outcome, instructional activities, assessment plan, and justification). The topics in this outline were taken from the final project lesson plan template. The final version of the lesson plan outline and all instructional materials for their planned solution were submitted for grading purposes. This completed Cycle I.

Web conference 1: Selecting curriculum standards and brainstorming solutions. Preservice teachers participated in a 15-30 minute recorded web conference with their team members to (a) assign roles (technology, pedagogy, content, and team leader) for Cycle II; (b) identify potential curriculum standards for their lessons; (c) brainstorm ideas for each preservice teacher's lesson; and (d) debrief the group process. These web conferences began Cycle II as team members began supporting each other in developing their individual technology-integrated lessons. Each design team scheduled and completed their web conference without the assistance of the instructor. One person took notes during the web conference, which were shared with all team members. The same guiding questions used for Design teams task 2 were provided for the brainstorming in this web conference. Preservice teachers received an assignment sheet that detailed the requirements for the web conference and step-by-step directions for completing the required tasks. Teams were instructed to consult the university technology support staff for web conferencing technical assistance if needed.

Design teams task 4: Promising solutions. Each design team drafted artifacts for two promising solutions for each team member for solving their instructional problem, including two instructional activities and assessment plans. Each team created a word processing document that included, for each team member, (a) potential learning outcomes, (b) potential solutions using technologies of their choosing, and (c) justification for most promising solutions in terms of how they would help students meet the potential learning outcomes. In addition, they selected a target student from their placement classroom and identified two assistive technologies that would help this student be successful in their lesson (similar to the comparison group's Mini-project 4, using a modified version of this template). Each preservice teacher submitted their draft artifacts, including a lesson plan outline, draft instructional materials for two of their potential solutions, and the completed PDF template for grading purposes. A poster session was planned for this class to allow preservice teachers to share their potential solutions and receive feedback. Due to time constraints, however, the poster session did not occur.

Design teams task 5: Testing and solutions. Preservice teachers worked in their teams to create a basic lesson plan outline for each preservice teacher's final project lesson plan. The design teams added to their documents from task 4 to include (a) the strengths and weaknesses of each potential solution in terms of technology, pedagogy, and content; (b) a list of the resources from the centers activity that would help them meet this learning outcome; and (c) a decision regarding which solution had the most potential for each team member and the rationale for this choice. Team members were given time to create or modify their artifacts before testing occurred. Artifacts were tested by other teams and all preservice teachers received peer feedback on their lesson plans and materials prior to the end of class. This was a non-graded in-class activity. No documents were submitted for grading.

Web conference 2: Practice. During the second web conference, teams (a) discussed any revisions each person had made to their lesson plan since the last class; (b) practiced their implementation (through sharing documents, providing directions, reviewed their implementation plan); (c) provided feedback to each person to improve the lessons; and (d) debriefed the group process. These conferences occurred during the first or second week of the second field placement (before lesson implementation). Like the first web conference, one person took notes, which were shared with all team members, and conferences were recorded. Preservice teachers received an assignment sheet that detailed the requirements for the web conference and step-by-step directions for completing the required tasks. Teams were instructed to consult the university technology support staff for web conferencing technical assistance if needed.

Reflections. Preservice teachers completed two individual, written reflections. The purpose of these assignments was for preservice teachers to apply what they had learned in class and discussed in their web conferences to real-world, teaching scenarios. The treatment group included the link to their team web conference recording in their reflections so the recordings could be reviewed by the instructor. These were submitted before Days 4 and 6.

One note with respect to the design teams approach when compared to the standard approach was that the inclusion of the web conferences resulted in the treatment group spending additional scheduled time on lesson planning whereas the comparison group planned independently. This potentially confounding variable is discussed further in the Discussion section.

Table 5 provides an overview of the instruction for the comparison and treatment groups.

Table 5

Overview of Comparison and Treatment Implementations

Day	Meeting Type	Comparison (Standard)	Treatment (Design Teams)
1	Class	• Lecture • Discussion/Activity • Review example rubrics • Mini-project	• Lecture • Discussion/Activity • Review example rubrics • Design teams task
2	Class	• Lecture • Discussion/Activity • Model lesson • Mini-project	• Lecture • Discussion/Activity • Model lesson • Design teams task
3	Class	• Lecture • Discussion/Activity • Model lesson • Mini-project • Reflection	• Lecture • Discussion/Activity • Model lesson • Design teams task
In Field	Web conference	• Independent lesson planning	• Design teams task • Reflection
4	Class	• Lecture • Discussion/Activity • Assistive technology centers • Mini-project	• Lecture • Discussion/Activity • Assistive technology centers • Design teams task
5	Class	• Lecture • Discussion/Activity • Model lesson/Centers • Reflection	• Lecture • Discussion/Activity • Model lesson/Centers • Design teams task
In Field	Web conference	• Independent lesson planning	• Design teams task • Reflection
In Field	Not applicable	• Lesson plan implementation in classroom	• Lesson plan implementation in classroom
6	Class	• Student presentations	• Student presentations

Analysis

The purpose of this study was to explore the impact that a design teams approach would have on increasing preservice teachers' attitudes toward technology, technology skills, and development of Technological Pedagogical Content Knowledge (TPACK). The data analysis focused on comparing the two conditions (treatment and comparison) on the three outcome variables to determine if the treatment group showed significantly more growth on these variables than the comparison group. This would suggest that the design teams approach was effective in improving these outcomes in preservice teachers. The data analysis, therefore, answered the following subquestions:

- What impact does participation in the design teams approach have on preservice teachers' attitudes toward technology?
- What impact does participation in the design teams approach have on preservice teachers' technology skills?
- What impact does participation in the design teams approach have on preservice teachers' development of TPACK?

Data from all survey instruments were downloaded from the online survey system directly into SPSS version 20. Data were sorted alphabetically by participant email addresses. A grouping variable was included to discriminate between the comparison and treatment groups. Random numbers were generated using an online tool and assigned to each participant. Email addresses were removed prior to analysis.

Scales or subscales were calculated as appropriate for each instrument based on the instructions provided by the instrument's author. For the TAC, 29 questions that were negatively worded were reversed for inclusion in the subscales. Scores from the TPACK rubric for each of the four criteria were entered by each rater into a Microsoft Excel spreadsheet. These scores were imported into SPSS version 20 for analysis. Overall scores were calculated for each rater for each lesson plan by summing each rater's four criteria scores, as suggested by the rubric's authors. These overall scores were used in subsequent analyses.

Data from all pre- and post-surveys were analyzed in terms of means and standard deviations of scale or subscale scores for both groups to check for possible anomalies in the data. Descriptive statistics were analyzed for potential pre-existing differences between the two groups on demographic variables. Descriptive statistics are included in the Results chapter.

Cronbach's alpha was calculated for all scales and subscales to check for reliability of these instruments with this sample. Correlations were calculated for all dependent variables, looking for moderate correlations, which would indicate these data were appropriate for use in the planned analysis. If correlations were not appropriate, alternative analyses were considered (Leech, Barrett, & Morgan, 2008).

Multivariate analysis of covariance (MANCOVA) was used in research "to assess the statistical significance of the effect of one or more independent variables on a set of… dependent variables" (p. 245) while using covariates to control for other variables known to impact the outcome (Weinfurt, 1994). In this study, multiple MANCOVAs were planned to compare the preservice teachers in the comparison group and preservice teachers in the treatment group on the set of subscale scores for the four survey outcome measures while controlling for preexisting differences between the two groups on these outcomes.

Three MANCOVAs were planned, one for each of the three outcome variables: attitudes toward technology, technology skills, and TPACK. The pre-survey scores were used, if appropriate, as the covariates to control for preexisting differences between the groups on these variables when necessary, with the grouping as the independent variable and the post-survey scores as the dependent variables. To ensure that the overall chance of making a Type I error was less than .05 in this data analysis, the Bonferroni correction was applied to lower the alpha level to accommodate multiple tests. For any significant results, discriminant analysis was planned to determine what variables contributed most heavily to the differences between the groups. This analysis could help identify exactly where the differences between the two groups were in order to fully explain how design teams impacted the preservice teachers on the outcome variables.

A bivariate correlation was calculated for the two overall scores on the lesson plans to check for adequate agreement between the two raters. The mean of the two raters' scores was then calculated to be used in the analysis. A *t*-test was used to compare the mean scores of the treatment and comparison groups to determine if the intervention had a significant effect on TPACK as measured by the rubric. This provided additional information to completely answer the third research subquestion.

A power analysis was completed for the study using G*Power3 (Faul, Erdfelder, Lang, & Buchner, 2007). Based on the sample size and medium effects as found by other researchers (Alayyar, 2011), the power for this study was .75. This suggested a 25% chance of committing a Type II error in this study. Unfortunately, as this research used intact groups, increasing the sample size to increase power was not possible.

It was hypothesized that there would be significant differences between the two groups for positive attitudes toward technology, technology skills, and TPACK based on the survey results. It was also hypothesized that there would be significant differences between the two groups on the scores from the TPACK Rubric. In all cases, it was hypothesized that the treatment group would show significantly greater scores on all measures, indicating that the design teams approach was effective in terms of promoting preservice teachers’ positive attitudes toward technology, technology skills, and TPACK.

Chapter 4: Results

This research was conducted to explore the impact that a design teams approach would have on increasing preservice teachers' attitudes toward technology, technology skills, and development of Technological Pedagogical Content Knowledge (TPACK). Results from the statistical analyses are presented in this chapter, including both demographic data describing the participants, descriptive statistics for all variables, and analyses intended to answer the three research subquestions and test the research hypothesis. The quantitative results presented in this chapter are discussed and potential explanations for these results are explored in Chapter 5.

Characteristics of Participants

Preservice teachers enrolled in the course during the 2011-2012 school year participated in this research. Almost all (96%) of the participants were female, including 100% of the comparison group. Ninety-eight percent of participants were between the ages of 18 and 22 years old. The group of participants indicated relatively ubiquitous access to basic technological tools, with 98% indicating they owned a laptop computer and 75.5% of the respondents owning a SmartPhone, including 81% of the treatment group and 71% of the comparison group. Participants indicated they spent an average of 5 hours on the computer each day, with the range being from 2 to 15, and modes of 3, 4, and 6. The mean hours for the treatment group was 4.95 (*SD* = 2.38) with a range of 2 to 10 and a mode of 4. The mean hours for the comparison group was 5.39 (*SD* = 2.53) with a range of 2 to 15 and modes of 5 and 6. A *t*-test indicated that there were no significant differences between the two groups on this variable, $t(51) = 0.63$, $p = .532$.

For both groups, 66% were planning on student teaching either in spring or fall of 2013. As students typed in these responses, and some students indicated dates that were not consistent with their progress in the program, there were likely some typing or mathematical errors affecting these responses. Though there were some exceptions in the program due to individual considerations, based on the program sequence, these students should all complete student teaching during the 2013 school year (M. Sarno, personal communication, May 31, 2012).

With respect to education major, 90.6% of the participants indicated they were inclusive elementary and special education majors. The 9.4% who were inclusive early childhood and special education majors were in the comparison group. Almost all members of the comparison group (97%) were juniors, while 81% of the treatment group were sophomores and 18% were juniors. This difference in classification between the two groups was a function of the program structure at this university, with preservice teachers who took Block II in the fall semester tending to be juniors, while preservice teachers in the spring semester tended to be sophomores. Despite this difference of year in school, all preservice teachers were at similar points in their education coursework. Prior research has found that neither gender, year in school, nor planned teaching level had an effect on the factors impacting technology integration in preservice teachers (Gorder, 2008; Lambert & Gong, 2010; Lambert, et al., 2008), so these differences between the groups should not affect the outcomes in this research. Pre-surveys were included in this study, however, to check and control for any pre-existing differences on the dependent variables.

Assessing Quality of Instruction

In order to control for the potential of the instructor's actions impacting the results, the mean scores for each of the six questions related to the quality of the instruction from the course evaluation were compared for the two groups. These items, with the variable name indicated in parentheses, were as follows:

1. Instructor is knowledgeable about the topic (Knowledge).

2. Instructor is prepared (Preparation).
3. Instructor presents material in a way that helps me learn (Presentation).
4. Instructor encourages participation (Participation).
5. Instructor is enthusiastic about teaching (Enthusiasm).
6. I would recommend the instructor to others (Recommend).

As the scale on these items was opposite from the scales of other instruments used in this research (1 = strongly agree, 5 = strongly disagree), all items were reversed prior to analysis. Cronbach's alpha for the six questions on this measure was .985. This very high alpha potentially indicates that items are repetitious or there are more items than are necessary to measure this construct (Leech, et al., 2008). As this was a control variable in this research, and removing items did not substantially reduce the alpha, it was deemed adequate for use despite the high alpha.

In order to maintain a significance level of .05 for this group of tests, the Bonferroni correction was applied and the alpha level reduced to .008 (.05/6) to accommodate the six tests conducted on these data. *T*-tests were then used to compare the means on these six variables for the two groups. There were significant differences with large effects between the comparison and treatment groups for three of these comparisons, with the comparison group having significantly higher means on these three variables. Table 6 includes the data from these comparisons, with effect sizes included for significant results.

These variables were included in this research to control for the potential of the instructor being better with the treatment group (consciously or unconsciously), and it was expected that there would be no significant differences on these variables between the two groups. In reality the opposite occurred, with the comparison group scoring the instructor significantly higher than the treatment group on questions 3, 4, and 6.

The class observer who completed the manipulation checks also rated the instruction based on questions 1, 2, 4, and 5. The observer did not respond to questions 3 and 6. The mean for the observer's ratings for both groups was 5.0. There were no differences in these scores as assigned by the observer for the two groups. These results suggest that the comparison group viewed the instructor more positively than the treatment group, while the class observer viewed the instructor equally positively in both versions of the course.

Table 6

Comparison of Quality of Instruction Variables

Variable	**Group**	**n**	**M**	**SD**	**SEM**	***t***	**df**	***p***	***d***
Knowledge	Comparison	31	4.65	1.02	0.18	1.81	51	.076	
	Treatment	22	4.14	0.99	0.21				
Preparation	Comparison	31	4.65	1.02	0.18	2.13	51	.038	
	Treatment	22	4.05	1.00	0.21				
Presentation	Comparison	31	4.55	1.03	0.19	2.96	51	.005*	0.82
	Treatment	22	3.68	1.09	0.23				
Participation	Comparison	31	4.61	1.02	0.18	2.85	51	.006*	0.80
	Treatment	22	3.77	1.11	0.24				
Enthusiasm	Comparison	31	4.68	1.01	0.18	2.49	51	.016	
	Treatment	22	3.91	1.23	0.26				
Recommend	Comparison	31	4.65	1.02	0.18	3.31[a]	38.2[a]	.002*	0.91
	Treatment	22	3.55	1.30	0.28				

Note. [a]The *t* and df were adjusted because variances were not equal. * Significant at $p \leq .008$.

Manipulation Checks

Both the treatment and comparison conditions were observed four times for the purpose of documenting that both the standard and design teams approaches were implemented as designed. For the comparison group, the manipulation check found that all course activities represented the standard instructional format. Classes consisted of lectures and discussions, model lessons, and mini-projects. Students were primarily grouped as a whole class, in pairs, or individually for instruction. No evidence of the design teams approach was observed during these classes. On a scale from 1 to 7, the observer indicated that both of the observed sessions were ranked a 7 in terms of their consistency with the standard instructional approach, and a 1 in terms of consistency with the design teams approach. These observation results suggest that the comparison group courses were implemented with the standard instructional approach, consistent with the research design.

For the treatment condition, the observer found evidence of lectures/discussions, model lessons, and community and design teams activities, as was described in the research design. Students were primarily grouped as a whole class, pairs, and in small groups for instruction. On a scale from 1 to 7, the observer indicated these sessions were ranked a 1 in terms of their consistency with the standard instructional approach, and a 7 in terms of consistency with the design teams approach. These observation results suggest that the treatment group courses were implemented with the design teams approach as described in the research design.

Exploratory Data Analysis

Raw data, as exported from the online survey system, were checked for possible inconsistencies and errors. Descriptives, including minimum and maximum values, means, and standard deviations, were examined for each question and for each scale or subscale. This analysis revealed that some participants responded on the TPSA and TECS post-surveys with the lowest possible scores for almost every item, whereas on the pre-surveys their scores were consistently higher. As this instrument focused primarily on basic technology skills (i.e. “I can send an email to a friend.”), it seemed unlikely that the post-survey scores would legitimately be lower than the pre-survey scores for all items. This could suggest that these respondents misread the scale when completing the post-surveys, making these responses invalid. This included three respondents (one from the comparison group and two from the treatment group) on the TPSA and five respondents (including the three from the TPSA and two additional from the comparison group) on the TECS. These respondents were not included in the analysis for these variables, reducing the total N for the analysis related to technology skills to 48. All responses appeared to be valid for the other instruments, resulting in an N of 53 for the analyses of attitudes toward technology and TPACK.

No other inconsistencies were identified in the data. As the online survey system required respondents to answer every question, there were no missing values in the data. With respect to lesson plans, all 53 lesson plans were complete and scored by both raters for this research.

Reliability of Measures

Reliability for all scales and subscales of the instruments used in this research was assessed using Cronbach’s alpha. All scales and/or subscales indicated alpha values at or greater than .7, which is generally considered acceptable reliability (Leech, et al., 2008). The scales and subscales were determined to be appropriate for the planned analysis in terms of reliability. All reliability data are included in Table 7.

Table 7

Reliability Statistics

Instrument	Subscales	Alpha pre	Alpha post
TAC	Interest	.88	.94
	Comfort	.93	.91
	Accommodation	.83	.89
	Interaction	.91	.92
	Concern	.91	.94
	Utility	.94	.93
	Perception	.93	.95
	Absorption	.80	.84
	Significance	.91	.94
TECS	None	.84	.89
TPSA	None	.91	.91
TPACK Survey	TK	.88	.91
	CK	.82	.89
	PK	.89	.95
	PCK	.70	.81
	TCK	.87	.90
	TPK	.93	.95
	TPACK	.92	.85
TPACK Rubric	None	Not Applicable	.95

Testing the Effect of the Design Teams Approach

There were three research subquestions in this study which were generated to explore the effect of the design teams approach on the three outcomes: attitudes toward technology, technology skills, and TPACK. For conducting statistical tests, the research hypothesis was separated into three parts to coincide with each research subquestion. Descriptive statistics for each scale and/or subscale, along with statistical results to answer each research subquestion, are presented in this chapter.

