May 2014

LEARNING BY DESIGN: TECHNOLOGY PREPARATION FOR "DIGITAL NATIVE" PRESERVICE TEACHERS

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Abstract

Effective technology integration in teaching requires teachers to construct technological pedagogical content knowledge (TPACK). To help teachers develop TPACK, the learning environment must address the situated nature and complex interplay of technology, pedagogy and content. Learning By design (LBD) has been proposed as one promising instructional model to create such a learning environment. To explore effective and theory-grounded technology instruction for digital native preservice teachers, an LBD environment was designed, developed and implemented in a technology integration course for preservice teachers. Using design-based research methodologies, this dissertation research study is intended to explore whether LBD is effective in helping digital native preservice teachers develop TPACK, how LBD takes effects, and what improvement can be made to the learning environment.

This dissertation is in multi-paper format and consists of four individual papers. Each paper focuses on one aspect of the research study. In paper #1 (Chapter 1), Learning by Design: Technology Preparation for Digital Native Preservice Teachers, the researcher describes the research purposes, the theoretical framework and instructional design model behind the courses, and the application of LBD in a technology integration course for preservice teachers. In addition, as the first paper in this multi-paper dissertation, the researcher also introduces the research design and methods of the study.

In paper #2 (Chapter 2), Learning By Design for Preservice Teacher Technology Preparation: How Effective Is It and in What Ways, the researcher examined whether an LBD environment is effective in helping preservice teachers develop TPACK, and described how the participants perceived the effectiveness of LBD. The results indicated that LBD can be an
effective instructional theory in designing learning environments to facilitate preservice teachers’ TPACK development. The participants generally agreed that LBD was helpful for them to learn about teaching with technology. They felt more comfortable with and confident in using technology in their teaching. Recommendations are made for future research and practices.

In paper #3 (Chapter 3), *Using Live Dual Modeling to Help Preservice Teachers Develop TPACK*, the researcher investigated whether a Live Dual Modeling strategy in the LBD environment was effective in helping preservice teachers develop TPACK and what conditions influenced the use of this strategy. The findings showed that preservice teachers demonstrated the initial ability to transfer what they learned in the modeling to real-world classroom teaching.

When Live Dual Modeling is used, attention should be paid to the conditions that influence the effectiveness of the strategy due to preservice teachers’ limitations in their overall knowledge base, practical experience, and ability to transfer learning to other contexts.

Paper #4 (Chapter 4), *Cultivating Reflective Practitioners in Technology Preparation: Constructing TPACK through Reflection*, investigated the participants’ TPACK development as manifested in their reflection journals and how reflection helped preservice teachers construct TPACK. Through content analysis of the participants’ reflection journals, the researcher found that the preservice teachers constructed their initial TPACK awareness. However, their TPACK development was incomplete and superficial. Interviews with the participants showed that reflection helped them describe and elaborate on their technology integration experience, be more confident in their ability to use technology for teaching, and be more reflective and open-minded about using technology in classrooms. Finally, the researcher discussed this study’s implications for teacher educators and researchers.
LEARNING BY DESIGN: TECHNOLOGY PREPARATION FOR

“DIGITAL NATIVE” PRESERVICE TEACHERS

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DISSERTATION
Submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in
Instructional Design, Development & Evaluation in the Graduate School of
Syracuse University

May, 2014
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Chapter 1

Learning By Design: Technology Preparation for “Digital Native” Preservice Teachers

Abstract

The promise for change in K-12 schools by integrating technology into instruction heavily relies on a workforce of teachers who can effectively teach with technology. Teacher educators have been exploring effective ways to help preservice teachers integrate technology into instruction. In recent years, technological pedagogical content knowledge (TPACK) (Mishra & Koehler, 2006) has emerged as a strong framework. TPACK identifies the essential knowledge for a teacher to effectively integrate technology in instruction. To teach TPACK, the instructional approach must address the situated nature and complex interplay of technology, pedagogy, and content. Learning By Design (LBD) is one such promising approach. To explore effective and theory-grounded technology instruction for digital native preservice teachers, this study was intended to investigate whether LBD was effective to help preservice teachers develop TPACK. This article described the research purposes, the theoretical framework and instructional design model, and the application of LBD in the research context. In addition, as the first paper in this multi-paper dissertation, the researcher also introduced the research methodologies of the study. It is expected that this study can extend the understanding of the theoretical grounding for the design of teacher technology preparation by revealing how LBD can be applied in technology integration programs and addressing issues in technology preparation for digital native preservice teachers.

Keywords: preservice teacher technology preparation, digital native, TPACK, Learning By Design
Introduction

Innovation driven by information and communication technologies (ICT) characterizes our era. As in other sectors of the society, technology is also the driving force for change and reform in schools (U.S. Department of Education, 2004). With the use of technology, learning in schools would be “qualitatively different” (U.S. Department of Education, 1996). The National Education Technology Plan 2010 (U.S. Department of Education, 2010) calls for educators to use technology to provide “engaging and powerful learning experiences and content, as well as resources and assessments that measure student achievement in more complete, authentic, and meaningful ways” (p. ix). To cultivate the development of the 21st-century competencies and expertise, such as “critical thinking, complex problem solving, collaboration, and multimedia communication” (U.S. Department of Education, 2010, p. xi), learners need to use technology tools to create opportunities to learn as professionals do in real world. For the new generation of students, growing up with the increasing presence and involvement of technologies, “the incorporation of the tools and applications is merely a natural extension of the way they are currently living and learning outside of that classroom” (Project Tomorrow, 2010. p.3). They envision learning to be “social-based,” “un-tethered,” and “digitally-rich” (Project Tomorrow, 2010. p.3).

Teachers can use technology to provide powerful learning experiences for students. However, to unlock the power of technology, it is widely recognized that integrating information technology into classrooms requires a change in teaching and learning (e.g., Clifford, Friesen, & Lock, 2004; Jonassen, 1995; Jonassen, Peck, & Wilson, 1999; Moursund & Bielefeldt, 1999; Resta, Allen, & Noonan, 2003; Sandholtz, Ringstaff, & Dwyer, 1997). The most productive and meaningful use of technology in learning should engage students in knowledge construction,
conversation, articulation, collaboration and reflection (Jonassen, 1995). According to Jonassen and his colleagues (1999), technology should be used as cognitive tools for students to learn with, not as tools to convey information or knowledge. A constructivist learning environment is thus believed to be more effective to support students’ learning with technology (Jonassen et. al., 1999). It emphasizes a learner’s role in actively constructing knowledge, instead of passively receiving knowledge from his/her teachers (Brooks & Brooks, 1993). When teachers relinquish their control and students are given the freedom and opportunities for creativity in a classroom rich in technology, the power of technology is unleashed (Nisan-Nelson, 2001; Papert, 1993).