Effect on Attitudes toward Technology. The first research subquestion investigated the impact of participation in the design teams approach on preservice teachers' attitudes toward technology. It was hypothesized that the treatment group would have significantly higher attitudes toward technology after the course than the comparison group, which would suggest that the design teams approach had a positive effect on this outcome.

Data from the pre- and post-administrations of the TAC were used to answer this subquestion. The 95 items on the instrument were organized into nine subscales (see Table 2). For the Perception subscale, scores can range from 1.0 to 7.0; for the remaining 8 subscales, scores can range from 1.0 to 5.0. Subscale scores (calculated as the mean of all items comprising each subscale) were calculated for use in the analysis. Raw summed subscale scores (calculated as the sum of all items comprising each subscale) were also calculated for descriptive purposes. Based on these response scales and the number of items that comprise each subscale, the total possible raw summed score for the Comfort subscale was 45, Perception was 49, and the remaining seven subscales had a total possible raw summed score of 50.

The descriptive statistics for the subscales show that the means for both groups on all subscales were above the midpoint with standard deviations of less than one. Many of these subscales have a negative skew, indicating that there are relatively few low values in the distribution of scores. The raw summed subscale score data also support that the scores were relatively high on both the pre- and post-surveys for both groups. Some respondents in each group scored the maximum amount possible on the pre-survey for five of the nine subscales, eliminating any possibility for growth between the pre- and post-surveys for these respondents. These statistics suggest that the preservice teachers reported very positive attitudes toward technology on both the pre- and post-surveys. Descriptive statistics for the TAC are included as Table 8.

Table 8

Descriptive Statistics for TAC (Attitudes)

					Raw Scores					
Variable	**Group**	**n**	**M**	**SD**	**Mdn**	**Range**	**Min**	**Max**	**Skew**	**Kurtosis**
Interest pre	Comparison	31	4.00	0.64	37.00	20.00	25.00	45.00	-0.34	-0.46
	Treatment	22	3.93	0.62	35.50	21.00	22.00	43.00	-0.61	-0.04
Interest post	Comparison	31	4.14	0.71	37.00	22.00	23.00	45.00	-0.53	-0.47
	Treatment	22	3.75	0.97	34.50	33.00	11.00	14.00	-1.30	1.99
Comfort pre	Comparison	31	3.96	0.78	32.00	32.00	8.00	40.00	-1.74	5.72
	Treatment	22	3.99	0.63	32.00	19.00	20.00	39.00	-0.74	0.80
Comfort post	Comparison	31	4.10	0.79	33.00	21.00	19.00	40.00	-0.89	-0.16
	Treatment	22	3.91	0.62	32.00	17.00	23.00	40.00	-0.06	-0.64
Accommodation pre	Comparison	31	4.40	0.42	50.00	16.00	39.00	55.00	-0.50	-0.60
	Treatment	22	4.31	0.42	49.00	19.00	36.00	55.00	-0.72	0.34
Accommodation post	Comparison	31	4.39	0.45	49.00	17.00	38.00	55.00	-0.43	-0.67
	Treatment	22	4.18	0.59	45.50	22.00	33.00	55.00	-0.42	-0.48
Interaction pre	Comparison	31	3.81	0.63	39.00	28.00	22.00	50.00	-0.39	0.49
	Treatment	22	3.97	0.45	40.00	17.00	33.00	50.00	0.73	0.54
Interaction post	Comparison	31	4.12	0.66	42.00	19.00	31.00	50.00	-0.05	-1.36
	Treatment	22	3.99	0.69	40.00	20.00	30.00	50.00	0.04	-1.43
Utility pre	Comparison	31	4.23	0.54	40.00	19.00	31.00	50.00	0.09	-0.99
	Treatment	22	3.99	0.45	40.00	20.00	30.00	50.00	0.12	1.97
Utility post	Comparison	31	4.24	0.48	40.00	15.00	35.00	50.00	0.43	-1.22
	Treatment	22	4.10	0.60	40.00	20.00	30.00	50.00	0.02	-0.51
Perception pre	Comparison	31	5.90	1.03	43.00	22.00	27.00	49.00	-0.67	-0.71
	Treatment	22	5.90	0.89	42.50	20.00	29.00	49.00	-0.47	-0.90
Perception post	Comparison	31	6.11	1.03	46.00	24.00	25.00	49.00	-1.05	-0.04
	Treatment	22	6.01	1.09	43.00	21.00	28.00	49.00	-0.77	-0.70
Absorption pre	Comparison	31	3.12	0.51	31.00	18.00	23.00	41.00	0.21	-0.79
	Treatment	22	3.00	0.51	29.50	24.00	16.00	40.00	-0.52	1.65
Absorption post	Comparison	31	3.12	0.64	32.00	28.00	19.00	47.00	0.31	0.13
	Treatment	22	3.14	0.55	30.50	25.00	23.00	48.00	1.17	2.67
Significance pre	Comparison	31	4.32	0.46	41.00	13.00	37.00	50.00	0.52	-1.40
	Treatment	22	4.21	0.45	40.00	14.00	36.00	50.00	0.65	-1.02
Significance post	Comparison	31	4.34	0.51	44.00	20.00	30.00	50.00	-0.56	0.02
	Treatment	22	4.09	0.62	40.00	20.00	30.00	50.00	0.05	-0.82
Concern pre	Comparison	31	3.44	0.85	34.00	29.00	20.00	49.00	0.09	-0.72
	Treatment	22	3.44	0.67	34.50	31.00	17.00	48.00	-0.49	1.24
Concern post	Comparison	31	3.47	0.90	32.00	30.00	20.00	50.00	0.43	-0.82
	Treatment	22	3.57	0.87	36.50	36.00	14.00	50.00	-0.35	0.46

In order to answer this research subquestion, a MANCOVA was planned to compare the two groups on the nine TAC subscales from the post-survey, using the subscale scores from the pre-survey as covariates to control for pre-existing differences between the two groups. Several tests were run prior to the main analysis to check for violations of the assumptions and requirements of MANCOVA: correlated dependent variables, correlations between covariates and dependent variables, multivariate normality, and homogeneity of covariance matrices (Weinfurt, 1994).

In order to conduct a MANCOVA, the dependent variables must be both theoretically and empirically correlated. In addition, the bivariate correlations between the covariates and the dependent variables for each proposed MANCOVA should be significant (Stevens, 2009; Weinfurt, 1994). Bivariate correlations were run to check for the necessary linear relationships between the post-survey subscale scores (dependent variables) and between the pre-survey subscale scores (covariates) and the post-survey subscale scores (dependent variables) for the TAC data.

There is no test for multivariate normality, but MANOVA is relatively robust to violations of normality. Tests for bivariate normality can provide evidence that multivariate normality is plausible (Stevens, 2009). Scatterplots can be used to check that the linear relationships between variables are normally distributed, but in research with a large number of variables (such as this study), this process can become unwieldy. When large numbers of variables exist, the skewness and kurtosis statistics can be used to determine where problems with normality may exist, and additional analyses can then be run on these variables (Tabachnick & Fidell, 2007). With respect to kurtosis, research suggests that extreme platykurtosis reduces power in MANOVA, thus the analysis of kurtosis in this study focused on this characteristic

(Stevens, 2009). Finally, Box's M was used to test for approximate equality of covariance matrices. When this test is not significant, the assumption of homogeneity of covariance matrices is met.

With respect to the TAC subscales, there were a few violations of the assumptions for MANOVA present in the variables. There were no skewness values greater than |2|, and no substantially platykurtic distributions, indicating that the variables were adequate for use in these analyses. Box's M was not significant, indicating the assumption of homogeneity of covariance matrices is met. When this assumption is met, Wilk's Lambda is an appropriate multivariate statistic to use in determining if there are significant differences between the two groups (Leech, et al., 2008; Weinfurt, 1994). Wilk's Lambda, therefore, was used in this analysis.

The correlations between the TAC post-survey subscales were deemed adequate to perform the planned analyses. The majority of the covariates were significantly correlated with the dependent variables, with correlation coefficients ranging from .27 to .75. Several of the subscales on the pre-surveys, however, were not significantly correlated with the post-survey subscales. The Interaction pre subscale was not significantly correlated with Interest post (r = .17), Accommodation post (r = .18), Absorption post (r = .07), or Significance post (r = .11). Concern pre was not significantly correlated with Interest post (r = .26) or Absorption post (r = .20). The Utility and Significance pre subscales were also not significantly correlated with Absorption post, with correlation coefficients of .17 and .01 respectively. These results suggested that these variables were not appropriate for use as covariates (Stevens, 2009; Tabachnick & Fidell, 2007).

The purpose of using a MANCOVA in this analysis was to control for the potential of preexisting differences on attitudes toward technology between the groups. As these variables were not appropriate to use as covariates, *t*-tests were conducted for all of the TAC pre-survey subscale scores, using group (comparison or treatment) as the dependent variable to determine if there were differences between the two groups on the pre-surveys. No significant differences were found between the groups on these variables. Based on these results, it was determined that it was not necessary to use covariates in this analysis. A MANOVA was used instead to test for differences between the two groups on the post-survey scores only. With this change, these data were deemed appropriate for this analysis.

To accommodate the multiple tests planned in order to answer the research question and reduce the chances of committing a Type I error, the Bonferroni correction was applied and the alpha level lowered to .017 for this MANOVA. The grouping variable (comparison or treatment) was entered as the independent variable. The nine TAC post-survey subscale scores were entered as the dependent variables. There were no significant differences found between the two groups for attitudes toward technology, Wilk's $\Lambda = .82$, $F(9,43) = 1.03$, $p = .435$, partial $\eta^2 = .18$. In addition, none of the variables entered significantly contributed to distinguishing between the two groups. As a result of these non-significant findings, the planned discriminant analysis to explore the differences was unnecessary. The results of this analysis are included in Table 11.

These results indicate that the treatment and comparison groups were not different with respect to their attitudes toward technology before they participated in the course. After the course, the two groups were still not different on this variable, suggesting that the design teams approach did not have an effect on preservice teachers' attitudes toward technology.

Effect on Technology Skills. The second research subquestion investigated the impact of participation in the design teams approach on preservice teachers' technology skills. It was hypothesized that the treatment group would have significantly higher technology skills on the post-surveys than the comparison group, which would suggest that the design teams approach had a positive effect on this outcome.

Data from the pre- and post-administrations of the TECS and TPSA were used to answer this subquestion. Each of these instruments had only one scale, with scores ranging from 1.0 to 5.0. Scale scores (calculated as the mean of all items in each instrument) were calculated for use in the analysis. Raw summed subscale scores (calculated as the sum of all items comprising each scale) were also calculated for descriptive purposes. Based on the response scales and the number of items in each instrument, the total possible raw summed score was 45 for the TECS and 100 for the TPSA. The descriptive statistics for the scales indicate that the means for both groups on all scales were above the midpoint with standard deviations of less than one. Like the attitudes scores, many of these scale score distributions have a negative skew, indicating that there are relatively few low values. The raw summed scale score data also support that scores were relatively high on both the pre- and post-surveys. None of the respondents, however, had the maximum possible score on the pre-survey for either instrument, allowing for the potential of growth from pre- to post-survey. These statistics suggest that the preservice teachers reported high levels of technology skills on both the pre- and post-surveys. Descriptive statistics for the TECS and TPSA are included as Table 9.

Table 9

Descriptive Statistics for TECS and TPSA (Skills)

					Raw Scores					
Variable	**Group**	**n**	**M**	**SD**	**Mdn**	**Range**	**Min**	**Max**	**Skew**	**Kurtosis**
TECS pre	Comparison	28	3.75	0.55	35.00	21.00	22.00	43.00	-0.77	0.50
	Treatment	20	3.83	0.39	35.00	17.00	25.00	42.00	-0.49	2.24
TECS post	Comparison	28	4.35	0.43	39.00	13.00	32.00	45.00	0.17	-0.94
	Treatment	20	4.23	0.57	38.50	18.00	27.00	45.00	-0.67	0.14
TPSA pre	Comparison	28	3.89	0.62	81.50	49.00	50.00	99.00	-0.75	0.20
	Treatment	20	4.00	0.40	81.50	33.00	61.00	94.00	-0.60	0.23
TPSA post	Comparison	28	4.33	0.52	90.00	36.00	64.00	100.00	-0.58	-0.89
	Treatment	20	4.35	0.51	89.00	40.00	60.00	100.00	-1.37	1.72

Tests were run on the data from the TECS and TPSA prior to the main analyses to check for violations of the assumptions and requirements of MANCOVA. The correlations between the proposed covariates and the dependent variables for TECS/TPSA were significant and appropriate for use in MANCOVA. There were no skewness values greater than |2|, and no substantially platykurtic distributions, indicating that the variables were adequate for use in these analyses. Box's M was not significant, so Wilk's Lambda was used as the multivariate statistic in this analysis.

The alpha level was lowered to .017 to accommodate the multiple comparisons; and the grouping variable (comparison or treatment) was entered as the independent variable. The pre-survey scale scores for both instruments were entered as covariates, and the post-survey scale scores were entered as the dependent variables. This analysis found no significant differences found between the two groups for post-survey technology skills, Wilk's $\Lambda = .94$, $F(2,43) = 1.43$, $p = .251$, partial $\eta^2 = .06$. In addition, none of the variables entered significantly contributed to distinguishing between the two groups. As a result of these non-significant findings, the planned discriminant analysis to explore the differences was unnecessary. The results of this analysis are included in Table 11.

These results indicate that the treatment and comparison groups were not different with respect to technology skills when controlling for their preexisting skills, suggesting that the design teams approach did not have an effect on preservice teachers' technology skills.

Effect on TPACK. The third research subquestion investigated the impact of participation in the design teams approach on preservice teachers' TPACK. It was expected that the treatment group would have significantly higher TPACK at the end of the course than the comparison group, which would suggest that the design teams approach had a positive effect on this outcome. As other research has suggested using multiple measures of TPACK due to differences between preservice teachers' perceptions of their TPACK and evidence of TPACK present in instructional materials (Hofer, et al., 2010; Schrader & Lawless, 2004), the answer to this research subquestion was explored in two ways.

TPACK Survey Analysis. Data from the pre- and post-administrations of the TPACK Survey were used in the first analysis for this subquestion. The 47 items on the instrument were organized into 7 subscales representing the 7 components of TPACK (see Table 2), with scores ranging from 1.0 to 5.0. Subscale scores (calculated as the mean of all items comprising each subscale) were calculated for use in the analysis. Raw summed subscale scores (calculated as the sum of all items comprising each subscale) were also calculated for descriptive purposes. Based on the response scales on the instrument and the number of items that comprise each subscale, the total possible raw summed score for the subscales were as follows: TK (30), CK (60), PK (35), PCK (20), TCK (20), TPK (45), and TPACK (20). Like the other instruments used in this study, the descriptive statistics for the subscales indicate that the means for both groups on all subscales were above the midpoint with standard deviations of less than one. Many of these scale score distributions had a negative skew, indicating that there are relatively few low values on these subscales. PK pre, PCK post, and TPACK post are the only three variables that had slight positive skew for both groups. With means of approximately 4 out of 5, however, the scores were still relatively high overall for these three subscales. The raw subscale score data also support that scores were relatively high on both the pre- and post-surveys. In the comparison group, some respondents scored the maximum amount possible on three of the seven subscales on the pre-survey. In the treatment group, some respondents scored the maximum possible on two of the subscales. This eliminates any potential for growth between the pre- and post-survey for these respondents on these subscales. These statistics suggest that the preservice teachers reported high levels of TPACK on both the pre- and post-surveys. Descriptive statistics for the nine TPACK Survey subscales are included as Table 10.