The promise for change in K-12 schools by integrating technology into instruction heavily relies on the continuous supply of teachers who can effectively integrate technology into classrooms (CEO Forum, 1999; NCATE, 1997; U.S. Department of Education, 1996). Teacher preparation programs play a critical role in reforming schools by supplying technologically competent teachers. In the past few decades, practitioners and researchers have been exploring how to help preservice teachers develop knowledge and skills to use technologies for instruction (e.g., Basham, Palla, & Pianfetti, 2005; Groth, Dunlap, & Kidd, 2007; Hargrave & Hsu, 2000; Maddux & Gibson, 2012; Moursund & Bielefeldt, 1999; Pope, Hare, & Howard, 2002, 2005). However, researchers continue to find that teachers feel inadequately prepared in using technology for instructional purposes (e.g., Hew & Brush, 2007; NEA, 2008). Even when teachers use technologies, they use technologies for teaching in a supplemental way, such as production of lesson materials and preparation for content (Graham, Tripp, & Wentworth, 2007) or “for teacher-centered activities, including information gathering or presentation” (Sheffield, 2011). One major barrier for teachers to use technology adequately or effectively is that they lack “specific technology knowledge and skills, technology-supported-pedagogical knowledge and
skills, and technology-related-classroom management knowledge and skills” (Hew & Brush, 2007, p. 227). For example, An and Reigeluth (2011) found that the teachers being surveyed in their study not only lacked knowledge about learner-centered instruction, but also lacked “knowledge about ways to integrate technology into learner-centered instruction” (p. 59).

However, teacher education programs have been criticized for not adequately preparing teachers to use technology effectively for instruction (Milken Family Foundation, 2007; NCES, 2000; NEA, 2008). One major criticism of teacher technology preparation has been that technology was taught as a set of context free and separate knowledge and skills in technology classes and workshops (e.g. Ertmer, 1999; Mishra & Koehler 2006; Pope, Hare, & Howard, 2005; Schrum, 1999; Stetson & Bagwell, 1999; Zhao, 2003). The argument behind this criticism is that technology knowledge and skills alone are not sufficient for teachers to unleash the power of technology and catalyze educational changes.

The technology-focused workshop styled training for teachers is resulted from an “add-on” (Koehler & Mishra, 2009, p.67) view about technology’s role in a teacher’s knowledge base. This “add-on” view maintains that with knowledge about software and hardware, teachers can unlock the power of technology for instruction in a classroom (Koehler & Mishra, 2005a). The add-on view was reflected in the early national and state technology standards. For example, since the adoption of International Society for Technology in Education (ISTE) technology foundation standards by the National Council for the Accreditation of Teacher Education (NCATE), the ISTE technology standards have had powerful impact on teacher preparation programs (e.g., Finley & Hartman, 2004; Hall, 2006; Wiebe & Taylor, 1997). The ISTE standards outlined what a teacher “should know about and be able to do with technology” (Wiebe & Taylor, 1997, p.5). The early ISTE standards described a teacher’s technology
proficiency as a list of technology competencies (Wiebe & Taylor, 1997; Koehler & Mishra, 2005a). Zhao, Kendall and Tan (2003) found similar orientation in some state standards. They called these standards technology-oriented standards, which concerned a teacher’s ability to use technology.

Aligning their technology instruction with the technology-oriented standards, many teacher preparation programs required preservice teachers to take at least one technology course (U.S. Congress, OTA, 1995; Hargrave & Hsu, 2000; Milken Family Foundation, 2007). The content focus of the technology courses was on basic computer skills, not on educational media or instructional design topics (Hargrave & Hsu, 2000). In addition, such technology instruction was not tied to preservice teachers’ experiences in teacher education program, such as method courses, field experiences and student teaching experiences (Willis & Mehlinger, 1996; Milken Family Foundation, 2007). Teacher preparation programs held the assumption that with basic knowledge and skills about computers, preservice teachers can apply their technological skills in their subsequent methodology and content courses, thus continue to develop their computer skills and use computers effectively in their own career (Widmer & Amburgey, 1994). However, critics said that this common practice would result in a focus of technological skills, not technology use (Zhao, 2003). Teaching those competencies may lead to “surface level processing” (Stuve & Cassady, 2005, p.319) in preservice teachers’ technology learning. Skill-based training is not enough to produce teachers who value integrating technology in the classroom (Basham, et al., 2005) and is not sufficient for preservice teachers to develop meaningful comfort and expertise to use technology (Schrum, 1999). Ertmer (1999) maintained that providing computer-skills training can break the extrinsic, first-order barriers to technology integration. However, eliminating the second-order barriers, which is intrinsic to teachers and related to their beliefs
about teaching, requires challenging teachers’ belief system and changing the routines of their practice. Therefore, teachers’ “pedagogical knowledge of effective instructional practices that incorporate meaningful uses of technology” (Ertmer, 1999, p. 48) is as important as their technical skills. Mishra and Koehler (2006) argued that teachers’ technological knowledge was not an add-on to a teacher’s knowledge, but an integral part of the overall teacher knowledge. Meaningful technology integration in a classroom must be guided by contents and a teacher’s pedagogical knowledge and beliefs. The Milken Exchange on Education Technology’s study (Moursund & Bielefeldt, 1999) found that additional technology-focused courses did not improve preservice teachers’ technology use, which supported the above criticism.

Another criticism of teacher technology preparation is the lack of theoretical foundations. Issroff and Scanlon (2002) claimed that “[t]heories are an important, but neglected area in research in educational technology” (p.11). Mishra and Koehler (2006) argued that technology use in education had lagged far behind advocates’ vision. One reason is that researchers and practitioners lack a theoretical base for understanding the process of technology integration in education. Theories and models can not only help researchers design, refine and validate learning technology cases, but also understand learners’ experiences in the cases (Issroff & Scanlon, 2002). Current educational technology research offered plenty of cases, examples and implementations. It is with “unified theoretical and conceptual frameworks” (Mishra & Koehler, 2006, p. 1018) that scholars can develop and identify themes and constructs across diverse cases and examples. In teacher technology preparation, practices should also be based on a theoretically well-articulated grounding (Schrum, 1999). Zhao (2003) argued that a framework was needed to understand teachers’ technological knowledge. When technology is used, technology becomes a tool and a solution to a local problem. Therefore, teachers’ technology
knowledge, which is an integral part of their pedagogical knowledge and beliefs, should help teachers use technology to solve educational problems. He suggested that these were the components of a framework for teacher technology knowledge.

Finally, although there is much research about preservice teacher technology preparation, few have recognized that teacher preparation programs are educating a new generation of preservice teachers. This generation of preservice teachers is a generation “growing up digital” (Tapscott, 1998). They are known as digital natives or the “Net generation” who are comfortable with using information technology, use technology differently and learn differently from their previous generations, the digital immigrants. As suggested by Prensky (2001a, 2001b), there is a technology use gap between the digital natives and the digital immigrants. However, research finds the digital divide between the two generations may be misleading. For example, Guo, Dobson, and Petrina (2008) found the difference of technology competence among different age groups of 2000 preservice teachers was not statistically significant. In addition, Lei (2009a) found that although the digital native preservice teachers had strong positive attitude toward technology and were very proficient in basic technology, they were moderately confident in using technology and their scope of technology use was limited. They also lacked experiences in using classroom technologies. The digital natives are not as competent as they are described by Prensky, especially in the instructional use of technology. The technology proficiency expected to be possessed by digital native preservice teachers does not seem to translate directly into proficiency in teaching with technology. As the first generation of digital natives had entered the teaching profession as teachers and preservice teachers, Lei (2009a) proposed that researchers start to discuss what technology preparation was needed for digital native as preservice teachers. However, the author used a quotation mark in the title of this paper to indicate when educating
the digital native preservice teachers, teacher educators may pay attention to their students’ actual technology experience, instead of assuming this generation of preservice teachers are ready and competent to use technology tools proficiently in their classroom.

Considering these challenges, what should teacher preparation programs do to prepare technologically competent teachers? Discussions of this question highlight the reform of teacher technology preparation programs. Among the discussions, the technological pedagogical content knowledge (TPACK) framework (Mishra & Koehler, 2006) emerges as a strong framework, which identifies the essential knowledge for a teacher to effectively integrate technology into instruction. At the heart of TPACK is the complex interplay of technological knowledge, pedagogical knowledge, and content knowledge. In recent years, teacher educators and researchers have developed an increasing interest in this framework and have been using it to guide the design of technology preparation programs for preservice teachers (e.g., AACTE Committee on Innovation and Technology, 2008; Chai, Koh, & Tsai, 2010; Jaipal & Figg, 2010; Jang & Chen, 2010; Koehler & Mishra, 2005a, 2005b; Maddux, 2011).

This particular research project examined one of such efforts exploring effective and theory-grounded technology instruction at a large northeastern university. Based on the TPACK framework, a team of researchers designed and developed a series of three technology integration courses for elementary preservice teachers. The goal of this initiative was to help preservice teachers become effective technology integrators by developing TPACK. According to Koehler and Mishra's suggestion on how to teach TPACK (Koehler & Mishra, 2005a, 2005b), teachers should learn about teaching with technology by designing technological artifacts to solve instructional problems. They posited Learning By Design (LBD) as a promising approach to help teachers develop TPACK (Koehler & Mishra, 2005a). In an LBD environment, learners
are engaged in the design of an artifact for a real-world context whereby they construct their understanding and meaning toward a topic or concept (Han & Bhattacharya, 2001). The team, therefore, applied LBD in the context of preservice teacher technology preparation. Focusing on the first course in the series, this article described the research purposes, the theoretical framework and instructional design model, and the application of LBD in the research context. In addition, as the first paper in this multi-paper dissertation, the researcher also introduces the research methods of the study.

**Research Questions**

This dissertation was intended to explore effective and theory-grounded technology instruction for preservice teachers. An LBD learning environment was designed and implemented in a preservice teacher technology integration course. To investigate whether and how LBD can be an effective approach to teach TPACK, the researcher investigated the following research questions:

a. Is an LBD learning environment effective in helping digital native preservice teachers construct TPACK? In other words, does preservice teachers’ TPACK change after learning technology integration in a LBD environment?

b. How did the preservice teachers perceive the effectiveness of LBD?

c. What improvements can be made to the LBD environment when it is used in designing technology instruction for digital native preservice teachers?

The above research questions guided the overall design and investigation of this dissertation study. Because this dissertation was organized in a multi-paper format, specific research questions in each paper were worded differently from the above questions. All research questions
in the individual papers were developed from the guiding questions and rephrased according to the specific research contexts.

**Literature Review**

To prepare preservice teachers with technology integration proficiency, teacher preparation programs inevitably face questions such as “what should teachers know about technology” and “how should they learn about it” (Mishra & Koehler, 2003, 2006; Zhao, 2003). This section reviews current literature on preservice teacher technology education, particularly research pertaining to the above questions and to the criticisms to current practices.

**What should teachers know about technology: The development of TPACK**

Before discussing how to help preservice teachers develop knowledge to effectively use technology in their classroom, a more logical step is to first review what teachers should know about technology in order to use it effectively for instruction. In this section, the researcher will first review literature on discussions about what teachers should know about technology. Then TPACK will be introduced as a recent theoretical development to capture the essences of teachers’ knowledge in technology integration.

Much has been discussed about what teachers should know about technology (e.g.: Koehler & Mishra, 2005a; Mishra & Koehler, 2006; Widmer & Amburgey, 1994; Wiebe & Taylor, 1997; Zhao, 2003). The discussion has shifted away from viewing a teacher’s technology knowledge as independent and technology knowledge alone is sufficient for effective technology integration in classrooms. More and more scholars acknowledge that a teacher’s technology knowledge is an inseparable component of her overall knowledge base for a teacher to effectively use technology for instruction.
Shifting away from the “add-on” view, scholars acknowledge that teacher technological knowledge is an integral part of a teacher’s complex knowledge base. Such knowledge is complex, situated and multifaceted (Margerum-Leys & Marx, 2003; Mishra & Koehler, 2006). The discussion and practice of teacher technology preparation must respect the rich contexts where teachers resides their profession in and consider the connection of technology with teacher’s content knowledge, pedagogical knowledge and educational practices. This view was reflected in the more recent ISTE standards, which emphasized higher-order goals connecting technology with pedagogical purposes (Koehler & Mishra, 2005a; ISTE, 2000, 2008). Zhao, Kendall and Tan (2003) named this type of standards education-orientated standards, which concerned a teacher’s ability to use technology to perform educational tasks. Zhao (2003) maintained that technology should be considered an integral part of teacher knowledge. Teacher pedagogical knowledge and beliefs should include knowledge of how technology can be used to solve their own problems.