Table 10

Descriptive Statistics for TPACK Survey (TPACK)

					Raw Scores					
Variable	**Group**	**n**	**M**	**SD**	**Mdn**	**Range**	**Min**	**Max**	**Skew**	**Kurtosis**
TK pre	Comparison	31	3.62	0.63	23.00	19.00	10.00	29.00	-0.94	2.13
	Treatment	22	3.61	0.62	22.00	17.00	13.00	30.00	-0.54	1.57
TK post	Comparison	31	3.61	0.77	22.00	18.00	12.00	30.00	-0.44	-0.08
	Treatment	22	3.79	0.57	23.50	15.00	15.00	30.00	-0.27	0.66
CK pre	Comparison	31	3.56	0.51	43.00	25.00	29.00	54.00	-0.18	-0.44
	Treatment	22	3.64	0.47	44.50	20.00	33.00	53.00	-0.36	-0.97
CK post	Comparison	31	3.73	0.57	46.00	32.00	28.00	60.00	-0.37	0.65
	Treatment	22	3.91	0.48	48.00	24.00	36.00	60.00	-0.39	1.16
PK pre	Comparison	31	3.90	0.48	28.00	15.00	20.00	35.00	0.21	0.67
	Treatment	22	3.94	0.40	28.00	12.00	23.00	35.00	0.55	1.28
PK post	Comparison	31	4.33	0.48	28.00	10.00	25.00	35.00	0.37	-1.43
	Treatment	22	4.24	0.59	28.00	14.00	21.00	35.00	-0.46	-0.03
PCK pre	Comparison	31	3.73	0.45	15.00	8.00	11.00	19.00	-0.36	-0.05
	Treatment	22	3.60	0.50	14.50	8.00	11.00	19.00	0.22	-0.56
PCK post	Comparison	31	4.06	0.51	16.00	8.00	12.00	20.00	0.47	0.39
	Treatment	22	4.02	0.52	16.00	8.00	12.00	20.00	0.25	0.78
TCK pre	Comparison	31	3.44	0.71	14.00	11.00	8.00	19.00	-0.75	0.09
	Treatment	22	3.39	0.57	13.00	8.00	8.00	16.00	-0.46	-0.31
TCK post	Comparison	31	3.90	0.69	16.00	12.00	8.00	20.00	-0.65	1.20
	Treatment	22	4.05	0.49	16.00	8.00	12.00	20.00	-0.07	1.25
TPK pre	Comparison	31	3.89	0.55	36.00	21.00	24.00	45.00	-0.25	0.74
	Treatment	22	3.70	0.51	35.00	21.00	20.00	41.00	-1.26	2.20
TPK post	Comparison	31	4.13	0.50	36.00	17.00	28.00	45.00	0.52	-0.24
	Treatment	22	4.12	0.52	36.00	18.00	27.00	45.00	-0.17	1.11
TPACK pre	Comparison	31	3.48	0.70	14.00	12.00	8.00	20.00	-0.54	0.39
	Treatment	22	3.49	0.54	14.00	8.00	8.00	16.00	-0.98	1.09
TPACK post	Comparison	31	3.97	0.50	16.00	8.00	12.00	20.00	0.08	0.85
	Treatment	22	3.98	0.51	16.00	8.00	12.00	20.00	0.47	1.32

Tests were run on the data from the TPACK Survey prior to the main analyses to check for violations of the assumptions and requirements of MANCOVA. There were no skewness values greater than |2|, and no substantially platykurtic distributions, indicating that the variables were adequate for use in these analyses. The correlations between the TPACK post-survey subscales were deemed adequate to perform the planned analyses. Like with the attitudes measures, the majority of the subscales on the pre-survey were significantly correlated with the post-survey subscales, with correlations coefficients ranging from .28 to .74. Several of the subscales on the pre-surveys, however, were not correlated with the post-survey subscales. The PCK pre subscale was only significantly correlated with one of the post-subscales, TK (r = .28). TCK pre was not significantly correlated with post-subscales for PK (r = .26), TCK (r = .24), or TPACK (r = .23). TPACK pre was not significantly correlated with TK post (r = .23), PK post (r = .24), or TPK post (r = .27). CK pre was not significantly correlated with post-subscales for PK (r = .12), TPK (r = .11), or TPACK (r = .11). PK pre was not significantly correlated with TPK post (r = .25). These correlations suggested that these variables were not appropriate for use as covariates.

T-tests were conducted for all of the TPACK pre-survey subscale scores, using group (comparison or treatment) as the dependent variable to determine if there were differences between the two groups with respect to pre-survey TPACK. No significant differences were found, so it was determined that it was not necessary to use covariates in this analysis. A MANOVA was used instead to test for differences between the two groups on the post-survey scores only. With this change, these data were deemed appropriate for use in this analysis.

For this MANOVA, Box's test was significant (p < .000), indicating that the assumption of homogeneity of covariance matrices was violated. When group sizes are similar, as in this study, Pillai's trace can be used as a multivariate statistic when Box's M is significant as it is considered more robust against heterogeneous covariance matrices (Leech, et al., 2008; Stevens, 2009). For this analysis, Pillai's trace was used as the multivariate statistic to determine if there were significant differences between the two groups.

As with the other analyses, the alpha level was lowered to .017 to accommodate the multiple comparisons. The grouping variable (comparison or treatment) was entered as the independent variable; and the post-survey subscale scores were entered as the dependent variables. This analysis found no significant differences between the two groups on the TPACK Survey, Pillai's trace = .09, $F(7,45) = .67$, $p = .698$, partial $\eta^2 = .09$. In addition, none of the variables entered significantly contributed to distinguishing between the two groups. As a result of these non-significant findings, the planned discriminant analysis to explore the differences was unnecessary. The results of this analysis are included in Table 11.

These results suggest that the treatment and comparison groups were not different with respect to their perceptions of their TPACK, potentially indicating that the design teams approach did not have an effect on preservice teachers' TPACK.

Table 11

MANOVA/MANCOVA Results for TAC, TECS/TPSA, and TPACK

Construct tested	**Effect**	**Value**	**F**	**df**	***p***	**Partial Eta Squared**
Attitudes	Wilk's Lambda	0.82	1.03	9, 43	.435	.18
Skills	Wilk's Lambda	0.94	1.43	2, 43	.251	.06
TPACK	Pillai's trace	0.09	0.67	7, 45	.698	.09

Note: Computed using alpha = .017

TPACK Rubric Analysis. Data from the TPACK Rubric were used in the second analysis to explore the answer to the third research subquestion regarding the impact of the design teams approach on preservice teachers' TPACK. As preservice teachers' implemented lesson plans in their field placement classrooms, the grade level of each lesson plan was dictated by that placement. All but two preservice teachers indicated the grade level of their students within their lesson plan. All lesson plans involved either mathematics or social studies, as the overall program dictated that preservice teachers focus on instruction in these content areas during their Block II semester. Preservice teachers, however, were allowed to choose which of these two subjects they used for their lesson. As the comparison group included early childhood preservice teachers, some of these students were assigned to kindergarten classrooms. As none of the students in the treatment group were early childhood majors, they were all placed in grades 1-3 classrooms. In both groups, more students chose to integrate technology into their social studies lesson than mathematics. A summary of the grade levels and subject areas of the lesson plans for both the comparison and treatment groups are included in

Table 12.

Table 12

Summary of Lesson Plan Grade Levels and Content

		Comparison Group	Treatment Group
Grade Level	Kindergarten	6	0
	First	8	4
	Second	9	12
	Third	6	6
	Not indicated	2	0
Content	Mathematics	9	4
	Social Studies	22	18

All lesson plans were scored by both raters. Each rater scored the lesson plans by rating each from 1 to 4 on four criteria: Curriculum Goals & Technologies, Instructional Strategies & Technologies, Technology Selection(s), and “Fit,” which are intended to measure TCK, TPK, and TPACK. Overall scores were calculated by adding the scores from the four criteria on the rubric for each lesson plan. A bivariate correlation was calculated to assess the agreement between the two raters with respect to the overall scores. The correlation was high and statistically significant ($r(51) = .092$,

$p < .001$). An overall mean score for each participant was then calculated as the mean of the two raters' overall scores. Table 13 presents the descriptive statistics for the TPACK Rubric scores.

Table 13

Descriptive Statistics for TPACK Rubric (TPACK)

Variable	**Group**	**n**	**M**	**Mdn**	**Variance**	**SD**	**Min**	**Max**	**Range**	**Skew**	**Kurtosis**
Rater 1	Comparison	31	9.48	9.00	4.86	2.20	7.00	16.00	9.00	1.33	1.50
	Treatment	22	11.68	12.00	5.28	2.30	8.00	15.00	7.00	-0.09	-1.20
Rater 2	Comparison	31	9.29	8.00	5.21	2.28	6.00	16.00	10.00	1.23	1.36
	Treatment	22	11.14	11.00	6.50	2.55	8.00	16.00	8.00	2.12	-1.09
Combined Mean	Comparison	31	9.39	9.00	4.78	2.19	6.50	16.00	9.50	1.44	1.83
	Treatment	22	11.41	11.50	5.68	2.38	8.00	15.50	7.50	0.07	-1.18

The means from the two groups were compared using a *t*-test. The *t*-test indicated there were significant differences between the two groups, $t(51) = -3.20$, $p = .002$, $d = .90$. This suggests that the treatment did make a difference, with a large effect, with respect to preservice teachers' TPACK as reflected in their written lesson plans. These differences suggest that the treatment group's lesson plans showed significantly more evidence of the TPACK components than did the comparison group's lesson plans as measured by the TPACK Rubric. This indicates that the design teams approach improved preservice teachers' TPACK as evidenced in written lesson plans. This conflicts with the results found in the TPACK Survey analysis, providing mixed results with respect to the effect of design teams on preservice teachers' TPACK. Table 14 presents the results of this analysis.

Table 14

T-test Results for TPACK Rubric Overall Mean Scores

Variable	**Group**	**n**	**M**	**SD**	**SEM**	***t***	**df**	***p***	***d***
TPACK (Rubric)	Comparison	31	9.39	2.19	0.39	-3.20	51	.002	.90
	Treatment	22	11.41	2.38	0.51				

Ancillary Analyses

Comparing means of all participants. While there were not significant differences in means between the groups, as indicated in Table 11, the post-survey means on almost every variable were higher for both groups than the pre-survey means. Further exploration was conducted in order to determine if there were significant differences pre- to post-survey for both groups combined, which would provide additional information about the effectiveness of the instructional approaches in increasing attitudes toward technology, technology skills, and TPACK.

As analysis of the pre-survey and post-survey data indicated there were no significant differences between the two groups on these measures, the two groups were combined for these additional analyses to determine if there were significant differences pre- to post-survey for all participants. After adjusting the alpha level for multiple comparisons, group means were compared for all subscales on the four survey instruments using a paired *t*-test. Contrary to what was expected based on the results from prior research, this analysis found no significant difference in any of the attitudes toward technology subscales. Statistically significant differences with medium to large effects were found with respect to technology skills on both measures (TECS and TPSA) and for six of the seven TPACK subscales: CK, PK, PCK, TCK, TPK, and TPACK. Table 15 includes the data from the comparisons for technology skills and TPACK, including *t*-values, *p*-values, and effect sizes for significant results.

Table 15

Comparison of Technology Skills and TPACK for All Participants

Variable	**Pre/Post**	**n**	**M**	**SD**	**SEM**	***t***	**df**	***p***	***d***
TPSA	Pre	50	3.96	0.54	0.08	-6.34	49	<.001*	0.74
	Post	50	4.36	0.52	0.07				
TECS	Pre	48	3.79	0.48	0.07	-7.36	47	<.001*	1.06
	Post	48	4.30	0.49	0.07				
TK	Pre	53	3.62	0.62	0.09	-1.00	52	.321	-
	Post	53	3.68	0.69	0.10				
CK	Pre	53	3.60	0.49	0.07	-3.16	52	.003*	0.43
	Post	53	3.81	0.53	0.07				
PK	Pre	53	3.92	0.44	0.06	-4.85	52	<.001*	0.84
	Post	53	4.29	0.52	0.07				
PCK	Pre	53	3.68	0.47	0.07	-4.23	52	<.001*	0.77
	Post	53	4.04	0.51	0.07				
TCK	Pre	53	3.42	0.65	0.09	-5.12	52	<.001*	0.83
	Post	53	3.96	0.61	0.08				
TPK	Pre	53	3.81	0.54	0.07	-4.04	52	<.001*	0.57
	Post	53	4.12	0.50	0.07				
TPACK	Pre	53	3.48	0.63	0.09	-5.36	52	<.001*	0.77
	Post	53	3.97	0.50	0.07				

Note. * Significant at $p \leq .006$.

Exploring TPACK subscale scores. The lack of correlations between some of the TPACK components measured by the TPACK Survey suggested a need for further exploration of these subscale scores. As each TPACK construct is considered a separate and unique entity, the individual constructs would not necessarily be expected to be correlated (Koehler & Mishra, 2009). One would, however, expect the pre-survey scores to be correlated with the post-survey scores of the same construct. In this study, however, this was not the case for either PCK or TCK. Scatterplots were run to explore the relationships for the pre- and post-survey scores for the two groups together and separately. These scatterplots showed no pattern of relationships between the pre- and post-scores for these subscales.

Analysis of the individual items from the instrument was conducted to further explore the response patterns for these questions. The PCK and TCK subscales each resulted from four questions about four subject areas—literacy, mathematics, social studies, and science. When each content area was examined separately, rather than as one overall construct, there were still no correlations between the pre- and post-survey scores for these two components.

In order to further examine the relationships between the pre- and post-survey scores on this instrument, an analysis was done to explore the direction of movement from pre-survey to post-survey for all participants on all TPACK subscales. The percentages of increasing, decreasing, and consistent scores for each construct per subscale are included in Table 16.

This additional exploration found that the measures of central tendency were masking some drops in preservice teachers' perceptions of their TPACK. Interestingly, for the comparison group, more than 25% of the respondents had scores that decreased for three subscales: TK (45%), CK (35%), and TPK (29%). The highest percentage of decrease for the treatment group was 23%, for both TK and CK. The TK scores saw the most decreases in both groups, and was the only one of the TPACK constructs that did not have a statistically significant change from pre- to post-survey when the groups were combined. The responses were also examined at the item-level for potential patterns, such as consistently low responses on one item or those whose scores decreased on one subscale also decreasing on other subscales, but no patterns could be identified.

Table 16

Percent of Changes in Scores by Group Between Pre- and Post-Surveys

	Comparison			Treatment		
	Increase	**Decrease**	**No change**	**Increase**	**Decrease**	**No Change**
TK	39%	45%	16%	55%	23%	23%
PK	74%	6%	19%	59%	14%	27%
CK	55%	35%	10%	55%	23%	23%
PCK	52%	13%	35%	68%	14%	18%
TCK	65%	13%	23%	73%	9%	18%
TPK	52%	29%	19%	68%	5%	27%
TPACK	55%	6%	39%	55%	14%	32%

Note: Totals may not equal 100% due to rounding.

Chapter 5: Discussion

This research studied the effects of using a design teams approach in a technology integration course for preservice teachers. The study explored the effects of this approach on preservice teachers' attitudes toward technology, technology skills, and their Technological Pedagogical Content Knowledge. The goal of the study was to determine if the design teams approach had a significant effect on these variables compared to a standard instructional approach that had been used in prior course implementations. For this research, the course was implemented in two ways with two different groups of preservice teachers. The comparison group received the standard instruction, while the treatment group's instruction included the design teams approach.

The preservice teacher participants completed four pre-surveys and four post-surveys to measure their attitudes toward technology, technology skills, and their TPACK. In addition, lesson plans written by preservice teachers as part of the course requirements were evaluated using a rubric to assess evidence of TPACK. Data from surveys and scores from lesson plans were compared for the two groups to determine if the design teams approach had an impact on these variables. Prior research on the use of design teams approaches with both inservice and preservice teachers suggested that this type of collaborative learning environment would have a positive impact on these outcomes (Alayyar, 2011; Koehler & Mishra, 2005b; Koehler, Mishra, Yahya, et al., 2004).

Analysis of the pre-survey data indicated that there were no significant differences on either demographic or study-related variables between the two groups prior to participating in the course. The manipulation checks indicated that the two approaches—standard and design teams—were implemented per the research design. Multivariate analyses of variance/covariance, however, indicated that there were no significant differences between the two groups on the post-survey data on any of the four measures. This suggested that the design teams approach had no significant impact on preservice teachers' attitudes toward technology, technology skills, or TPACK. The analysis of the rubric data from the lesson plan scoring did find significant differences with large effects between the means of the two groups' TPACK. Follow-up analyses with the survey data found that, when the groups were combined to compare mean scores pre to post for the entire sample, there were significant differences with medium to large effects with respect to technology skills and six of the seven TPACK subscales (CK, PK, PCK, TCK, TPK, and TPACK). There were no significant differences in preservice teachers' attitudes toward technology.

These results partially supported the hypothesis that preservice teachers participating in the course implementation that included the design teams approach would show significantly greater increases their TPACK than a group of preservice teachers who participated in the same course using the standard instructional approach, as there were significant differences found between the two groups' TPACK Rubric scores but no differences with respect to the TPACK Survey scores. The results did not support the hypothesis in terms of preservice teachers' attitudes toward technology and technology skills, as no differences were found between the two groups on these variables. Prior research had suggested that design teams was a potentially preferable approach for improving these particular outcomes and suggested additional research was needed in this area (Koehler & Mishra, 2005a). These mixed results provide important information about this approach, in that it was not universally more effective than a standard approach in improving scores on these variables in this particular research.

As initial analyses indicated there were no differences between the comparison and treatment groups with respect to attitudes toward technology, technology skills, and TPACK as measured by the survey instruments, follow-up analyses were conducted in order to better understand the effect of the course instruction on these outcomes. These analyses suggested that there were significant differences on technology skills and TPACK between pre- and post-surveys for the entire sample of preservice teachers. As prior research had indicated that the standard approach to this course resulted in increased PK, PCK, TCK, TPK, and TPACK in preservice teachers (L. Lu, et al., 2011) and that the design teams approach resulted in improvement in technology skills and in six of the TPACK components (Alayyar, 2011); this was not an unexpected result. The findings from the current study suggested that, while the design teams approach was not more effective in producing the desired outcomes in preservice teachers, both the design teams and the standard approaches improved preservice teachers' technology skills and self-reported TPACK. These results also indicated that neither approach was successful in significantly improving preservice teachers' attitudes toward technology.

In this study, however, TPACK was measured with two separate instruments: the survey instrument and the rubric. Based on the comparison of mean scores from two raters on the TPACK Rubric, the design teams approach did significantly improve preservice teachers' TPACK as evidenced in lesson plans. The non-significant findings on the survey data, combined with the significant findings on the lesson plan data, could potentially be highlighting a difference in the particular aspect of TPACK being measured by each instrument. So and Kim (2009) expressed that there may be two different types of TPACK: (1) espoused, which preservice teachers can talk about and (2) in-use, which preservice teachers can actually apply to their planning and teaching. Alayyar (2011) also found evidence of two types of TPACK, as survey data and scores from lesson plans did not always suggest common understandings. Other research has suggested a slightly different explanation, that self-report survey instruments may measure preservice teachers' *TPACK confidence* while lesson plan analysis potentially measures *TPACK in practice* (Harris, Hofer, & Grandgenett, 2010).