A teacher’s technological knowledge is an integral part of his overall teacher knowledge base. The development of this notion follows a similar trail through which educational researchers and practitioners understood a teacher’s pedagogical content knowledge. Shulman (1986) criticized the sharp distinction between content knowledge and pedagogy in teacher’s knowledge base. His study found that more than a century ago, subject knowledge was defined as the most important component of teacher knowledge, while pedagogical knowledge played a secondary role in the qualifications of a teacher. In teacher qualification tests of the 1980's, "research-based" teaching competence was heavily emphasized, while the subject matter knowledge was ignored relatively. Shulman believed that the disconnection of content knowledge and pedagogical knowledge reflected that educational researchers ignored the central
questions in researches on teaching which distinguished teaching from other professions. He proposed the pedagogical content knowledge (PCK) concept to connect the two bodies of teacher knowledge. PCK includes “the ways of representing and formulating the subject that make it comprehensible to others” and “an understanding of what makes the learning of specific topics easy or difficult” (Shulman, 1986, p.9).

Following the notion that teaching is a complex cognitive activity and Shulman’s PCK theory, scholars suggested theoretical frameworks to describe teachers’ knowledge in technology integration. Margerum-Leys (1999) suggested that Shulman’s framework was potentially useful to describe teachers’ knowledge of educational technology. Margerum-Leys and Marx (2003) extended Shulman’s framework to include educational technology into a teacher’s knowledge base. Although their study recognized that educational technology served for teaching the subject matter, the content knowledge in their framework meant computer knowledge and skills. They ignored the analysis of content knowledge, in a way separating subject matters from the use of technology. Similarly, Niess (2005) proposed a technology PCK. When investigating preservice science teachers’ PCK development concerning integrating technology, Niess suggested that preservice teachers should “develop an overarching conception of their subject matter with respect to technology and what it means to teacher with technology – a technology PCK (TPCK)” (p. 510). Niess was among the first scholars who pointed out the importance of the interplay of technology, teaching and subject and tried to establish a theoretical framework. However, the concept of “technology PCK” was not widely used by teacher educators or educational technology researchers.

Mishra and Koehler (2006) formally established and articulated the framework of technological pedagogical content knowledge. They proposed that a conceptual framework was
needed to capture the essence of teacher technology knowledge. They argued that “thoughtful pedagogical uses of technology require the development of a complex, situated form of knowledge,” which they called “Technological Pedagogical Content Knowledge (TPACK)” (p.1017). The framework addresses “the complex, multifaceted, and situated nature of this knowledge” (Mishra & Koehler, 2006, p.1017) and respects the dynamic relationship of content, pedagogy and technology. At the center of the framework is the interplay of content knowledge, pedagogical knowledge and technology knowledge, which is the essence of teachers’ knowledge about technology integration. Content knowledge, pedagogical knowledge, technology knowledge, and their intersections thus form the seven components of TPACK: technology knowledge (TK), pedagogical knowledge (PK), content knowledge (CK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), pedagogical content knowledge (PCK), and technological pedagogical content knowledge (TPACK). Mishra and Koehler not only described the essence of the framework in detail, but also defined each TPACK component. Graph 1 demonstrates the TPACK framework and how each component is connected in the model. Table 1 lists the description of each TPACK construct.

After Mishra and Koehler published their conceptual paper about TPACK, TPACK has received increasing attention from educational technology researchers and practitioners and is used as a theoretical framework in studies and practices about teacher technology preparation or development (e.g., AACTE Committee on Innovation and Technology, 2008; Brush & Saye, 2009; Bull & Bell, 2009; Chai, Koh, & Tsai, 2010; Jaipal & Figg, 2010; Jang & Chen, 2010). However, some scholars questioned the robustness and maturity of the framework and suggested considerable theoretical development on it. Major criticism includes unclear construct clarity, unsure relationship between the TPACK elements, and the fuzzy boundaries associated with the
TPACK constructs (e.g., Angeli & Valanides, 2009; Graham, 2011). Although the researcher of this study was aware of the framework’s limitations, TPACK was adopted in this study because of its relatively clear articulation of the complexity in teacher technology preparation. TPACK not only offered a theoretical foundation for the program design in this research, but also offered analytical lenses for interpreting research results. With the researcher’s awareness of its theoretical weakness, it was expected that the research results in this study would be interpreted within the boundary of the framework’s limitations and that the research would contribute to the theoretical development of the framework. In the next section, the researcher will discuss how preservice teachers should learn about TPACK.

*Figure 1. TPACK (reproduced from [http://tpack.org/](http://tpack.org/))*
Table 1

*Description of TPACK Constructs (Edited from Mishra & Koehler, 2006)*

<table>
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<th>TPACK Construct</th>
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<td>Technology knowledge (TK)</td>
<td>Knowledge about standard technologies, such as books, chalk and blackboard, and more advanced technologies, such as the Internet and digital video.</td>
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<tr>
<td>Pedagogical knowledge (PK)</td>
<td>Deep knowledge about the processes and practices or methods of teaching and learning and how it encompasses, among other things, overall educational purposes, values, and aims.</td>
</tr>
<tr>
<td>Content knowledge (CK)</td>
<td>Knowledge about the actual subject matter that is to be learned or taught.</td>
</tr>
<tr>
<td>Technological pedagogical knowledge (TPK)</td>
<td>Knowledge of the existence, components, and capabilities of various technologies as they are used in teaching and learning settings, and conversely, knowing how teaching might change as the result of using particular technologies.</td>
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<tr>
<td>Technological content knowledge (TCK)</td>
<td>Knowledge about the manner in which technology and content are reciprocally related. Teachers need to know not just the subject matter they teach but also the manner in which the subject matter can be changed by the application of technology.</td>
</tr>
<tr>
<td>Pedagogical content knowledge (PCK)</td>
<td>PCK includes knowing what teaching approaches fit the content and knowing how elements of the content can be arranged for better teaching.</td>
</tr>
<tr>
<td>Technological pedagogical content knowledge (TPACK)</td>
<td>TPACK requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students’ prior knowledge and theories of epistemology, how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones</td>
</tr>
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</table>

How should preservice teachers learn technology integration?

Since TPACK is a strong framework that captures the essence of a teacher’s knowledge to teach with technology, how do preservice teachers develop TPACK? In this section, the author will first summarize three important aspects in current preservice teacher technology education that can inform the teaching of TPACK, followed by an introduction of why Learning By Design (LBD) is a promising instructional approach for preservice teachers to learn about TPACK, and
then Learning By Design will be proposed as a promising instructional approach to teach TPACK.