What both of these potential explanations emphasize is the importance of examining the lesson plans for evidence of the capabilities of preservice teachers with respect to technology integration. Evidence from other research also suggests the possibility that preservice teachers tend to over-estimate their TPACK on self-report measures, thus including additional measures that are more closely related to teaching practice could produce a more complete picture of preservice teachers' technology integration knowledge (Alayyar, et al., 2010; Archambault & Barnett, 2010; Harris, Hofer, & Grandgenett, 2010). The literature has supported that TPACK should be assessed with multiple measures, as improvements on self-report measures were often inconsistent with preservice teachers' abilities to apply their TPACK in instructional contexts (Archambault & Barnett, 2010; Hofer, et al., 2010; Lawless & Pellegrino, 2007; Shin, et al., 2009). The results from this study seem to indicate that the design teams approach potentially worked as well as the standard approach in increasing espoused TPACK and/or their confidence with respect to TPACK, but worked better than the standard approach with respect to their TPACK as applied to their teaching practice.

Some components of the design teams approach seemed particularly conducive to improvements specifically related to lesson planning and teaching practice. For example, in both courses, the instructor provided feedback on submitted assignments, including advice for improving their performance. In the design teams approach, however, each assignment built on the previous assignment. Students were seen reading the instructor's feedback and advice during class to their teammates, then discussing how to apply that feedback to their current task. Other research has suggested that expert feedback, as was provided to the preservice teachers in this course, can have positive effects on subsequent tasks, provide pedagogical guidance, and provide structure for future pedagogical decisions (Angeli & Valanides, 2009; Englert & Sugai, 1983; Kicken, Brand-Gruwel, van Merrienboer, & Slot, 2009). As the comparison group completed stand-alone assignments, however, the feedback on one assignment was not necessarily applicable to the next assignment. For the treatment group, the feedback on an assignment could help improve their performance on subsequent assignments. This feedback was likely more relevant and immediately useful to these preservice teachers, potentially impacting their pedagogical decisions during their lesson planning.

Treatment group preservice teachers also seemed more likely to use technologies presented in class in their lesson plans. Both instructional approaches provided exposure to classroom uses of specific new technologies during each class, and required preservice teachers to use those technologies to create a student-appropriate product. In the standard approach, however, the instructor provided the classroom scenario for which students would create the technology product. In the design teams approach, preservice teachers were required to apply the new technology to their existing lesson ideas. While the standard approach provided practice for preservice teachers in using the new tools, the design teams approach provided the scaffolding necessary for the preservice teachers to learn to use their new knowledge in a context of their choosing. Lubin and Ge (2012) found that, without this type of scaffolding, preservice teachers would not apply their new knowledge to solve future technological problems. The lesson plans assessed for the current study seemed to lend support this finding as four students in the treatment group utilized wikis for the lesson plans, a technology that was taught on Day 2 of the course. None of the comparison group’s lesson plans included any of the Web 2.0 tools that were taught during the class sessions. Consistent with Lubin and Ge’s (2012) findings, the lesson plans suggested that the comparison group was able to successfully use the new technologies when given specific directions to do so, but some members of the treatment group were also able to also apply these technologies to new scenarios. These examples are encouraging, but given the small number of preservice teachers who used these technologies, more research would be necessary to confirm this pattern.

This difference in application of the new technologies could be the result of how the two groups interacted with the tools during class activities. The standard approach provided examples of technology tools used for instructional purposes, while the design teams approach required teams to analyze different tools, comparing and contrasting different solutions to determine how to best teach a particular piece of content. While the preservice teachers in the standard approach used the technological tools to create instructional products, the focus of the tasks was primarily on operating the technology. Preservice teachers in the design teams approach had discussions about pedagogy and content specifically related to the technological tools. Koehler and Mishra (2003) noticed similar interactions in their design teams as they worked together to consider and analyze the affordances of specific technological tools for particular applications. This suggests that the treatment group potentially developed a deeper understanding of the new technologies and their benefits for teaching and learning, which allowed them to successfully integrate them into their lesson plans.

Harris and Hofer (2011) found that a collaborative planning process can result in preservice teachers making more conscious and varied choices with respect to learning activities and technologies. They also found that preservice teachers made more “deliberate decisions” for technology use and that those working in collaborative groups had higher standards for what was considered to be high-quality technology integration than individuals working alone (p. 211). Other research also supports that collaborative, authentic environments have a tendency to produce these outcomes in preservice teachers (Alayyar, 2011; Amador, et al., 2006; Koehler & Mishra, 2003; Lubin & Ge, 2012).

In reviewing the lesson plans for the current study, it was found that the treatment group tended to use more technology in their lessons and used it in more sophisticated and nuanced ways than the comparison group. For example, the lesson plan template asked preservice teachers to include a variety of technological solutions for their lesson plan. The comparison group tended to list only one solution—the one they ultimately used with their students. The treatment group was more likely to list multiple appropriate potential solutions, suggesting a better understanding of how a variety of technology tools could potentially enhance students' learning.

The treatment group's lesson plans often suggested an understanding of the affordances of a variety of tools for teaching and learning, a willingness to experiment with different technological tools, and a tendency to push themselves beyond their technology and instructional comfort zone. For example, preservice teachers in the comparison group tended to use technology tools in their lessons in order to repeat an activity they had already completed with non-technological tools, such as using electronic versions of math manipulatives for solving equations. Several treatment group preservice teachers, however, used technologies in various parts of their lessons for multiple purposes. For example, a preservice teacher used a mapping website to provide a visual of different types of communities, created a wiki for students to use to access appropriate internet resources, then had students create an electronic presentation to demonstrate their learning. This type of lesson used multiple tools, each with a unique purpose, demonstrating a greater understanding of TPACK (Koehler & Mishra, 2003).

The significant differences on the lesson plan scores suggest that the design teams approach improved preservice teachers' TPACK as evidenced in lesson plans. A potential rival explanation however, is that the time spent in class on lesson planning in the treatment condition (rather than the design teams approach) resulted in the growth seen in the lesson plans. Hofer, Grandgenett, Harris, and Richardson (2010), however, found no differences in TPACK in lesson plans between a group of preservice teachers that had no opportunities for lesson planning during class and a group that had a non-collaborative lesson planning component in a technology integration course. Simply including time during class for lesson planning, therefore, did not result in increased TPACK. This finding, when combined with the results from the current study, lends support to the assertion that the collaborative, design teams approach is potentially the mechanism that resulted in the TPACK increases seen in the lesson plans.

The fact that there were no significant differences between the treatment and comparison groups at the beginning of the course, and the manipulation check indicated that the design teams were effectively implemented, suggest that the differences between the two groups on TPACK as measured with the rubric seems to be attributable to the differences in the instruction between the two courses. The design teams approach, therefore, shows substantial potential with respect to increasing preservice teachers' TPACK as it pertains to knowledge in practice (Harris, Hofer, Blanchard, et al., 2010).

Patterns and Trends

Detailed exploration of specific aspects of the data revealed some interesting trends and patterns beyond those uncovered in the main analyses. These serve both to provide additional detail regarding the phenomenon under study and provide guidance and direction for future research in the field.

Sample. The demographic characteristics of the sample indicated that the participants were overwhelmingly female. This is not atypical of early childhood and elementary education programs however, as the U.S. Census Bureau’s American Community Survey indicated that 97% of those who major in early childhood education and 91% of those who major in elementary education are female (Carnevale, Strohl, & Martin, 2011). Due to the scheduling in this particular program by the university, the treatment group had completed less university coursework than the comparison group, including predominantly preservice teachers classified as sophomores as opposed to the juniors in the comparison group. Prior research has suggested that, with the exception of college freshmen, gender and year in school do not have an impact on the variables measured in this study (Gorder, 2008; Lambert & Gong, 2010; Lambert, et al., 2008), suggesting that these characteristics of this sample should not have impacted the outcomes of this research.

Measures. The raw summed subscale score data suggest that ceiling effects were likely an issue with the TAC Survey. On five of the variables, a number of respondents scored the highest possible score on the pre-survey. This eliminates any possibility of these scores increasing over time, potentially explaining the non-significant results with respect to attitudes toward technology. Ceiling effects were more of a problem with the comparison group, however, as only one or two respondents in the treatment group had the highest pre-survey score, while up to eight respondents in the comparison group had the highest possible pre-survey score on one subscale. The raw summed subscale scores do not seem to indicate a problem with ceiling effects on the TPACK survey. On those variables where the maximum value was equal to the highest possible score on that subscale, there was only one respondent who obtained that score. For the majority of respondents on this survey, there was room to improve their score between the pre- and post-survey. While ceiling effects may not have been an issue in this case, the relatively high scores overall on both the pre- and post-surveys raises some questions about the measuring capabilities of the instruments, and whether the instruments were sensitive enough to detect the intervention effects.

Similar to previous studies that utilized these survey instruments, the mean scores on the survey instruments were above the midpoint on the response scales for both the pre- and post-surveys, with standard deviations of less than 1 (Agyei & Voogt, 2011; Alayyar, 2011; Chai, Koh, Tsai, & Tan, 2011; Morales, et al., 2008; Ropp, 1999). These high means, a mode of 4 for all items, and small standard deviations (which indicate data points were all relatively close to the mean), pose the possibility of issues regarding the sensitivity of the scales. As both groups showed growth between the pre- and post-surveys on most subscales, regression toward the mean on the post-survey does not seem to be a likely problem. Some researchers have explored increasing the sensitivity of the response scale in measuring the TPACK constructs by including a 7-point rather than the standard 5-point Likert scale as was used in this research (Chai, Koh, & Tsai, 2010; Chai, et al., 2011). As these studies also had means above the midpoint and standard deviations of less than one, further research would be needed to determine if this practice substantially increases the reliability and validity of these instruments with preservice teachers, or if this causes the response scale to exceed the preservice teachers' abilities to discriminate between the response options.

The lack of correlations between the pre- and post-survey scores on some of the TAC subscales was an unexpected result. While there are several examples in the literature of increases on TAC scores following an intervention, these studies did not report correlations between the pre- and post-scores, so it is not known how the correlations found in this study may compare to those from other research. In this research, nine subscales were used for the TAC, as recommended in the original validation of the instrument, though some recent studies have used fewer subscales (Alayyar, 2011; Christensen & Knezek, 2001; Ward & Overall, 2011). In this study, the Absorption post subscale was the most problematic in terms of non-significant correlations, thus removing this subscale or combining it with another subscale could have a substantial impact on the correlations between the pre- and post-subscales. It is possible, therefore, that reducing the number of scales would have produced more significant correlations between pre- and post-scores.

The lack of correlations between the pre- and post-scores for PCK and TCK from the TPACK Survey was also unexpected. Other studies using the TPACK Survey have reported small to moderate correlations between the seven subscales, but have predominantly run the correlations with larger samples using one administration of the instrument rather than with pre- and post-survey scores (Alayyar, 2011; Schmidt, et al., 2009). Researchers using this instrument have found some difficulties with the items from these two constructs cross-loading on other factors, suggesting that PCK and TCK may be difficult to isolate in practice as the boundaries are unclear (Archambault & Barnett, 2010; Chai, et al., 2011; Cox & Graham, 2009). Research has also suggested that these constructs and the relationships between them evolve for preservice teachers as they complete their coursework, suggesting that there may be non-linear patterns rather than linear relationships between pre- and post-scores for these TPACK components (Chai, et al., 2010), which would be consistent with the results in this study.

The non-significant correlations between the pre- and post-scores on these instruments raises concerns about the measuring capabilities of the instruments in this context. While the instruments were selected based upon their use in other similar research studies, there is actually little presentation of the measures' consistency over time in the literature. Additional research on these instruments with larger samples is necessary to determine if they are adequate measures of these constructs, particularly with respect to their consistency when used as repeated measures.

Another interesting finding was the relatively large percentages of preservice teachers indicating decreases on TK scores from pre- to post-survey, as the same pattern was not seen for the TECS/TPSA scores even though these instruments measure similar constructs. This could be because TK is measured with six questions that ask preservice teachers to consider their technology skills, habits, and interest as a whole. TECS and TPSA on the other hand, contain a greater number of questions and ask preservice teachers to consider specific aspects of their technology skills. The TPSA and TECS, therefore, were likely more sensitive to the subtle differences in preservice teachers' technology skills with respect to specific tools and their applications to teaching contexts than the TK subscale.

Another possible explanation for these score variations is response shift bias. This is defined by Cantrell (2003) as when “a respondent's internal metric or frame of reference is changed during the time between the pretest and the posttest, due to the effects of a training program or other intervention” (p. 178). For example, both groups' means were lower on the post-survey on the question, “I keep up with important new technologies.” As this course covered Web 2.0 technologies that preservice teachers may not have used previously, using these technologies in class may have caused them to reassess their knowledge of new technologies. Other studies have found that exposure to new instructional tools can cause both preservice and inservice teachers to reevaluate their skill level and, potentially, score themselves lower on a post-assessment of these skills than on the pre-assessment (Harris, Hofer, & Grandgenett, 2010; Rohs, 1999; Tschannen-Moran & McMaster, 2009). As recent studies on the TPACK constructs have not indicated an exploration of these types of response patterns, future research can further explore these response patterns to look for evidence of this, and other, explanations.

Unexpected attitudes. The only measure on which preservice teachers did not significantly increase between the pre- and post-surveys was on their attitudes toward technology as measured by the TAC. In actuality, several of the group mean scores were lower on the post-survey than on the pre-survey. For the treatment group, the mean scores for the Comfort, Interest, and Accommodation subscales dropped between the pre- and post-surveys; the mean score for Accommodation dropped for the comparison group. One explanation in this case could be either a ceiling effect or regression toward the mean, as pre-survey scores were relatively high, leaving little or no room for improvement. Another possible explanation could be the effect of preservice teachers' limited experiences with technology integration in their field placements. In this course, preservice teachers were required to implement one technology integrated lesson. As positive experiences are a key factor in attitudes toward technology integration (Mueller, et al., 2008), a negative experience with this one lesson (such as technical difficulties) could potentially impact a preservice teachers' attitudes toward technology in education in general. Other research has found decreases in teachers' attitudes toward innovations immediately following their first attempts at implementation likely due to their discomfort with the new tools or methods (Joyce & Showers, 1980, 2002). This could potentially have resulted in the slight decreases in the attitudes subscales seen in this research.

Other recent studies on technology integration courses with preservice teachers have also found stagnant or even decreasing attitudes (Allsopp, McHatton, & Cranston-Gingras, 2009; Chu, 2006; Lambert, et al., 2008). Some researchers have suggested that ceiling effects may be the cause (Allsopp, et al., 2009), which the raw summed subscale score data indicated may be an issue in this research. Lei (2009) found in her study of freshman education majors, however, that they had strong positive attitudes about technology for learning purposes, but were hesitant to abandon the more traditional instructional methods in favor of technological solutions, particularly with students in the lower grades. This suggests another potential explanation, that preservice teachers are entering their education programs with strong feelings about the role of technology in education based on both their prior personal and educational experiences with technology.

When universities began offering technology courses in their education programs, preservice teachers likely had few opinions about technology integration as technology was a relatively new innovation in K-12 education at the time. Now that preservice teachers are entering education programs with existing attitudes about technology and its role in education, the types of instruction that have increased attitudes toward technology in the past may no longer be adequate. Focused instruction intended to promote attitudinal change may be necessary for significant changes in attitude to take place (Kamradt & Kamradt, 1999). Future research is necessary to explore how attitudes toward technology have been changed by preservice teachers' exposure to technology prior to entering their university education program, whether targeted instructional methods are needed to improve attitudes in technology integration courses, or if more sensitive instruments are needed to better measure preservice teachers' developing attitudes.

Perceptions of course instruction. The significant difference between the comparison and treatment groups on the variables related to the quality of the instruction was an unexpected finding in this research. These variables were included in the study to control for the potential that the instructor could, whether consciously or unconsciously, manipulate the instruction in the courses in an effort to impact the results of the study. The expectation was that the two groups would have very similar evaluations of the quality of the instruction. The comparison group, however, ranked the instruction significantly higher on three of the six questions included in this measure, raising the question of whether there was something about the design teams approach that impacted these scores.

One possible explanation for these differences could relate to the prior relationship between many members of the comparison group and the instructor. In the comparison group, 21 of the preservice teachers had this instructor in a prior course and an additional 7 had some prior interaction with this instructor. None of the preservice teachers in the treatment group had any prior interactions with this instructor. It is possible that the prior relationships with the comparison group resulted in these preservice teachers having a more favorable view of the instructor before this course began, thus affecting their perception of the quality of the instruction on the post-course evaluations. As this measure was only administered at the end of the course, it is not known whether or not there were preexisting differences between the two groups. It is possible, therefore, that these differences in instructor rankings were the result of prior experiences and not related to the instructional approaches used in the course under study.

Other research on the use of a design teams approach in educational technology coursework provides little guidance with respect to instructor-related variables. Some studies reported positive outcomes related to participants’ views of collaboration and teamwork, but no data on their perceptions of the instructor were included in the analysis (Alayyar, 2011; Fessakis, et al., 2008; Koehler, et al., 2007). Koehler and his team (2007) did report that, particularly early in the process, participants reported discomfort with the design teams approach. Researchers have found the collaborative, open-ended process to be contradictory to students' expectations of both college-level coursework and their role as students in a university classroom (Fritschner, 2000; Koehler, et al., 2007). Leeds, Stull, and Westbrook (1998) found that more active teaching methods, like a design teams approach, did not result in more positive evaluations from university students, suggesting that dissonance between their expectations of their passive role in a university classroom and a more active environment could potentially impact their perceptions of instructor effectiveness (Fritschner, 2000; Leeds, et al., 1998; Lubin & Ge, 2012).

Research on collaborative teams with preservice teachers has also found that participants in these environments have lower expectations for external help (Lubin & Ge, 2012). They tended to rely on their classmates for information rather than the instructor, a result of the facilitative teaching style common to collaborative teaching approaches, potentially impacting their perception of the instructor's knowledge and effectiveness (Lubin & Ge, 2012). Other research has suggested that preservice teachers in more rigorous courses tend to evaluate the instructor more harshly than in less rigorous courses; and that students perceive classes with more rigid schedules as having less opportunities for student participation (Fritschner, 2000; Overbaugh, 1998). These were potentially issues in the treatment condition in this research. While the treatment condition was not intended to be more rigorous that the comparison condition, attempts to integrate the design teams approach without removing substantial portions of the standard instruction (to isolate the intervention for this research), likely resulted in a more rigorous course for the treatment group. It also resulted in more rigidly scheduled class sessions, in order to provide both the instruction on the technology tools and sufficient time for preservice teachers to complete the design teams tasks. These features potentially lowered the instructor evaluations for the treatment condition.