Trends in preservice teacher technology preparation

In this section, the author will review three trends in teacher technology preparation practices that have shifted away from the technology-centered workshop approach (Koehler & Mishra, 2005a). The first trend is connecting technology instruction with pedagogy and content knowledge instruction. The second trend is adopting constructivist learning, which emphasizes learners’ active role in learning, in technology integration instruction. The third trend is emphasizing the hands-on experiences in technology integration training. Although many of these practices do not address the TPACK framework directly, they may inform how TPACK should be taught to preservice teachers.

1) Technology instruction was connected with instruction of pedagogy and content knowledge in various ways.

With support from the Preparing Tomorrow’s Teachers to Use Technology initiative, many teacher education programs explored various approaches to prepare technologically competent preservice teachers. Although many of the initiatives are before the formalization of TPACK (Mishra & Koehler, 2006; Thompson & Mishra, 2007), these efforts respect the notion that underlies the TPACK framework, attempting to address the dynamic relationship among a teacher’s knowledge of technology, pedagogy and content knowledge.

Adding the technology component into existing teacher education courses, especially methods courses, is viewed as a solution to the drawbacks that are brought by standalone technological skill centered courses (e.g. Collier, Weinburgh, & Rivera, 2004; Hughes, 2004; Moursund & Bielefeldt, 1999; Rowley, Dysard, & Arnold, 2005; Zhao, 2003). For example,
Collier, Weinburgh, and Rivera (2004) suggested a total integration of technology in and across the curriculum in a teacher education program. For instance, in the School of Education and Allied Professions at University of Dayton, teacher educators chose to integrate established TeacherLine online technology modules into their curriculum by matching the modules with specific undergraduate courses (Rowley, Dysard, & Arnold, 2005). Rowley et al. reported positive results of preservice teachers’ perception on the integrated program and their technology integration knowledge and skills. Additionally, when technology is connected with pedagogy and content knowledge, emphasis must be placed on preservice teachers’ technology use for content specific purposes (Finley & Hartman, 2004). For example, the School of education at University of Illinois at Urbana-Champaign offered preservice teachers with hands-on cooperative learning experiences, which required preservice teachers to work cooperatively in a group to produce online artifacts that reflected their technological skill and understanding of subject content (Basham, Palla, & Pianfetti, 2005).

Connecting technology with pedagogy and content can also be realized by integrating pedagogy or content knowledge into technology courses. For example, the College of Education and Human Development at University of Minnesota used a content-area specific technology preparation strategy. The essence of this strategy was the “dual integration,” which meant “technology integrated in the content area methods course, and the content area integrated into the technology course” (Dexter, Doering, & Riedel, 2006). Kariuki and Duran (2004) introduced anchored instruction in their teacher education institution. Using anchored instruction means anchoring the theme of a curriculum development class into a technology class. In the technology class, preservice teachers use technology to “research, record, and document their experiences in the curriculum development class” (Kariuki & Duran, 2004, p.431).
Meaningful technology instruction for preservice teachers should be connected with instruction of pedagogy and content knowledge. Connecting technology instruction with instruction of pedagogy and content offers opportunities for preservice teachers to see “how technology can be used in authentic teaching situations” (Zhao, 2003, p11) and to deepen their understanding of the complexity in technology integration in connection with teaching and learning (Lock & Clark, 2004). Such learning opportunities are necessary for the development of TPACK.

2) Some scholars called for a change in pedagogy for technology integration in teacher education curriculum. Constructivist methods are believed to be effective in teaching technology integration in teacher preparation programs.

Teachers tend to teach as they were taught (Lortie, 1975). If their students are to learn with technology in a constructive environment, preservice teachers themselves must be engaged in a similar context when they learn how to teach with technology. Some scholars called for a change in pedagogy for technology integration in teacher education curriculum (e.g., Finley & Hartman, 2004; Lock, 2007; Resta, et al., 2003). For example, Finley and Hartman (2004) introduced that faculty in College of Education at Western Michigan University established the vision of using constructivist approaches to help preservice teachers learn how to teach with technology. Resta and his colleague (2003) believed that only a change in pedagogy could influence technology adoption in teacher preparation programs. Practices in their study supported that the teacher-centered pedagogy should be changed to student-centered pedagogy, which provided “collaboration and inquiry-based learning” (p.33).

Using constructivist instructional approaches in teaching technology integration in teacher preparation programs is consistent with Jonasson and his colleagues’ assumptions about
constructivist learning. Jonasson and his colleagues (1999) believe that learners construct knowledge, from activities, not from remembering facts. When learners learn in an activity, the context of the activity becomes part of the knowledge and the problem that learners attempt to solve becomes their problem. As Putnam and Borko (2000) put it, the situation in which a person learns a particular set of knowledge and skills is “a fundamental part of what is learned.” Therefore, the learning environment should engage students in meaningful real-world learning tasks and provide new and different contexts for learners to practice knowledge and skills. When they developed the TPACK framework, Mishra and Koehler (2006) insisted that to develop TPACK, teachers must have the opportunity to tackle the complex and dynamic relationships that are involved in the framework. A constructivist learning environment provides such opportunities, which make preservice teachers’ technology experience contextual, relevant and meaningful to themselves (Bird & Rosaen, 2005). Pope, Hare and Howard (2005) also suggested that “preservice teachers need opportunities to learn with the technology by being exposed to authentic, learner-centered activities that allow them to construct their own understanding of the learning outcomes.”

To associate preservice teachers’ technology experiences with authentic teaching and learning contexts, examples of successful technology use are important (Brush & Saye, 2009; Kay, 2006; Moursund & Bielefeldt, 1999; U.S. Congress, OTA, 1995). Some teacher educators chose to demonstrate authentic cases of teachers utilizing various technology resources to implement inquiry-based learning activity in their classrooms (Brush & Saye, 2009). Some teacher preparation faculty modeled technology use in their classrooms (Hall, 2006). Some scholars also emphasized the importance of using technology to teach in field placements (Brush, et. al, 2003; Schrum, 1999).
In recent years, teacher educators geared their practices towards the TPACK framework. Many of the instructional approaches to develop TPACK have at least one hands-on component that involves teachers using technology in real-world setting (e.g., Jang & Chen, 2010; Koh & Divaharan, 2011).

Many scholars insisted the importance of hands-on experiences for preservice teachers to develop technology integration knowledge. For example, An and Reigeluth (2011) argued that “teachers should be able to build technology skills in the context of designing learner-centered learning activities in their subject areas” (p. 60) in order for them to create technology-enhanced learner-centered instruction. Niess (2008) maintained that preservice teachers needed experiences in understanding students, planning and designing instruction, developing effective instructional strategies, gaining effective classroom management strategies, and assessing student learning with technology. Lecture does not provide such experience necessary for preservice teachers to develop TPACK. Direct instruction has its constraint in conveying the complexity of teaching with technology. Having preservice teachers cooperate with one another in developing lesson plans can provide the opportunities for higher level thinking, such as analysis, synthesis, and evaluation.

Empirical research showed that hands-on experience can help preservice teachers develop TPACK. For example, Koh and Divaharan (2011) proposed a three-phase training model to help preservice teachers develop TPACK. In Phase 3, Pedagogical Application, Koh and Divaharan suggested using hands-on design projects to help preservice teachers to make the connections between their content knowledge, pedagogical knowledge, and technology knowledge. Preservice teachers in their study worked in groups to create a few Interactive Whiteboard lesson activities, which the groups shared with their peers at the end of the technology integration
program. Koh and Divaharan found that the preservice teachers predominantly developed technological pedagogical knowledge after completing the Phase 3 design projects. The design projects helped the participants better articulate their instructional decision making for using the Interactive Whiteboard in the learning activities.

The trends discussed above reflected efforts to design and develop effective technology preparation programs in recent years. These practices can inform the future design and development of technology programs for preservice teachers. In next section, the researcher will discuss in detail one of the instructional approaches to helping preservice teachers develop TPACK: Learning By Design.

**Learning By Design (LBD)**

In addition to developing the TPACK framework, Koehler and Mishra (2005a) also suggested an approach to teach TPACK, learning technology by design. In their study, Koehler and Mishra engaged teachers in the design and evaluation of technology artifacts, such as online courses or movies that were aimed at solving authentic educational problems. They argued that for teachers to construct a deep understanding of the interplay of content, pedagogy and technology, teachers should learn TPACK in contexts that honored the dynamic relationship of the three components. LBD offers opportunities for teachers to use technology in authentic problem solving contexts and to explore “the rich connections between technology, the subject matter (content), and the means of teaching it (the pedagogy)” (Koehler & Mishra, 2005a, p.95).

LBD has been implemented in various settings from K-12 classrooms to higher education (Fessakis, Tatsis, & Dimitracopoulou, 2008; Koehler, Mishra, Hershey, & Peruski, 2004; Kolodner et al. 2003). It is a learner-centered instructional approach, which evolves from the theoretical traditions of social constructivism (Kim, 2001; Koehler & Mishra, 2005a) and
constructionism (Papert, 1993; Han & Bhattacharya, 2001), case-based reasoning (Kolodner, 1997), problem-based learning (Han & Bhattacharya, 2001; Koehler & Mishra, 2005a; Kolodner, et al. 2003) and theories about design (Koehler & Mishra, 2005a). The essential goal of an LBD environment is to engage learners in the designing of an artifact for a real-world context whereby learners construct their understanding and meaning toward a topic or concept (Han & Bhattacharya, 2001). The learning environment provides opportunities for learners to participate in dialogues between “ideas and the world, theories and their application, concepts and their realization, tools and goals” (Koehler & Mishra, 2005a).

Although they proposed the LBD approach to teach TPACK and pointed out its values, Koehler and Mishra did not specify how to use LBD in teacher technology training. They also did not elaborate on the instructional method, its components, and the optimal situations to use or not to use the methods. These are considered as essentials of an instructional design theory. Describing the methods in a relatively detailed manner can provide useful guidance to educators (Reigeluth, 1999).

Other researchers have further explored how to construct an LBD learning environment. For example, Han and Bhattacharya (2001) described the steps of a design process, which involved seven steps: 1) choose a topic or task; 2) describe the audience; 3) create the artifact; 4) pilot the artifact; 5) receive feedback; 6) reflect on the artifact and the feedback; and 7) redesign the artifact. Although Han and Bhattacharya described in greater details how to create and manage a LBD learning environment, their model is general and not tailored to specific audience. In addition, it is not clear how those LBD components and the design activity facilitate students learning.
Kolodner and her colleagues (2003) went one step further and created an LBD model for middle school science classroom by merging cased-based reasoning (CBR) and problem-based learning (PBL) theory. They insisted that in middle school science classroom, students should not only learn knowledge and skills about science, but also transfer their knowledge and skills in solving real-world ill-structured problems. They argued that CBR prescribed the learning experiences that could lead to such deep learning in a science classroom. CBR emphasizes the connection of new experience and old experience. A person’s knowledge is extended when old experience is reinterpreted and reindexed to interpret and solve new problem, and thus incorporated into new experience. Reasoning plays a key role in the transition from old to new experience. According to Kolodner et al. (2003), CBR’s cognitive focuses have five suggestions on learning: (1) the focus on the role of failure in promoting learning suggests learners should have the opportunities to develop and implement their ideas and receive feedback; (2) the focus on explanation suggests learners should be able to articulate their reasoning; (3) the focus on indexing as the key to reuse of previous experience suggests the importance of reflection on previous experience; (4) the focus on iterative refinement suggests that learners should be given chance to refine their ideas; and (5) the focus on the role previous experience plays in reasoning suggests that learners should be encouraged to relate their old experience to solve new problems. These suggestions imply that design activities can provide students with such learning experiences.

To implement CBR in a classroom, PBL, the other root of this LBD model, provides guidance on how such learning experiences should be organized. The LBD model characterizes two consecutive cycles, design/redesign and investigation/exploration cycle with a set of ritualized and sequenced activities (See Figure 2). The steps involved in the design/redesign
cycle are similar to those steps of a design process suggested by Han and Bhattacharya (2001). In the investigation/exploration cycle, students investigate scientific issues that emerge from the design/redesign cycle. According to Kolodner and her colleagues (1998), there are seven key components that constitute a LBD environment. These components are:

- Authenticity: tasks based on real-world applications
- Multiple contexts for design activities
- A balance of constrained, scaffolded challenges with open-ended design tasks
- Rich, varied feedback for designers
- Discussion and collaboration
- Experimentation and exploration
- Reflection

Although existing research (Koehler & Mishra, 2005a; Han & Bhattacharya, 2001; Kolodner et al. 2003) has provided valuable information on how LBD can be used to promote learning, as described above, scarce research has been done to explore how LBD can be used to guide the design of technology integration programs for preservice teachers. Using LBD for preservice teacher technology preparation entails a discussion of the affordance of the learning environment for this context. The LBD model in current literature should be tailored in order to serve the design and development of effective technology preparation programs.