Perhaps most interesting were the significantly lower scores for the instructor with respect to "encouraging participation" with the treatment group. As the design teams approach is centered on active participation, these lower scores were surprising. While preservice teachers were actively participating in their design teams in every class, research suggested that undergraduate students define class participation primarily in terms of whole group discussions that involve the instructor and the entire class (Fritschner, 2000). Due to the time constraints in the treatment group implementation of the course, and the reliance on the small group interactions to answer questions and solve problems, less time was devoted to whole class discussions than in the comparison condition. If preservice teachers interpreted this question to refer to whole class discussions, and did not consider the design teams' work as "participation," this could explain the significant difference between the two groups on this variable.

It is interesting to note that the observer who conducted the manipulation checks also answered four of these six questions for both groups. She selected the highest score, Strongly Agree, for all questions for both groups. The observer, therefore, did not document any differences in the quality of instruction between the two implementations. These scores were not given anonymously however, which could have potentially impacted the scores. She also did not respond to two of the questions where significant differences were found, as these questions related to each preservice teacher's personal opinions of the instruction rather than specific characteristics of the instruction. Further research would be needed to better explain these discrepancies in the perceptions of the quality of the instruction, and to determine how the design teams approach may have affected the preservice teachers overall satisfaction with the course instruction.

Impact of lesson plan grade levels. Differences in the grade levels and content areas represented in the written lesson plans could potentially impact the content of the lesson plans and, therefore, the scores on the TPACK Rubric. The preservice teachers were required to implement the lesson plan they wrote in their field placement classrooms, so the grade level of the lesson plan was determined by the grade level of the placement classroom. At this point in their program at this university, preservice teachers were assigned to first- through third-grade classrooms whenever possible. Early childhood majors were assigned to kindergarten classrooms if other appropriate placements were not available. As a result, all of the lessons assessed in this research were written for these grade levels. As only the comparison group contained early childhood majors, there were no kindergarten lessons included in the treatment group lesson plans.

There was limited research available on how this focus on the early elementary grades impacts technology use and integration, as many studies only differentiate by overall level (elementary, middle, and high school) rather than by grades (J. D. Becker, 2008; Gorder, 2008). Some research suggests that primary classrooms tend to use computers more for educational games than for higher-order thinking tasks and collaboration, but data on quantity of use by grade level were limited in the existing, published research (J. D. Becker, 2008; Project Tomorrow, 2009). As the rubric used in this study was intended to assess evidence of preservice teachers’ TPACK and not the quality of either technology use or the implementation of the lesson, it was possible that some students did not communicate their existing TPACK effectively in their lesson plan if they felt limited by the capabilities of their young students. This scenario would have had a greater impact on the comparison group, as overall they had younger students than the treatment group.

Selection of lesson plan content area. While the grade level of the lesson was predetermined by the placement, each preservice teacher chose whether the lesson focused on mathematics or social studies. While it would be expected that approximately half of the lessons would be mathematics lessons, the lessons were actually overwhelmingly social studies lessons. There are several possible explanations for this result. As part of the requirements for the methods courses, the preservice teachers received a grade for their lesson plan in both the technology course and in the methods course. The requirements and grading system set forth by the methods instructors may have influenced which content the preservice teachers selected for integrating technology. If they believed that including technology in their mathematics lessons would negatively impact their grade in that class, they may have chosen instead to integrate technology into their social studies lesson plans.

Another potential explanation could lie in the modeling of the methods instructors with respect to technology integration. Wentworth (2006) found that the modeling of faculty members impacted preservice teachers' lesson planning. The TPACK Survey includes questions asking preservice teachers to rate their methods instructors' modeling of appropriate technology integration practices. In this study, the means for the mathematics education instructors on this variable were 3.13 (comparison group) and 3.27 (treatment group) on a 5-point Likert scale. For the social studies education instructors, the means were 3.61 (comparison) and 4.00 (treatment). This suggests that the preservice teachers perceived that the social studies instructors modeled technology integration more appropriately than the mathematics instructors, which may have affected their choice of content for their technology-integrated lesson.

The modeling by the technology integration instructor could also have had an impact on preservice teachers' selection of content for their lesson plans. During the class sessions for this course, resources and examples were provided for both mathematics and social studies technology integration. However, the course instruction included three actual model lessons, all of them focusing on social studies. This was not intentional on the part of the researcher, as the original instructional materials for this course were designed by a prior instructor. Unfortunately, this inadvertent emphasis on modeling of social studies technology integration may have impacted preservice teachers' selection of content for lesson plans.

As many studies assessing TPACK in preservice teachers have focused on only one content area, it is not clear how the choice of content area may impact evidence of TPACK in the lesson plans (Alayyar, 2011; Hammond & Manfra, 2009; Meagher, Ozgun-Koca, & Edwards, 2011). In their validation of the rubric, Harris and her colleagues (2010) included lessons from a variety of content areas, but did not specifically report on any potential differences between these lessons based on content area. While not the focus of this study, future research should explore the relationships between the modeling of methods instructors and preservice teachers' technology integration practices, as well as the potential impact of content area focus on lesson plan characteristics related to the TPACK framework.

Future directions. The findings of this study continue to emphasize the complexity of improving preservice teachers' technology integration abilities, as has been suggested by other researchers in the field. While this study explored several factors that contribute to preservice teachers' technology integration within the context of particular instructional approaches, it may be useful to examine potential moderating or mediating relationships among these variables to better comprehend how they interact. This study used multiple measures in an attempt to create a more complete picture of preservice teachers' knowledge and skills than has been seen in prior studies, but an ideal scenario would be to combine measures of all aspects of preservice teachers' technology integration process, including (a) surveys; (b) analysis of instructional materials and reflections; and (c) observations of planning, instruction, and interactions with students (Harris, Hofer, & Grandgenett, 2010). Future research is obviously necessary to continue to explore the complex relationships among preservice teachers' attitudes toward technology, technology skills, and knowledge related to teaching and technology integration, as well as the evolution of these skills and knowledge over time. In addition, more research that compares multiple instructional approaches is necessary to provide information about approaches that are most effective in increasing preservice teachers' technology integration knowledge and skills, and ultimately their practice.

Implications

The findings of this study suggest that a design teams approach in a technology integration course for preservice teachers has potential with respect to improving TPACK as it relates to teaching practice. This study provides one description of an implementation of a design teams approach that can be used by future instructors and researchers who wish to build upon this research and compare a design teams approach to other instructional approaches. In order to provide additional guidance to others in their efforts to implement this approach, this section includes anecdotal notes on this implementation and provides further details for purposes of information and potential comparisons with future research efforts.

Implementation of design teams approach. The course in which the design teams approach was implemented was a one-credit course that had only six class meetings over the period of one semester. As other studies examining design teams approaches tended to focus on two- or three-credit courses, sometimes with twice as many class sessions (Alayyar, 2011; Koehler, et al., 2007; Kolodner, et al., 2003), adapting the design teams approach to this short timeline was challenging. The design teams tasks completed during class time required teams to complete a modified version of the comparison group's mini-project, drafts of additional instructional materials, and an outline of their developing unit. While it is difficult to measure the quantity of work required for a course, the instructor perceived that the treatment group version of the course required more work on both the part of the preservice teachers, and for the instructor in terms of planning and grading assignments. Courses with longer timelines could have more flexibility in terms of adapting requirements and distributing workloads over time.

Time constraints and scheduling issues occasionally caused deviations from the original plan for the design teams approach. For example, on Day 4, the implementation plan included a Poster Session during which preservice teachers would share their working instructional materials with the entire class, to receive feedback to inform revisions of their lesson plan and instructional materials. Unfortunately, many of the preservice teachers did not yet know what their specific topic would be for their technology integrated lesson plan as they were waiting to receive this information from their host teacher. Some preservice teachers expressed frustration as they felt they were unable to produce useful materials for the lessons without this information. As a result, preservice teachers shared their ideas with their design teams and provided feedback and support to their teammates, but the poster session did not occur that day. All preservice teachers did receive feedback from their classmates on Day 5 during the testing and feedback activity, though some preservice teachers still did not know the topic for their lesson. Future implementations could require all preservice teachers to have a potential topic prepared, regardless of whether or not it will actually be the topic of their final lesson. Alternative activities could also be provided, such as modifying existing non-technology lesson plans to include effective use of technology tools, such that all participants will complete an activity that requires consideration of technology, pedagogy, and content.

Other implementation issues arose with respect to the second design teams' web conference. The instructions provided by the instructor communicated that the purpose of the web conference was to practice lesson implementation. While all preservice teachers completed Web conference #2 with their teams, no one reported being able to practice their lesson implementation during this conference, as was indicated on the assignment sheet. According to the preservice teachers, this was due to the difficulty of scheduling this web conference at a time when all of the team members were ready to practice. Preservice teachers primarily reported either sharing and reflecting on their lesson with their teammates if they had already implemented it, or sharing ideas and receiving feedback from their team if they had not yet implemented the lesson in their placement classroom. Many of the preservice teachers also used technology in their lesson implementations that they could not access during their web conferencing session (such as interactive whiteboards or proprietary software). This made practicing the implementation via web conferencing virtually impossible. While the practice session was intended to help preservice teachers be better prepared for their implementations, it was not a successful component of this design teams approach. Future efforts could modify this requirement to include a feedback session more similar to prior team meetings in class, or might arrange scheduling and access to technology tools in advance to ensure that a practice session is a reasonable expectation.

Anecdotal observations. While no qualitative data were collected or analyzed for this research, as the researcher was also the course instructor, some interesting anecdotal observations were made during course implementation which may inform future research agendas. While minor issues with implementation were to be expected, there were other differences noticed between the two groups that were neither expected nor intended. These differences seemed anecdotally to be related to the differences in instructional approach, and how the different approaches impacted the conversations and communication amongst the preservice teachers and their instructor with respect to course-related issues. As no data were collected to document these differences, however, additional research will be necessary to further explore these issues.

An interesting occurrence noticed by the instructor in comparing the two course implementations was the communication between the preservice teachers and the instructor. Though data were not specifically collected on these interactions, anecdotal observations suggest that the treatment preservice teachers contacted the instructor less during the course of the semester, particularly when in their field placement classrooms, than did the comparison group. This was consistent with some research on collaborative instruction in technology integration courses which suggested that the collaborative groups tended to consult with their group members on their assignments, whereas students in more traditional classes generally asked the instructor for input and feedback (Lubin & Ge, 2012). Interestingly, in the treatment group, this sometimes resulted in situations where submitted assignments were not always as the instructor expected. It seems likely that in a collaborative environment, setting clear expectations for communication is extremely important as preservice teachers will default to consulting their peers rather than the instructor when questions arise related to requirements or assignment expectations.

Similar to other studies (Harris & Hofer, 2011; Koehler & Mishra, 2005a) that reported changes in the language used as design team participants worked through their tasks, preservice teachers in the treatment group in the current study had conversations during each class in which they discussed and debated the technology, pedagogy, and content for their lessons. The design team members would discuss whether or not particular technologies were appropriate for certain grade levels and if the activity they were planning actually related to the selected content. A classroom observer commented at one point, “They sound like teachers.” In the comparison group, conversations between the preservice teachers typically revolved around how to operate the technology tools and clarifications of the requirements stated on the assignment sheets.

These differences continued into their in-class communications with the instructor. Preservice teachers in the comparison group often requested clarifications or even specific technology directions from the instructor. In the treatment group, questions were rarely aimed at the instructor. The treatment group did occasionally ask questions about the requirements for each task and for assistance with submitting their documents for grading purposes, but tended to be more self-sufficient during class sessions. The design teams were responsive when approached by the instructor with general questions related to their progress and their perceptions of the quality of their lesson plans or materials, but did not often initiate these conversations. These exchanges also primarily occurred during class sessions with the treatment group. Email communication with the instructor while preservice teachers were in their field placements was common with the comparison group, yet relatively rare with the treatment group. These differences in communication suggest that the design teams approach potentially both changed the type of conversations between preservice teachers, and the relationships between the preservice teachers as well.

Where prior research looked only at the effectiveness of the design teams approach in improving factors related to preservice teachers' technology integration abilities, this study looked at effectiveness of the design teams approach compared to another instructional method in an attempt to determine if the design teams approach was more effective in promoting improvements in the technology integration knowledge and skills of preservice teachers. The findings of this study do suggest that a design teams approach can be effective, and perhaps raises the questions of when, with whom, and for exactly what purposes? The results seem to suggest that both the standard instructional approach and the design teams approach worked well at improving technology skills and TPACK. The results also suggest that a design teams approach works better than the standard approach in terms of improving TPACK related specifically to lesson planning. It is still unclear, however, whether these results from lesson planning carry over into lesson implementation. It is also unclear whether these results have long-term impacts. All of these inquiries can provide direction for future research in this area.

Limitations and Strengths

A limitation in this research is the potential of unmeasured, confounding variables. As this research was conducted within an existing educational program, there were many variables that pose alternative explanations that could not be controlled. One particular setting that was difficult to control for research purposes was the preservice teachers' field placement classrooms. For example, in exploring the individual items that comprise the PK subscale, the means of both groups improved from pre- to post-survey on items related to the teaching of literacy and science. As all of the university coursework for these preservice teachers focused on mathematics and social studies, these changes were likely the result of their exposure to the teaching of these subjects in their placement classrooms rather than the result of any university instruction, particularly the technology integration course under study. The host teacher also poses a potential rival explanation, though the literature on a host teacher's impact showed mixed results. Some research has suggested that there are some relationships between preservice teacher technology use and the host teacher's technology use, while other research has found the host teacher's use to make little difference (Dawson, 2006; Pope, Hare, & Howard, 2005). As technology integration ability was not a criterion for selection of host teachers, it was expected that this variable would be randomly distributed in both the comparison and treatment groups. Data were not collected on this however, so the impact of the host teachers' technology integration for this study is unclear.

Another potentially confounding variable was the effect of preservice teachers' other coursework on these outcomes. The preservice teachers in this study were enrolled in the technology integration course under study concurrent with other methods courses. These methods courses were intended to improve preservice teachers' pedagogy and content knowledge, in this case specifically related to mathematics and social studies instruction. Some of the gains seen in this study, likely those related specifically to content and pedagogy rather than technology, were potentially caused by their participation in these courses or by the combination of courses. It is difficult to isolate one course's effects when implementing a research study within a real educational context. In this case, as the preservice teachers complete their coursework as a cohort, all study participants took the same coursework over the semester in which they were participating in the study. The effects of this coursework, therefore, should be similar for the two groups, likely minimizing this as a rival explanation for the significant differences found between the two groups on their TPACK in the lesson plans.

The fact that the design teams approach included two meetings via web conferencing, to include all components of the design teams approach and provide lesson planning support to preservice teachers while they were in their placement classrooms, may have had unintended consequences in this research. These web conferences were arranged, completed, and recorded by the preservice teachers, and not attended by the instructor. Thus, while the web conferences did not increase the amount of instructional time in the course, the addition of web conferencing did result in additional required time for course-related activities for the treatment group. Based on the length of the recordings, each of the web conferences for the treatment group ranged from 13 to 31 minutes, with a mean of 22 minutes.

In an attempt to make the activities completed via web conferencing similar to the lesson planning completed independently by the comparison group, the guiding questions provided by the instructor to be answered during the web conferences were taken directly from the lesson plan templates. The conferences, therefore, focused on answering questions that were required for all preservice teachers as part of the lesson plan. The design teams approach had preservice teachers complete these tasks with their design team, whereas the comparison group completed these same tasks independently. The intention, therefore, was that all preservice teachers would spend approximately the same amount of time in lesson planning: the comparison group working independently and the treatment group working in their design teams. It is not known exactly how the time spent on lesson planning compared between the two approaches. It seems plausible; however, that the additional structured time and not the tasks associated with the design teams approach were the causal mechanism that resulted in the significant differences between the two groups with respect to the lesson plan scores.

The web conferencing experiences should not have impacted the treatment group’s scores with respect to their technology skills, however, as the instruments used in this research measured foundational technology skills and did not include questions related to advanced technologies like web conferencing. The lack of significant differences between the two groups on this variable suggests that the use of web conferencing did not affect the treatment group’s technology skills as they were measured for this study.

This study used a small, convenience sample of preservice teachers enrolled in one university’s teacher preparation program. This sample was unique in several ways when compared to the more general population of preservice teachers. Based on the demographic information, they had almost ubiquitous access to technology. They were also, as a result of the requirements for the degree program at this university, all prepared to be dual-certified: in special education and either early childhood or elementary education. While this study provides information to explain the phenomenon as it occurred in this context, the small sample and unique characteristics of the sample greatly limits the leverage for making strong inferences and the generalizability of these findings. Further research with larger sample sizes at multiple universities will be necessary in order to make statements that are generalizable to the greater population of preservice teachers.

In an attempt to compensate for some of the potential rival explanations, lesson plans were assessed for this study, rather than lesson implementation. As lesson implementation is more likely to be impacted by first order technology barriers (i.e., access to technology) and other factors beyond the preservice teacher’s control (i.e., the host teacher’s technology use), lesson plans were the focus of analysis in this study. All components of the lesson plan were considered during the scoring process, including brainstormed ideas and reflections, to try to obtain the most accurate assessment of the preservice teachers' knowledge with respect to the relationships between technology, pedagogy, and content.

Unlike other research examining preservice teachers and TPACK, which focused on individual content areas, this study included both mathematics and social studies. As most elementary teachers are responsible for instruction in more than one content area, conducting research in courses that include multiple content areas can provide a better representation of the preservice teachers' overall technology integration abilities. Future research that includes additional content areas will further build upon both this research and the literature base in this field.