First of all, in their cases, Koehler and his colleagues (2004) applied LBD in Master’s level technology courses for in-service teachers or faculty who had significant teaching experience. Lessons learned from their study may not be helpful for preservice teachers. Preservice teachers have no or limited full time teaching experience. It is reasonable to hypothesize that how they construct TPACK might be different from those in-service teachers and faculty. Thus, when teaching TPACK to preservice teachers, attention must be paid to the fact that they are new to the teaching profession and are building up their understanding toward content and pedagogy, as well as technology.

Secondly, preservice teachers are a generation “growing up digital” (Tapscott, 1998). They are known as digital natives (Prensky, 2001) who are comfortable with using information technology, use technology differently and learn differently from their previous generations. Their experiences of using technology and understanding of technology might affect the design of the LBD environment. For example, instead of focusing on teaching technology knowledge and skills, the technology integration instruction that digital native preservice teachers need might have to “bridge the gap between their own levels of fluency and their ability to think like
teachers” (Clifford, Friesen, & Lock, 2004, p.157). Thus, their experiences of using technology and understanding of technology can affect the design of technology courses when LBD is used.

Finally, there are a myriad of literature, discussing how preservice teachers should learn about technology integration, many of which are grounded on the constructivist perspective. LBD has its root in the constructivist tradition. Those practices from the constructivist perspective can inform the development of an adapted LBD instructional model for preservice teacher technology integration programs. In the Research Design section, the researcher will describe the research context, the LBD model implemented in the context, and the implementation of LBD. Data collection and analyses in this dissertation will also be shared.

**Research Design**

**Research context**

The proposed LBD model was implemented in a series of three mandatory face-to-face technology integration courses in an elementary teacher preparation baccalaureate degree program in the School of Education at a large private northeastern university. The target course in this study was the first one in the series.

This teacher preparation program organizes preservice teachers’ learning experiences into blocks. In their pre-block semesters, preservice teachers enroll in subject matter courses with some classroom observation and tutoring experiences. In blocks, preservice teachers have both methodology courses and teaching field placements. This series of technology integration courses is structured as three one-credit courses, which are taught in preservice teachers’ pre-block, Block II, and Block III semester. The courses help preservice teachers build up meaningful connections among their knowledge of subject matter, pedagogy knowledge and technology knowledge (Lei, 2009b).
The first course is taught in preservice teachers’ pre-block semester. The pre-block semester is usually arranged in the second semester of the freshman year or the first semester of the sophomore year. In this semester, preservice teachers focus on learning subject matters and are engaged in classroom observation and tutoring activities in their field placement. This course introduces general technologies, such as Microsoft Word and PowerPoint, Microsoft Excel, and Internet, with an emphasis on connecting preservice teachers’ technology and learning experience with teaching tasks through hands-on technology projects in authentic teaching contexts.

The second course is taught in preservice teachers’ Block II semester. The Block II semester is usually arranged in the second semester of the sophomore year or the first semester of the junior year. In this semester, preservice teachers learn teaching methods in math and social studies and are engaged in full-lesson teaching in their field placements. This course introduces emerging technologies, such as Web 2.0 technologies, with an emphasis on enhancing preservice teachers’ understanding toward the concept of technology integration by using technology in real world teaching.

The third course is taught in preservice teachers’ Block III semester. The Block III semester is usually arranged in the second semester of the junior year or the first semester of the senior year. In this semester, preservice teachers learn teaching methods in math, literacy and science and are engaged in full-lesson teaching in their field placements. This course introduces more advanced technologies, such as video production, gaming and simulation, and advance assistive technologies, with an emphasis on comprehensive and skillful integration of technology in real world PreK-12 teaching.
This study focused on the LBD model implementation in the first course. Before taking the first technology integration course, the preservice teachers had limited teaching experiences, especially experiences of teaching with technology. By the time when they take the second and third courses, the preservice teacher will have had some teaching experiences from the field placement. Therefore, the researcher expected to see more prominent effect of the LBD environment on the preservice teachers’ development of TPACK in the first course.

Learning By Design: Adaptations for the context

To create an LBD learning model for digital native preservice teacher, the research team referenced Kolodner’s LBD model (2003) and Han and Bhattacharya’s suggestions (2001) on how to create an LBD environment. In the adaptation for the context, the team also referenced current trends and successful strategies in preservice teacher technology preparation. To address the context of technology education for digital native preservice teacher, the following adaptations were made to Kolodner’s LBD model.

1) In Kolodner’s LBD model, students’ learning began with a challenge. Understanding the challenge was the learning task in the first step. In the adapted model, modeling was the major activity to help preservice teachers understand the challenge. Modeling meant instructors modeled or demonstrated successful use of technology in real classrooms by engaging preservice teachers in hands-on activities. Many researchers have pointed out that examples of successful technology use are important (e.g., Brush & Saye, 2009; Kay, 2006; Moursund & Bielefeldt, 1999). Kolodner’s LBD model (2003) emphasized the connection between old and new experience. To construct new knowledge, learners must re-index their old knowledge and apply it to a new situation. Preservice teachers have no or little real-world teaching experiences. Their knowledge about teaching and learning with technology is either
from their own learning experiences as students or from their observation on their teachers. In addition, their learning experiences with technology may vary. Modeling successful use of technology may bridge the gap of preservice teachers’ lacking previous experiences. Being actively engaged in the learner-centered model lessons, preservice teachers can re-index their previous learning experiences and index their experiences in the model lessons by thinking about teaching with technology from both a student’s and a teacher’s standpoint.

2) The second step in Kolodner’s model was Plan Design. In this step, students sketched their ideas about how to design the artifact and made hypotheses about the behavior of the artifact. The third step was Present and Pin-up Session, in which students shared their design ideas with their classmates and received feedback. These two steps in Kolodner’s model were combined into one activity in the adapted model. When preservice teachers were planning their design, learning activities were organized to help them communicate their ideas within the team and with other project teams, and receive feedback both from other teams and the instructors.

3) Kolodner’s fourth step was Construct and Test, where students implemented their design, tested the artifact, and collected data from the testing. This activity was conducted within the project group. However, in the context of designing an instructional artifact or solution, an ideal test involves targeted audience using the instructional artifact or implementing the solution on targeted audience. Thus, in the adapted model, test was separated from the fourth step. Preservice teachers were given the opportunity to formally teach the technology-enhanced lesson they designed in the testing activity and receive feedback from both their classmates and instructors.
The fifth step in Kolodner’s model was Analyze and Explain, where students were required to investigate scientific issues that emerged from the design and testing process. To investigate the scientific issues, students analyzed the data collected in the previous step to test the hypotheses that they had made and explained the test outcome. However, if LBD is used to teach preservice teachers how to teach with technology, issues emerge from the design and testing process are hard to be testified by scientific research. As Reigeluth (1999) put it, instructional methods are “probabilistic” (p.11). This means instructional solutions cannot guarantee desired learning outcomes, which is very different from the causal relationship in a science rule. Therefore, it is more important for preservice teachers to argue their rationale of the design in a given situation and how likely the design can bring the highest possible probability of the desired results (Reigeluth, 1999). Opportunities for reasoning were seen as important in Kolodner’s model. In the adapted model, various forms of reflection were used to help preservice teachers articulate the relationship between their design and the outcomes.