Summary

Like much research, the results of this study pose a substantial number of additional questions to guide future research efforts. Future researchers should continue to explore the primary research questions of this study, as well as the additional questions raised in order to build a literature base that can ultimately answer these questions.

Chapter 6: Conclusions

The ability to effectively integrate technology into instruction has become an essential component of effective teaching. Teacher preparation programs have attempted to prepare preservice teachers to integrate technology using a variety of instructional approaches in technology integration education coursework. This study investigated the design teams instructional approach in a university course for preservice teachers to determine whether this approach was effective in improving the skills and knowledge necessary for technology integration. The results of this study provide guidance for designers and instructors of similar courses in selecting instructional approaches to develop effective technology integration coursework for preservice teachers.

In an attempt to provide information on the effectiveness of a design teams approach, the effects of two different instructional approaches were compared on three different outcomes: attitudes toward technology, technology skills, and TPACK. The results suggest that design teams may not be more effective than other instructional approaches in increasing preservice teachers' perceptions of their attitudes toward technology, technology skills, and Technological Pedagogical Content Knowledge. Specifically, both instructional approaches used in this study were effective in increasing two of these outcomes in preservice teachers: technology skills and TPACK.

This research also explored the effect of the design teams approach on preservice teachers' TPACK as present in lesson plans that were implemented with students in classrooms. Rather than measuring preservice teachers' perceptions of their own knowledge, this attempted to provide a more detailed picture of their knowledge in practice. The results did indicate that the design teams approach had a positive impact on preservice teachers' TPACK as it relates to teaching practice, particularly with respect to their ability to plan lessons that effectively integrate technology.

As this is one study with a small sample of preservice teachers, additional research is necessary to support or reject these findings in order to generalize to larger, more diverse populations. The results of this study can provide the basis for future research that further explores how participating in a design teams approach impacts classroom teaching, short-term and long-term. Any future research that compares the impact of various instructional approaches on these outcomes will be an important contribution to both this field of research and the practice of teaching preservice teachers.

More research is necessary to explore a variety of additional questions raised by this study. What are the patterns of preservice teachers' TPACK growth throughout their teacher preparation program? How does a collaborative approach such as design teams impact preservice teachers' perception of the instructor's effectiveness? How have preservice teachers' attitudes toward technology changed over time? Are different types of instruction necessary in order to have a positive impact on these attitudes? How does the effectiveness of a design teams approach compare to other instructional approaches in this context? How does participation in a design teams approach impact preservice teachers' teaching practice? These questions offer important new directions for additional explorations into the understanding of the technology integration education of preservice teachers.

Overall, this research has begun the important process of determining not just what instructional approaches improve preservice teachers' attitudes toward technology, technology skills, and TPACK, but comparing approaches to determine what approaches show more potential than others in promoting these outcomes. Future research can continue to explore instructional approaches to provide guidance as to the best combination of instruction to produce the desired ultimate outcome: teachers who effectively integrate technology to enhance student learning.

Appendix A

TAC v. 5.1

Your SU e-mail address (e.g., username@syr.edu)

☐

Please complete all items even if you feel that some are redundant. This may require 10 minutes of your time. Usually it is best to respond with your first impression, without giving a question much thought. Your answers will remain confidential and have no effect on your course grade. Thank you.

Part 1: Select one level of agreement for each statement to indicate how you feel.

	1=strongly disagree	2=disagree	3=undecided	4=agree	5=strongly agree
1. I think that working with computers would be enjoyable and stimulating.	○	○	○	○	○
2. I want to learn a lot about computers.	○	○	○	○	○
3. The challenge of learning about computers is exciting.	○	○	○	○	○
4. Learning about computers is boring to me.	○	○	○	○	○
5. I like learning on a computer.	○	○	○	○	○
6. I enjoy lessons on the computer.	○	○	○	○	○
7. I can learn many things when I use a computer.	○	○	○	○	○
8. I believe that it is very important for me to learn how to use a computer.	○	○	○	○	○
9. A job using computers would be very interesting.	○	○	○	○	○
10. The people who give me the best ideas for improving teaching also tend to know a lot about computers.	○	○	○	○	○
11. I concentrate on a computer when I use one.	○	○	○	○	○
12. I believe that I am a better teacher with technology.	○	○	○	○	○

Part 2: Select one level of agreement for each statement to indicate how you feel.

		1=strongly disagree	2=disagree	3=undecided	4=agree	5=strongly agree
1.	I get a sinking feeling when I think of trying to use a computer.	❍	❍	❍	❍	❍
2.	Working with a computer makes me feel tense and uncomfortable.	❍	❍	❍	❍	❍
3.	Working with a computer makes me nervous.	❍	❍	❍	❍	❍
4.	Computers intimidate me.	❍	❍	❍	❍	❍
5.	Using a computer is very frustrating.	❍	❍	❍	❍	❍
6.	I feel comfortable working with a computer.	❍	❍	❍	❍	❍
7.	Computers are difficult to use.	❍	❍	❍	❍	❍
8.	I think that computers are very easy to use.	❍	❍	❍	❍	❍
9.	I have a lot of self confidence when it comes to working with computers.	❍	❍	❍	❍	❍
10.	Computers are hard to figure out how to use.	❍	❍	❍	❍	❍

Part 3: Select one level of agreement for each statement to indicate how you feel.

		1=strongly disagree	2=disagree	3=undecided	4=agree	5=strongly agree
1.	If I had a computer at my disposal, I would try to get rid of it.	❍	❍	❍	❍	❍
2.	Studying about computers is a waste of time.	❍	❍	❍	❍	❍
3.	I can't think of any way that I will use computers in my career.	❍	❍	❍	❍	❍
4.	I will probably never learn to use a computer.	❍	❍	❍	❍	❍
5.	I see the computer as something I will rarely use in my daily life.	❍	❍	❍	❍	❍
6.	Knowing how to use a computer is a worthwhile skill.	❍	❍	❍	❍	❍
7.	I look forward to having a computer in my home.	❍	❍	❍	❍	❍
8.	Using a computer prevents me from being creative.	❍	❍	❍	❍	❍
9.	You have to be intelligent to work with computers.	❍	❍	❍	❍	❍
10.	Not many people can use computers.	❍	❍	❍	❍	❍
11.	I would never take a job where I had to work with computers.	❍	❍	❍	❍	❍

Part 4: Select one level of agreement for each statement to indicate how you feel.

		1=strongly disagree	2=disagree	3=undecided	4=agree	5=strongly agree
1.	The use of Electronic mail (E-mail) makes the student feel more involved.	○	○	○	○	○
2.	The use of E-mail helps provide a better learning experience.	○	○	○	○	○
3.	The use of E-mail makes a class more interesting.	○	○	○	○	○
4.	The use of E-mail helps the student learn more.	○	○	○	○	○
5.	The use of E-mail increases motivation for class.	○	○	○	○	○
6.	More courses should use E-mail to disseminate class information and assignments.	○	○	○	○	○
7.	The use of E-mail creates more interaction between students enrolled in the course.	○	○	○	○	○
8.	The use of E-mail creates more interaction between student and instructor.	○	○	○	○	○
9.	E-mail provides better access to the instructor.	○	○	○	○	○
10.	E-mail is an effective means of disseminating class information and assignments.	○	○	○	○	○

Part 5: Select one level of agreement for each statement to indicate how you feel.

		1=strongly disagree	2=disagree	3=undecided	4=agree	5=strongly agree
1.	Computers are changing the world too rapidly.	○	○	○	○	○
2.	I am afraid that if I begin to use computers I will become dependent upon them.	○	○	○	○	○
3.	Computers dehumanize society by treating everyone as a number.	○	○	○	○	○
4.	Our country relies too much on computers.	○	○	○	○	○
5.	Computers isolate people by inhibiting normal social interactions among users.	○	○	○	○	○
6.	Computers have the potential to control our lives.	○	○	○	○	○
7.	Working with computers makes me feel isolated from other people.	○	○	○	○	○
8.	Use of computers in education almost always reduces the personal treatment of students.	○	○	○	○	○
9.	Working with computers means working on your own, without contact with others.	○	○	○	○	○
10.	The Internet will help narrow the societal gap between the "haves" and "have nots".	○	○	○	○	○
11.	Computers will some day be smarter than people.	○	○	○	○	○

Part 6: Select one level of agreement for each statement to indicate how you feel.

	1=strongly disagree	2=disagree	3=undecided	4=agree	5=strongly agree
1. Computers could increase my productivity.	○	○	○	○	○
2. Computers can help me learn.					
3. Computers are necessary tools in both educational and work settings.	○	○	○	○	○
4. Computers can be useful instructional aids in almost all subject areas.	○	○	○	○	○
5. Computers improve the overall quality of life.	○	○	○	○	○
6. If there was a computer in my classroom it would help me to be a better teacher.	○	○	○	○	○
7. Computers could enhance remedial instruction.	○	○	○	○	○
8. Computers will improve education.	○	○	○	○	○
9. Computers can be used successfully with courses which demand creative activities.	○	○	○	○	○
10. Having a computer available to me would improve my general satisfaction.	○	○	○	○	○

Part 7: Choose one location between each adjective pair to indicate how you feel about computers.

Computers are…

1.	unpleasant	○	○	○	○	○	○	○	pleasant
2.	suffocating	○	○	○	○	○	○	○	fresh
3.	dull	○	○	○	○	○	○	○	exciting
4.	unlikable	○	○	○	○	○	○	○	likable
5.	uncomfortable	○	○	○	○	○	○	○	comfortable
6.	bad	○	○	○	○	○	○	○	good
7.	unhappy	○	○	○	○	○	○	○	happy

Part 8: Select one level of agreement for each statement to indicate how you feel.

		1=strongly disagree	2=disagree	3=undecided	4=agree	5=strongly agree
1.	I like to talk to others about computers.	❍	❍	❍	❍	❍
2.	It is fun to figure out how computers work.	❍	❍	❍	❍	❍
3.	If a problem is left unsolved in a computer class, I continue to think about it afterward.	❍	❍	❍	❍	❍
4.	I like reading about computers.	❍	❍	❍	❍	❍
5.	The challenge of solving problems with computers does not appeal to me.	❍	❍	❍	❍	❍
6.	When there is a problem with a computer that I can't immediately solve, I stick with it until I have the answer.	❍	❍	❍	❍	❍
7.	Computers can be exciting.	❍	❍	❍	❍	❍
8.	I don't think I would do advanced computer work.	❍	❍	❍	❍	❍
9.	I will use computers many ways in my life.	❍	❍	❍	❍	❍
10.	I like to scan computer journals.	❍	❍	❍	❍	❍

Part 9: Select one level of agreement for each statement to indicate how you feel.

	1=strongly disagree	2=disagree	3=undecided	4=agree	5=strongly agree
1. It is important for students to learn about computers in order to be informed citizens.	○	○	○	○	○
2. Students should understand the role computers play in society.	○	○	○	○	○
3. All students should have some understanding about computers.	○	○	○	○	○
4. All students should have an opportunity to learn about computers at school.	○	○	○	○	○
5. Computers could stimulate creativity in students.	○	○	○	○	○
6. Computers could help students improve their writing.	○	○	○	○	○
7. Computers can help accommodate different learning styles.	○	○	○	○	○
8. Students work harder at their assignments when they use computers.	○	○	○	○	○
9. Students help one another more while doing computer work.	○	○	○	○	○
10. Student time on the Internet is time well-spent.	○	○	○	○	○
11. Learning about computers is worthwhile.	○	○	○	○	○
12. Having computer skills helps one get better jobs.	○	○	○	○	○
13. I am sure that with time and practice, I can be comfortable working with computers.	○	○	○	○	○
14. Learning to operate a computer is like learning any new skill - the more you practice, the better you become.	○	○	○	○	○

Part 10: Please read the descriptions of each of the six stages related to adoption of technology. Choose the stage that best describes where you are in the adoption of technology.

○ **Stage 1: Awareness**
I am aware that technology exists but have not used it - perhaps I'm even avoiding it. I am anxious about the prospect of using computers.

○ **Stage 2: Learning the process**
I am currently trying to learn the basics. I am sometimes frustrated using computers. I lack confidence when using computers.

○ **Stage 3: Understanding and application of the process**
I am beginning to understand the process of using technology and can think of specific tasks in which it might be useful.

○ **Stage 4: Familiarity and confidence**
I am gaining a sense of confidence in using the computer for specific tasks. I am starting to feel comfortable using the computer.

Stage 5: Adaptation to other contexts
I think about the computer as a tool to help me and am no longer concerned about it as technology. I can use it in many applications and as an instructional aid.

○ **Stage 6: Creative application to new contexts**
I can apply what I know about technology in the classroom. I am able to use it as an instructional tool and integrate it into the curriculum.

Thank you for completing this survey.

Appendix B

Technology in Education Competency Survey (TECS)

Your SU e-mail address (e.g., username@syr.edu)

Instructions: Select one level of agreement for each statement to indicate how you feel.

I feel competent…

	1=strongly disagree	2=disagree	3=undecided	4=agree	5=strongly agree
using a word processor and graphics to develop lesson plans.	○	○	○	○	○
using e-mail to communicate with colleagues.	○	○	○	○	○
using the World Wide Web to find educational resources.	○	○	○	○	○
using an electronic grade book.	○	○	○	○	○
constructing and implementing project-based learning lessons in which students use a range of information technologies.	○	○	○	○	○
to help students learn to solve problems, accomplish complex tasks, and use higher-order thinking skills in an information technology environment.	○	○	○	○	○
in recognizing when a student with special needs may benefit significantly by the use of adaptive technology.	○	○	○	○	○
about teaching K-12 students age-appropriate information-technology skills and knowledge.	○	○	○	○	○
working with students in various IT environments (such as standalone and networked computers, one-computer classrooms, labs, etc.).	○	○	○	○	○

Thank you for completing this survey.

Appendix C

Technology Proficiency Self-Assessment (TPSA)

Your SU e-mail address (e.g., username@syr.edu)

Instructions: Select one level of agreement for each statement to indicate how you feel.

I feel confident that I could:

		1=strongly disagree	2=disagree	3=undecided	4=agree	5=strongly agree
1.	send e-mail to a friend.	○	○	○	○	○
2.	subscribe to a discussion list.	○	○	○	○	○
3.	create a "nickname" or an "alias" to send e-mail to several people at once.	○	○	○	○	○
4.	send a document as an attachment to an e-mail message.	○	○	○	○	○
5.	keep copies of outgoing messages that I send to others.	○	○	○	○	○
6.	use an Internet search engine (e.g., Internet Explorer or Firefox) to find Web pages related to my subject matter interests.	○	○	○	○	○
7.	search for and find the Smithsonian Institution Web site.	○	○	○	○	○
8.	create my own World Wide Web home page.	○	○	○	○	○
9.	keep track of Web sites I have visited so that I can return to them later. (An example is using bookmarks.)	○	○	○	○	○
10.	find primary sources of information on the Internet that I can use in my teaching.	○	○	○	○	○
11.	use a spreadsheet to create a pie chart of the proportions of the different colors of M&Ms in a bag.	○	○	○	○	○

12.	create a newsletter with graphics and text in 3 columns.	○	○	○	○	○
13.	save documents in formats so that others can read them if they have different word processing programs (e.g., saving Word, RTF, or text).	○	○	○	○	○
14.	use the computer to create a slideshow presentation.	○	○	○	○	○
15.	create a database of information about important authors in a subject matter field.	○	○	○	○	○
16.	write an essay describing how I would use technology in my classroom.	○	○	○	○	○
17.	create a lesson or unit that incorporates subject matter software as an integral part.	○	○	○	○	○
18.	use technology to collaborate with other interns, teachers, or students who are distant from my classroom.	○	○	○	○	○
19.	describe 5 software programs that I would use in my teaching.	○	○	○	○	○
20.	write a plan with a budget to buy technology for my classroom.	○	○	○	○	○

Thank you for completing this survey.

Appendix D

TPACK Survey

Thank you for taking time to complete this questionnaire. Please answer each question to the best of your knowledge. Your thoughtfulness and candid responses will be greatly appreciated. Your responses will be kept completely confidential and will not influence your course grade.

Section 1: Demographic information

1. Your SU e-mail (e.g., username@syr.edu)

Items 2-8 below on pre-survey only

2. What semester and year (e.g. Spring 2008) do you plan to take the following? If you are currently enrolled in or have already take one of these professional blocks, please list semester and year completed.
   Pre-Block
   Professional Block I
   Professional Block II
   Professional Block III
   Student teaching

3. Are you currently enrolled or have you completed a practicum experience in a PreK-6 classroom?
   - Yes
   - No

4. Year in College
   - Freshman
   - Sophomore
   - Junior
   - Senior
   - Other

5. Gender
   - Female
   - Male

6. What is your age range?
   - 18-22
   - 23-26
   - 27-32
   - 33+

7. What is your education major?
   - Inclusive Early Childhood Special Education
   - Inclusive Elementary and Special Education
   - Other (Please specify) ___________________________

8. What is your liberal arts major/concentration?
    - ○ African American Studies
    - ○ Anthropology
    - ○ English and Textual Studies
    - ○ Fine Arts/Art or Music History
    - ○ French Language, Literature, and Culture
    - ○ Geography
    - ○ History
    - ○ International Relations
    - ○ Mathematics
    - ○ Philosophy
    - ○ Political Science
    - ○ Sociology
    - ○ Spanish Language, Literature, and Culture
    - ○ Women’s Studies
    - ○ None
    - ○ Other (Please specify) ___________________________

Items 2 and 3 below on post-survey only

2. In hours, how much time do you spend on a computer every day?

3. Which of the following devices do you own? Select all that apply.
    - ○ Desktop computer
    - ○ Laptop computer
    - ○ Tablet computer (ex. iPad)
    - ○ Smartphone (ex. iPhone, Blackberry)
    - ○ MP3 player (ex. iPod)
    - ○ None of the above

Section 2: Technology is a broad concept that can mean a lot of different things. For the purpose of this questionnaire, technology is referring to digital technology/technologies, that is the digital tools we use such as computers, laptops, iPods, handhelds, interactive whiteboards, software programs, etc. Please answer all of the questions. If you are uncertain of or neutral about your response you may always select "Neither Agree or Disagree."

	1=strongly disagree	2= disagree	3=neither agree or disagree	4=agree	5=strongly agree
1. I know how to solve my own technical problems.	○	○	○	○	○
2. I can learn technology easily.	○	○	○	○	○
3. I keep up with important new technologies.	○	○	○	○	○
4. I frequently play around the technology.	○	○	○	○	○
5. I know about a lot of different technologies.	○	○	○	○	○
6. I have the technical skills I need to use technology.	○	○	○	○	○
7. I have sufficient knowledge about mathematics.	○	○	○	○	○
8. I can use a mathematical way of thinking.	○	○	○	○	○
9. I have various ways and strategies of developing my understanding of mathematics.	○	○	○	○	○
10. I have sufficient knowledge about social studies.	○	○	○	○	○
11. I can use a historical way of thinking.	○	○	○	○	○
12. I have various ways and strategies of developing my understanding of social studies.	○	○	○	○	○
13. I have sufficient knowledge about science.	○	○	○	○	○
14. I can use a scientific way of thinking.	○	○	○	○	○
15. I have various ways and strategies of developing my understanding of science.	○	○	○	○	○
16. I have sufficient knowledge about literacy.	○	○	○	○	○
17. I can use a literary way of thinking.	○	○	○	○	○
18. I have various ways and strategies of developing my understanding of literacy.	○	○	○	○	○
19. I know how to assess student performance in a classroom.	○	○	○	○	○
20. I can adapt my teaching based-upon what students currently understand or do not understand.	○	○	○	○	○
21. I can adapt my teaching style to different learners.	○	○	○	○	○

22. I can assess student learning in multiple ways.	❍	❍	❍	❍	❍
23. I can use a wide range of teaching approaches in a classroom setting.	❍	❍	❍	❍	❍
24. I am familiar with common student understandings and misconceptions.	❍	❍	❍	❍	❍
25. I know how to organize and maintain classroom management.	❍	❍	❍	❍	❍
26. I can select effective teaching approaches to guide student thinking and learning in mathematics.	❍	❍	❍	❍	❍
27. I can select effective teaching approaches to guide student thinking and learning in literacy.	❍	❍	❍	❍	❍
28. I can select effective teaching approaches to guide student thinking and learning in science.	❍	❍	❍	❍	❍
29. I can select effective teaching approaches to guide student thinking and learning in social studies.	❍	❍	❍	❍	❍
30. I know about technologies that I can use for understanding and doing mathematics.	❍	❍	❍	❍	❍
31. I know about technologies that I can use for understanding and doing literacy.	❍	❍	❍	❍	❍
32. I know about technologies that I can use for understanding and doing science.	❍	❍	❍	❍	❍
33. I know about technologies that I can use for understanding and doing social studies.	❍	❍	❍	❍	❍
34. I can choose technologies that enhance the teaching approaches for a lesson.	❍	❍	❍	❍	❍
35. I can choose technologies that enhance students' learning for a lesson.	❍	❍	❍	❍	❍
36. My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom.	❍	❍	❍	❍	❍
37. I am thinking critically about how to use technology in my classroom.	❍	❍	❍	❍	❍
38. I can adapt the use of the technologies that I am learning about to different teaching activities.	❍	❍	❍	❍	❍
39. I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn.	❍	❍	❍	❍	❍
40. I can use strategies that combine content, technologies and teaching approaches that I learned about in my coursework in my classroom.	❍	❍	❍	❍	❍

41. I can provide leadership in helping others to coordinate the use of content, technologies and teaching approaches at my school and/or district.	○	○	○	○	○
42. I can choose technologies that enhance the content for a lesson.	○	○	○	○	○
43. I can teach lessons that appropriately combine mathematics, technologies and teaching approaches.	○	○	○	○	○
44. I can teach lessons that appropriately combine literacy, technologies and teaching approaches.	○	○	○	○	○
45. I can teach lessons that appropriately combine science, technologies and teaching approaches.	○	○	○	○	○
46. I can teach lessons that appropriately combine social studies, technologies and teaching approaches.	○	○	○	○	○

Section 3: Models of technology integration

	0=not applicable	1= strongly disagree	2= disagree	3=neither agree or disagree	4=agree	5= strongly disagree
47. My mathematics education professors appropriately model combining content, technologies and teaching approaches in their teaching.	○	○	○	○	○	○
48. My literacy education professors appropriately model combining content, technologies and teaching approaches in their teaching.	○	○	○	○	○	○
49. My science education professors appropriately model combining content, technologies and teaching approaches in their teaching.	○	○	○	○	○	○
50. My social studies education professors appropriately model combining content, technologies and teaching approaches in their teaching.	○	○	○	○	○	○
51. My instructional technology professors appropriately model combining content, technologies and teaching approaches in their teaching.	○	○	○	○	○	○
52. My educational foundation professors appropriately model combining content, technologies and teaching approaches in their teaching.	○	○	○	○	○	○

53. My professors outside of education appropriately model combining content, technologies and teaching approaches in their teaching.	○	○	○	○	○	○
54. My PreK-6 cooperating teachers appropriately model combining content, technologies and teaching approaches in their teaching.	○	○	○	○	○	○

	Not applicable	25% or less	26% - 50%	51% - 75%	76%-100%
55. In general, approximately what percentage of your teacher education professors have provided an effective model of combining content, technologies and teaching approaches in their teaching?	○	○	○	○	○
56. In general, approximately what percentage of your professors outside of teacher education have provided an effective model of combining content, technologies and teaching approaches in their teaching?	○	○	○	○	○
57. In general, approximately what percentage of the PreK-6 cooperating teachers have provided an effective model of combining content, technologies and teaching approaches in their teaching?	○	○	○	○	○

Thank you for completing this survey.

Appendix E

Technology Integration Assessment Rubric (TPACK Rubric)

Criteria	4	3	2	1
Curriculum Goals & Technologies (Curriculum-based technology use)	Technologies selected for use in the instructional plan are strongly aligned with one or more curriculum goals.	Technologies selected for use in the instructional plan are aligned with one or more curriculum goals.	Technologies selected for use in the instructional plan are partially aligned with one or more curriculum goals.	Technologies selected for use in the instructional plan are not aligned with any curriculum goals.
Instructional Strategies & Technologies (Using technology in teaching/ learning)	Technology use optimally supports instructional strategies.	Technology use supports instructional strategies.	Technology use minimally supports instructional strategies.	Technology use does not support instructional strategies.
Technology Selection(s) (Compatibility with curriculum goals & instructional strategies)	Technology selection(s) are exemplary, given curriculum goal(s) and instructional strategies.	Technology selection(s) are appropriate, but not exemplary, given curriculum goal(s) and instructional strategies.	Technology selection(s) are marginally appropriate, given curriculum goal(s) and instructional strategies.	Technology selection(s) are inappropriate, given curriculum goal(s) and instructional strategies.
"Fit" (Content, pedagogy and technology together)	Content, instructional strategies and technology fit together strongly within the instructional plan.	Content, instructional strategies and technology fit together within the instructional plan.	Content, instructional strategies and technology fit together somewhat within the instructional plan.	Content, instructional strategies and technology do not fit together within the instructional plan.

Harris, J., Grandgenett, N., & Hofer, M. (2010). Testing a TPACK-based technology integration assessment instrument. In C. D. Maddux, D. Gibson, & B. Dodge (Eds.). *Research highlights in technology and teacher education 2010* (pp. 323-331). Chesapeake, VA: Society for Information Technology and Teacher Education (SITE).

Adapted from: Britten, J. S., & Cassady, J. C. (2005). The Technology Integration Assessment Instrument: Understanding planned use of technology by classroom teachers. *Computers in the Schools*, *22*(3), 49-61.

Appendix F

Manipulation Check Recording Sheet

Format	Instruction	Minutes Spent
Shared	Lecture	
	Discussion/Activity	
	Model lessons	
	Student-developed lesson plans (final project)	
Standard	Mini-projects	
Design Teams: Community	Setting expectations & goals	
	Poster session	
	Testing & feedback	
	Sharing & reflection	
Design Teams: Small groups (3-4)	Selecting curriculum objectives	
	Assigning roles	
	Brainstorming	
	Artifact creation	
	Practice	
	Debriefing	
Student groupings	Whole class	
	Large groups (5-10)	
	Small groups (3-4)	
	Pairs	
	Individual	

Extent to which the class activities were consistent with the standard approach.

1	2	3	4	5	6	7

Extent to which the class activities were consistent with the design teams approach.

1	2	3	4	5	6	7

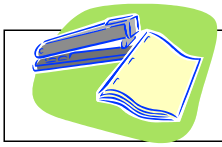
Teacher Characteristics

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Teaching					
Instructor is knowledgeable about the subject.					
Instructor is prepared.					
Instructor encourages participation.					
Instructor is enthusiastic about teaching.					

Appendix G

Social Studies Lesson Plan Template

Inclusive Lesson Planning Template



COVER PAGE

Include the Following:
Name:
SU Instructor's Name(s):
School and Grade:
Host Teacher's Name and Signature:
Date:

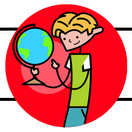
Section 1 - THE STUDENTS

A. Describe Your Class:
School:
Grade Level:
Number of Students:
Demographic information (race, gender, class, dis/ability):
Other important information about your class:

B. Positive Student Profile for 3 Students:
Target Student 1:

Target Student 2:

Target Student 3:



Section 2 - THE SUBJECT

A. Subject:

B. Lesson Standards:

- In addition to Subject area standard, include Technology standard:
    - Use National Educational Technology Standards for Students (also available on Blackboard, under Web Resources)
    - Copy and paste the standard that you address in your lesson

C. Background:

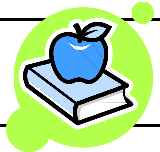
Section 3—THE CONCEPT MAPS

Provide evidence through your own concept maps/webs/ brainstorms/think-tac-toes that you have thought about the following questions.

Attach your Concept Maps as Appendix 1.

Technology Specific Considerations:

- *What technology or technologies can be used to facilitate or enhance student learning in this lesson? What is the rationale to use the technology or technologies?*
- *Can students use technology to create the product in a way that enhances learning?*
- *Can you use technology to assess students' learning? If students use technology to create learning products, how do you assess those products? Consider using a rubric.*
- *What technology skills will students need to participate in your lesson activities? How will you modify the lesson for students who do not have these skills?*



Section 4—THE LESSON

What specifically will you do during your lesson?

A. Lesson Goals:

B. Lesson Objectives

- **Whole-Class Objectives:**
- **Student Specific Objectives:**
- **Technology Specific Objectives/Learning Outcomes**

C. Pre-assessment Tool:

Following the implementation, how did the information from the pre-assessment impact your planning?

Include a sample pre-assessment as Appendix 2.

D. Assessment of Student Learning Tools:

Include a sample summative assessment as Appendix 3.

Include a rubric or checklist as Appendix 4.

E. Definitions of Targeted Terms:

Include both a formal and grade level appropriate definition for each word.

F. Co-Teaching & Collaboration:

- **Role of each adult present:**

Include task cards as Appendix 5.

G. Behavioral Expectations: Include behavioral expectations as Appendix 6.

- *When you use technology in the lesson, how would you adjust behavioral/management strategies?*

H. Lesson Outline

Have you included the following in your lesson outline?

- ☐ **Lesson Content:** Double check that your objectives are aligned with the information presented and your assessment.
- ☐ **Assessment:** Be sure to include when and how assessment takes place throughout the body of your lesson.
- ☐ **Student and Room Arrangement:** How will students be grouped during this lesson? How will the physical arrangement of the room be configured for the lesson to ensure student success?
- ☐ **Transitions:** Include how you will transition students (activity to activity, location to location, whole class/small group, etc.).
- ☐ **Teaching Strategies:** Consider: **t**hink-pair-share, graffiti, talk-walk, questioning, cueing, pre-teaching, foreshadowing, adjust pacing, sequence, periodically check performance, reduce or increase complexity, physical guidance, pair verbal instruction with visuals, adjust behavior management.
  When you use technology in the lesson, how would you adjust teaching strategies?
- ☐ **Directions:** Describe step by step how you will explain the various concepts or activities to the students.
- ☐ **Pacing:** Have you practiced so that your timing is correct? *If you are using technology, how will you set up and practice before the lesson?* What will you do if some students finish early? What will you do if students don't finish?

I. Materials and Technologies:

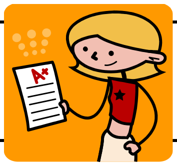
- Include numbers of each material that is needed and how many are needed for each group. (i.e. 12 timers; or each group will receive 1 thermometer, 2 sponges, 3 containers of hot water).
- Describe any unique material considerations for specific students.
- Are there any types of assistive technology (high or low tech) that will be useful for any student to help them to do a particular step in this lesson?
- Make sure all materials look professional (i.e. worksheets must be computer generated).
- Consider: *Access to written material, communication, the physical space etc.*

Lesson Outline for Social Studies—Complete this section of the Lesson Outline for each day of your extended lesson. (*Describe in detail how you use technology for instruction in this section.*)

STANDARDS-BASED Lesson Objectives
- **Whole-Class Objectives:**
- **Student Specific Objectives:**

Clock Time 9:00- 9:10	**Sequence of Steps** Write each step that will occur during your lesson. Include SPECIFIC DETAILS of your plan for grouping, directions, strategies, assessment, and directions. Include key questions and anticipated student responses.	**Adaptations** Write any specific adaptations that are needed for the corresponding step of the lesson.
	Creative Introduction:	**Adaptations:**
Teacher Notes		
	Explaining Behavioral Expectations:	**Adaptations:**
Teacher Notes		
	Sharing Agenda and Objectives:	**Adaptations:**
Teacher Notes		
	Body:	**Adaptations:**
Teacher Notes		
	Closure:	
Teacher Notes		
Materials and Assistive Technologies:		

Section 5 –ASSESSMENT OF STUDENT LEARNING and REFLECTION



A. Assessment and Evidence of Student Learning:

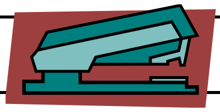
<u>Include 3 student work samples as Appendix 8</u>.

B. Reflection:

- Was the technology use effective in enhancing student learning in your lesson? If the use of technology was effective, what were the evidence(s)? If not effective, why was the technology use ineffective? What changes would you have made to make it more effective? Generally what did you learn about technology integration for instruction in this lesson?
- Treatment group only: How did your team help you with planning and designing your lesson?

Section 6—REFERENCES

Section 7—THE APPENDICES



Appendix 1 - Concept Map
Appendix 2 – Pre-assessment
Appendix 3 – Summative Assessment
Appendix 4 – Assessment Rubric or Checklist
Appendix 5 - Task Cards for Collaboration
Appendix 6 - Behavioral Expectations
Appendix 7 - Agenda
Appendix 8 - Student Work Samples
Appendix 9 - Book Summary for SS Lesson

Appendix H

Comparison Group Math Lesson Plan Template

Block II Mathematics Lesson/Unit Planning Guide

Modified for IDE301 October, 2011

This lesson planning guide is designed to help you develop skills and attitudes about thoughtful, inclusive lesson design. Therefore, I expect detailed evidence of your thinking. Please understand, when you are designing lessons as a certified teacher, your written plans will not include as much detail, however you will engage in a similar, albeit abbreviated, thinking process.

Sections 1, 2, 3 and 4 are due on Sakai before you teach. However, please print out all sections, Front Page through Section 8, and place in a 3 ring binder for final evaluation of your work for each placement.

<u>Cover Page</u>
Your Name
District, School, Grade in which you taught
Number of students taught
Dates you actually taught the lesson or connected-lessons/mini unit
Host teacher's name
Host teacher's signature____

Section 1—Mathematics Class Observation

- **Placement A: Due on Sakai due before you teach but no later than Oct. 9.**
- **Placement B: No later than Nov. 12th.**

Be sure to include demographic information of this class. Does this class represent the population of the school or is it different in some aspects? (You will need to look up the District Demographics on their website or check on the NYS website.) What does mathematics class look like and sound like? Who talks? What kinds of questions does the teacher ask? What is the structure of the majority of the classes? What textbook or materials are used?

Sections 2 and 3—Mathematics Content Concept Paper—This is the Specialized Content you must know as a teacher but be sure that you also speak to the Common Content Knowledge about this topic.

- **Placement A: Due on Sakai 1 week before your planning time. This must be approved before you teach.**
- **Placement B: Due 1 week before you teach. You must receive a positive response from the Course Instructor before you begin to develop this mathematics topic as a lesson.**

In this concept paper you will explain all the mathematics needed to teach the topic you have selected to teach. You are to speak to the mathematical ideas that come before your lesson and those that come after. You need to explain the larger mathematical idea of which your topic is a part. You should address that question: What is mathematically important about this topic? This paper is not about how to teach this mathematics but should convince the instructor that you are well grounded and have a deep understanding of the mathematics you will be teaching. You may need to scan this paper and then attach it. If you need to get it to me in person, please be sure to make an appointment to do so.

Section 4 (a, b, c and d). Due on Sakai 72 hours (3 days) before you teach. In this section you should address the Pedagogical Content Knowledge required for this lesson/mini unit. Your lessons should reflect what you know about the mathematics content, student learning and best practices for teaching.

4a: Overview: Write a 1-2 page overview of your connected-lessons/mini-units. Use the categories listed below. For each lesson taught complete step II. Your connected-lessons/mini-unit will have I & III for the unit.

I. Pre-assessment: What information will you collect on each student before you plan and teach? How will you gather this information? What do students know about this topic? If you are using data from a lesson your host teacher taught say so and describe how you will gather and use that information.

- *What technology skills will students need to participate in your lesson activities? How will you modify the lesson for students who do not have these skills?*

II. The lesson or connected lessons/mini-unit

1. Launch: How are you introducing the lesson?
2. Explore/Investigate: What are students doing to learn?
   a. *Whole Class Objectives*
   b. *Technology Specific Objectives/Learning Outcomes*
3. Summarize: Whole-class congress/discussion on what has been learned.
4. Technology Considerations
   a. *What technology or technologies can be used to facilitate or enhance student learning in this lesson? What is the rationale to use the technology or technologies?*
   b. *Can students use technology to create the product in a way that enhances learning?*
   c. *When you use technology in the lesson, how would you adjust teaching strategies?*
   d. *When you use technology in the lesson, how would you adjust behavioral/management strategies?*

III. Summative assessment: What type of evidence are you collecting that students learned? How do you plan to collect that data? What rubric are you using to assess the student work?
Consider: *Can you use technology to assess students' learning? If students use technology to create learning products, how do you assess those products? Consider using a rubric.*
You may not do a review-type lesson. Also you may not teach a lesson that focuses on the learning of a procedure only. DO NOT use any type of food unless its properties are part of the mathematics. If a color chip will work instead of an M&M, use the chip. Use of food/candy must be cleared with the instructor. You may not teach a clock lesson on telling time. Any "time" lesson must be cleared with the instructor.

On a separate page (page 4) respond to 4b, 4c and 4d:

Section 4b: Mathematics & Technology Standards:

- Use the Common Core Standards—check both New York State and then NCTM for wording.
- Give a description, not just a number.
- Select the most pertinent Content Standard;
- Select the most pertinent Process Standard;
- If your District has District Standards, then also include those.
- In addition to Subject area standard, include Technology standard:
    - Use National Educational Technology Standards for Students (also available on Blackboard, under Web Resources)
    - Copy and paste the standard that you address in your lesson

Section 4c: Definitions of vocabulary important to this lesson:
List needed content specific words and both of the corresponding definitions. USE the NYS Ed. Math glossary. Do not use a dictionary.
1. Formal (content related) definition and
2. Grade-level appropriate definition

Section 4d: Advanced Preparation Reminders:
What do you need to take care of before the lesson? List these to help you organize yourself before the lesson.
If you are using technology, how will you set up and practice before the lesson?

Materials and Technologies:

- Include numbers of each material that is needed and how many are needed for each group. (i.e. 12 timers; or each group will receive 1 thermometer, 2 sponges).
- Describe any unique material considerations for specific students.
- Are there any types of assistive technology (high or low tech) that will be useful for any student to help them to do a particular step in this lesson?
- Make sure all materials look professional (i.e. worksheets must be computer generated).
- Consider: *Access to written material, communication, the physical space etc.*

THIS SHOULD BE DONE AFTER THE APPROVAL OF THE PREVIOUS SECTIONS

SECTION 4E: Implementation Outline—format for math. You will have a plan for each day of instruction (Due to your host teacher and supervisor at least 48 hours in advance.) (*Describe in detail how you use technology for instruction in this section.*)

	Clock Time	Sequence of questions guiding the progress of the lesson	Problems/ examples	Anticipated Student Response /possible misconceptions	Differentiation	Daily notes from observer and from you as teacher.
		Each lesson needs to contain the essential questions that support the flow of the lesson and engage the students in meaningful learning. [Note that this template will be significantly longer in each section as you give the detail needed to design a lesson that has worthwhile content and organization that supports good implementation.]	Write out the specific problem(s) or activity that will be used in each part of the lesson.	Write what you anticipate the students will say and what the students will do. Indicate if there are misconceptions you need to be aware of. This should focus on math **content**, not management or attitudinal responses. This supports your Formative Assessment for the lesson.	Indicate any specific adaptations that are needed for the corresponding step of the lesson. Indicate any differentiation of materials or instruction.	Leave this column space blank initially. During your lesson, have your host teacher give you feedback here. YOUR HOST TEACHER'S NOTES ARE HIGHLY RECOMMENDED. Following your lesson, add **your** notes in a different color. YOUR NOTES ON THE LESSON AFTER TEACHING ARE REQUIRED
		Launch: How will you engage the students to think about the mathematics that will be the focus of your lesson/ connected-lessons? For a set of connected lessons you will need to do a brief continuation piece in place of the introduction on the following days.		How will you know the launch is supporting the learning that you expected?		

		Exploration or Investigation: What questions will you ask to support the students, inquiry? In this portion the students need to be gaining an understanding of the concepts you have targeted. They may be using manipulatives to explore and idea; gathering data either in groups or whole class, etc.		How will you know the exploration/ investigation is supporting the learning you intended for the students?		
		Summarize/Congress/ Discussion: What questions will help students organize their learning, to reinforce major points to clarify any confusion. How will you help students to make sense of what they learned and transition to the next activity? **This should be engaging & interesting. It should not be a review or you as teacher summarizing but rather you gathering what the students say about what they have learned.** **For a series of connected lessons your main congress may come after several days. Describe transition into the next day's work.**				

Section 5: Evidence of Student Learning—Summative Assessment (required for the Connected-Lessons/Mini Unit)

A. Evaluation of your students' learning. This may be modified from what you wrote in Section 4.

- What are you assessing? This should be connected to your goals of the unit and the Common Core Standards.
- How you are assessing it?
- What criteria you are using? Include any materials/ rubrics you have developed.

B. Thinking about student learning—your analysis:
What specifically did your students learn from your lesson as measured by your summative assessment? Think about the whole class. Be sure to include evidence that students have learned. This is both their work (and/or words) and your analysis. You should include the rubric with your data. The student's voices should come out in your reflection as well as student work (if applicable). Please turn in copies of work from at least 3 students and your assessment of that work. One that may be just at the beginning stages of understanding and two that were on target for learning or 1 that was on target and 1 that that extended what you intended.

Section 6: After writing your lesson plan, include references of sources, ideas, theory, etc.

Section 7: Horizon Observation and Analytic Protocol Form:

Complete this form. Evidence for your rankings should be visible in your plans, your assessment and evidence of student learning and your reflection. Complete each page giving additional explanation as needed.
Give your rating of the quality of your connected-lessons (page 9). Include this protocol with your completed lesson plans.

Section 8: After Teaching the Lesson Reflect on the Following: This should be written as a narrative.

- Think about: Student participation and your planning, preparation and teaching.
  a. What did you learn about teaching the specific **content** from this lesson?
  b. What would you do differently & what were you proud of?
  c. What did you learn about teaching in mathematics in general from this lesson?
  d. What would you do differently & what were you proud of?
  e. How have your used/applied what you learned in class and readings in this lesson?
  f. Was the technology use effective in enhancing student learning in your lesson? If the use of technology was effective, what were the evidence(s)? If not effective, why was the technology use ineffective? What changes would you have made to make it more effective? Generally what did you learn about technology integration for instruction in this lesson?

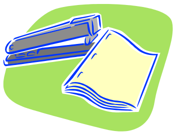
Appendix I

Treatment Group Math Lesson Plan Template

Math Lesson Planning Template

Modified for IDE 301 Spring 2012

This lesson-planning template is designed to help you develop skills and attitudes about thoughtful, inclusive lesson design. Therefore, we expect a great amount of detail as evidence of your thinking. Please understand, when you are designing lessons/units as a certified teacher, your written plans will not include as much detail, however you will engage in a similar, albeit abbreviated, thinking process.



COVER PAGE: Spring 2012

Name: ______________________________

SU Instructor's Name: ______________________________

School & Grade: ______________________________

Unit Topic: ______________________________

Number of Students: ______________________________

Teaching Dates: ______________________________

Host Teacher's Name & Signature: ______________________________

Section 1 – CLASSROOM OBSERVATION

A. Observe (not evaluate) mathematics instruction early in your placement. After observing several different math lessons, write a brief (one - two pages) paper below describing the trends and themes in your observations and reflect on your observations using the knowledge you have gained thus far in the course. Describe what actually occurs rather than your evaluation or interpretation of what occurs. Be sure to include student and teacher dialogue (quotes). You must address the mathematical culture of the classroom. This paper should be word processed, but your field notes may be hand written. Copy and paste your observation on Sakai. Save your field notes and hard copy for your binder.

Type here.

Section 2 – MATHEMATICS CONTENT PAPER

A. **This is the Subject Matter Knowledge needed for teaching.** It is both the Specialized Content you must know as a teacher and the Common Content Knowledge about this topic. In this paper you will explain all the mathematics needed to teach the topic you have selected to teach. You are speaking to the mathematical ideas that come before your lesson and those that come after. You need to explain the larger mathematical idea of which your topic is a part. You should address the question: *What is mathematically important about this topic?* This paper is not about how to teach this mathematics but should convince the instructor that you are well grounded and have a deep understanding of the mathematics you will be teaching.

Type here

Section 3—LESSON OVERVIEW

You may **not** do a review lesson or one that focuses on the rote learning of a procedure.

Lesson Standards:

What grade level specific common core math & technology standard(s) are being addressed?

- **Common Core – Content**—Include no more than 4 specific *content* standards (i.e., "2.NBT.5—Fluently add and subtract within 100 using strategies based on place value, properties of operations, and/or the relationship between addition and subtraction"). You can look to other grade levels.

- In addition to Subject area standard, include Technology standard:
  - Use National Educational Technology Standards for Students (also available on Blackboard, under Web Resources)
  - Copy and paste the standard that you address in your lesson

Type here.

- **Common Core—Mathematical Practices**—Include at least one Mathematical Practices (i.e., "MP1—Make sense of problems and persevere in solving them"). Give specific examples of how you are addressing/incorporating it.

Type here.

Pre-Assessment:

How did you collect information about what each student already knew before you planned your lesson? What did the students already know about this topic?

You can, but do not have to, create a formal pre-assessment, but you do need to provide evidence of students' prior knowledge. You can use formal *or* informal assessment, a quiz, work from previous lessons, anecdotal information, etc.

- *What technology skills will students need to participate in your lesson activities? How will you modify the lesson for students who do not have these skills?*

Type here.

Section 4—LESSON DETAILS

You may **not** do a review lesson or one that focuses on the rote learning of a procedure.

A. Lesson Goal(s):

By the end of your *Summary*, what *should* students know and be able to do? What is this lesson's big idea?

Technology Specific Objectives/Learning Outcomes

B. Differentiated Objectives & Strategies:

What is *essential* for even your most struggling students to learn and do? How will you *engage/extend* your higher-achieving students? List any strategies that will be used to support each differentiated objective (e.g., think-pair-share, buddy-checkers, manipulatives, example/counter-example, questioning, pre-teaching, adjusted pacing, reduce or increase complexity, pair verbal instruction with visuals, periodic slate checks, etc.).

C. Duration of the Lesson:

_______ minutes

D. Sequence of Lesson:

- *The Launch, the Exploration/Investigation, & the Summary/Discussion.*

E. Definitions of Targeted Terms:

List the targeted terms or content specific words and both of the corresponding definitions.

1. Formal definition (from NYS Glossary, if present)
2. Grade-level appropriate definition

F. Materials, Technologies, & Advanced Preparation Reminders:

List materials you need to gather / prepare before the lesson. (e.g., make special dice). All materials must look professional (i.e., worksheets must be computer generated). If you are using technology, how will you set up and practice before the lesson?

- Include numbers of each technology resource that is needed and how many are needed for each group. (i.e. 4 laptops, 4 copies of Inspiration, or 1 laptop per group).
- Describe any unique material considerations for specific students.
- Are there any types of assistive technology (high or low tech) that will be useful for any student to help them to do a particular step in this lesson?

G. Co-Teaching & Collaboration:

List the specific role for each adult present. Share this information with each of the adults who will be present during this lesson.

Options for co-teaching: *Station teaching, one teach—one model, parallel teaching,*

H. Technology Considerations

a. *What technology or technologies can be used to facilitate or enhance student learning in this lesson? What is the rationale to use the technology or technologies?*
b. *Can students use technology to create the product in a way that enhances learning?*
c. *When you use technology in the lesson, how would you adjust teaching strategies?*
d. *When you use technology in the lesson, how would you adjust behavioral/management strategies?*

Make sure you have included the following in your lesson outline:

☐ **KEY:** Mark each step in your plan with the following code.

I	Individual work	W	Whole class work
G	Small group work	↑	When you got students up and moving
P	Partner work	X	Use of various multiple intelligences

☐ **Transitions:** Include how you will transition students (activity to activity, location to location, whole class/small group, etc.).

☐ **Directions:** Describe step-by-step how you will explain the various concepts or activities.

☐ **Assessment:** Be sure to include when and how assessment takes place in the body of your lesson.

☐ **Flow:** Double Check that your objectives match your teaching and your assessment.

☐ **Technology** *Describe in detail how you use technology for instruction in this section.*

Detailed Outline

Clock Time & Key	Sequence of Steps / Questions	Anticipated Student Response	Adaptations	Notes
9:10 - 9:25 * See section I for key	Each lesson needs to contain detailed step-by-step procedures. You will have many steps. Write the key questions you will ask. Insert a new row for each new step / question.	Write what you anticipate the students will say and what the students will do in response to each question. This should focus primarily on content, not management.	Write any specific adaptations (i.e., assistive tech. or unique material considerations) that are needed for the corresponding step of the lesson.	Leave this space blank initially. During your lesson, have your teacher take notes and give feedback in one color. Following your lesson, add your notes in a different color. Your notes should include quotes of what students actually said and did.
	Sharing Agenda: List the agenda for your lesson. This should focus on the math, not the management. Be sure you write or draw your agenda to share it with the students.	NA		
	Behavioral Expectations: How will you explain these?	NA		
	Launch: How will you grab the students' attention and prepare them to be engaged with the specific problems that they will explore? This should be relatively brief.			
	Explore: Students should be working to solve the problem(s) you posed during the launch.			
	Summary: How will you help students organize their learning, reinforce major points, & clarify any confusion? This part of the lesson should ensure that students have achieved your learning goals and should draw heavily from student work in the Explore. How will you transition to the next activity?			

Note: Be sure to include the key symbols from section 3 (page 5)

Section 5—ASSESSMENT

A. Evaluation of your students' learning—summative assessment:
What are you assessing? (This should be connected to your unit standards and each lesson's goals.)
How are you assessing it? (Include your post-assessment and/or the rubric you are using to assess each student's work.)

Consider: *Can you use technology to assess students' learning? If students use technology to create learning products, how do you assess those products? Consider using a rubric.*

Type here.

B. Examples of student work:
Provide evidence of student learning—at least 3 examples of student work. Include at least one student's work that shows limited understanding (below grade level), at least one student's work that shows good (at grade level) understanding, and at least one student's work that is exemplary (beyond grade level). If you do not have a student at each level, explain why.

Type here.

C. Analysis/thinking about student learning:
What did your students learn from your lessons? Discuss the whole class and individual students—Be sure to include evidence. The student's voices should come out here and in your reflection. Photo and/or video documentation can be very powerful.

Type here.

Section 6—REFLECTION

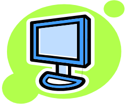
A. **After teaching the unit reflect on the following**:

- As you write, think about your planning, preparation, and teaching as well as student participation.
  - a. What did you learn about teaching the specific **content** from this unit?
    - i. Where did students/you have difficulty with the content?
    - ii. Where did students/you have success with the content?
    - iii. What would you do differently?
    - iv. What are you proud of?
  - b. What did you learn about teaching in general (preparation, management, etc) from this unit?
    - i. What would you do differently?
    - ii. What are you proud of?
  - c. How have your used/applied what you learned in class and readings in this unit?
  - d. Was the technology use effective in enhancing student learning in your lesson? If the use of technology was effective, what were the evidence(s)? If not effective, why was the technology use ineffective? What changes would you have made to make it more effective? How did your team help you with planning and designing your lesson? Generally what did you learn about technology integration for instruction in this lesson?
- Whenever possible, quote your students to support your reflection.

Type here.

B. **The Horizon Protocol**:

- Complete the first 9 pages of this form. Evidence for your rankings should be visible in your plans, assessment/student work samples, and your reflection. Be sure to give your final rating (1 to 5) of the quality of your connected-lessons (page 9). Include this packet in the back pocket of the binder with your final mini-unit.



Section 7—REFERENCES

Include at least 3 references of books, people, websites, etc.
You must use at least one published math program for ideas, even if you don't use the exact lesson(s). Include full titles and page numbers.

Type here.

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VITA

NAME OF AUTHOR: Laurene Johnson

PLACE OF BIRTH: Wisconsin, USA

GRADUATE AND UNDERGRADUATE SCHOOLS ATTENDED:

City University, Renton, Washington
Vanderbilt University, Nashville, Tennessee

DEGREES AWARDED:

Masters in Education, 1997, City University
Bachelor of Science in Elementary Education, 1992, Vanderbilt University

AWARDS AND HONORS:

Syracuse University School of Education, Research and Creative Grant Award Recipient—2012
Syracuse University Future Professoriate, Certificate of University Teaching Recipient—2012
Edvantia Shining Star Award, First Quarter—2008
North Carolina Association for Educational Communications and Technology Conference (NCaect) Best Presenter—2004 and 2005
Technology and Learning Magazine Ed Tech Leader of the Year Semifinalist—2003
Virginia Piedmont Technology Council Red Apple Award Finalist—2002

PROFESSIONAL EXPERIENCE:

Educational Consultant, Self-employed, 2006-present

Graduate Teaching Assistant, Department of Teaching and Leadership/Instructional Design, Development, and Evaluation, Syracuse University, 2010-2012

Research and Development Specialist—Technology, Appalachia Regional Comprehensive Center at Edvantia, 2007-2009

Enhancing Education Through Technology (EETT) Project Coordinator/Trainer, Guilford County Schools, 2003-2006

Curriculum and Technology Integration Partner, Hollymead Elementary/Sutherland Middle; Classroom Teacher/Technology Lead Teacher, Scottsville Elementary; Albemarle County Public Schools, 2000-2003

District Technology Coordinator/Grant Writer, Omak School District, 1998-2000

Adjunct Faculty, Master in Educational Technology Program, City University, 1998-1999

Classroom Teacher/Technology Lead Teacher, Sunny Hills Elementary & Endeavour Elementary, Issaquah School District, 1994-1998