Reflection can also help preservice teachers articulate their learning in the course and connect their in-class learning experiences with their future teaching career. Kolodner and her colleagues (2003) suggested that learners in an LBD environment should be encouraged to relate their old experience to solve new problems. To do that, their previous experiences must be indexed. Through articulating their learning experiences in the course, preservice teachers were engaged in conversations with themselves about the complexity that resides in using technology for real-world teaching tasks. Such conversations may help them develop a deeper understanding of the dynamic and complex relationship between and among technology, content and pedagogy. With the indexed previous experiences, preservice
teachers can connect what they learned with what they would do in their future profession as PreK-12 school teachers.

5) The last step in Kolodner’s model was Present & Share, where students presented and shared their artifact and findings. In the adapted model, the Present and Share step was combined with the Test step.

Learning By Design: The adapted model for preservice teacher technology preparation

According to the above adaptations, an LBD model for the context of preservice teacher technology preparation was created. Figure 3 illustrates steps in the adapted LBD model and the learning activities organized along the design process. In the LBD environment, the central tasks were projects, including mini projects and a course project. For the mini project in each module, preservice teachers used one technology to design an instructional product or an instructional solution to a real-world teaching task. The technology preservice teachers chose was from several technologies with similar technological affordance, which were carefully chosen to match real-world contexts and challenges in their future teaching career. Besides the mini projects in each module, preservice teachers were required to conduct a course project. The course project required them to illustrate ability to identify useful technology resources and develop instructional strategies to use technology effectively for a real-world teaching task. Learning activities organized around each project represented an LBD cycle. Therefore, each module was organized as one LBD cycle for a mini project. Learning activities for the course project represented one LBD cycle and were spread throughout the course. Figure 4 demonstrates how the LBD cycles were organized in a course designed as an LBD environment. Next the researcher will discuss how the learning tasks and the LBD activities were designed.
Figure 3. An LBD model for preservice teacher technology preparation

Figure 4. Application of LBD in a technology integration course for preservice teachers
Learning tasks

In the LBD environment, the central tasks were projects, including mini projects and a course project. The projects were designed representing real-world instructional challenges. Learning tasks in the projects were designed based on the following understanding of LBD requirements and characteristics of preservice teachers.

1) In the adapted LBD environment, preservice teachers were engaged in solving authentic instructional tasks in the design projects. The real-world teaching tasks were from scenarios of real-world instructional tasks. The tasks required preservice teachers to design an instructional artifact with technology or use technology to teach content. Therefore, preservice teachers had to consider the affordance of the technology, the content to be taught, and the pedagogy to teach the content in a project. These project activities provided preservice teachers opportunities to negotiate the relationship between their content knowledge, pedagogical knowledge and technological knowledge.

2) The learning tasks focused on technology use for instructional purpose in authentic contexts, not how to use technology. This focus was based on the premise that this generation of preservice teachers are digital natives. They have positive attitudes toward technology and considerable technological knowledge (Lei, 2009a). It was expected that the digital native preservice teachers learn how to use technology independently with moderate help from the instructors. However, attention must be paid to those preservice teachers who had little access to technologies and few opportunities to use technologies when they grew up.

3) Learning activities in the adapted LBD environment were carefully scaffolded for the audience. As mentioned above, preservice teachers had little pervious experiences in teaching with technology. Their experiences of using technology to learn were from their
experiences as students. To help them think about technology use from a teacher’s standpoint in model lessons, a worksheet (See Appendix A) was provided to help them identify the audience, technology, content, and pedagogy involved in the activities. Careful scaffolding was also represented in the projects. Kolodner and her colleagues (1998) suggested that there should be a balance of constrained, scaffolded challenges with open-ended design tasks in the LBD environment. Considering that most preservice teachers may use the technology for instructional purposes for the first time in mini projects, the challenges in the mini projects were less open-ended as compared with the challenges in the course project. Instructions in the mini projects were structured and detailed (See Appendix B). The design challenges in the course project were open-ended and preservice teachers received less support from instructors (See Appendix C). This was based on the assumption that preservice teachers would develop a moderate level of confidence and experiences in using technology to teach from the mini projects.

**LBD activities**

*Understand Challenges:* In this step, preservice teachers were informed of the design challenge, usually designing an instructional product with technology or designing a technological solution to a real-world teaching task. Through hands-on activities in model lessons, in-class exploration activities and discussion, preservice teachers explored how technology can be effectively used for instructional purposes. These activities were closely connected with students’ design tasks in mini projects. Readings would also be provided to preservice teachers to further their understanding in this step.

*Plan Design:* In this step, preservice teachers were given specific tasks regarding the project. They either work independently or with their teammates to plan the design for the
instructional product or solution. Depending on the project requirements, preservice teachers had to choose, analyze, and make decisions about their audience, the content, instructional strategies, and technology. Sharing activities were organized for project teams to communicate their draft ideas.

*Construct/Design:* In this step, preservice teachers began to design and construct their instructional product or solution according to their planning in the *Plan Design* step.

*Test:* In this step, preservice teachers implemented their design in a real teaching context. In mini projects, preservice teachers did not have in-class opportunity to test their products because of the constraint of time and lack of audience. However, preservice teachers were encouraged to test their product in a less formal sense, such as having a peer use or review the product. In course project, preservice teachers had opportunities to test their lesson design in the technology class. The rest of the class was their intended audience.

*Analyze and Explain:* Through written report and various form of reflection, preservice teachers were required to explain and articulate their design experience. They articulated their learning in the project, reflected on the test outcomes, suggested possible redesign plans, and built connection between their technology use experiences in this course and their future career as a teacher.

Throughout the LBD cycle, various forms of feedback were provided to preservice teachers regarding their design product or solution. The forms of feedback included in-class feedback from instructors, in-class feedback from peers, and written feedback from instructors. Table 2 summarizes the sample instructional activities and how the activities can be applied in the context in each LBD step.
### Table 2

**An LBD Model for Preservice Teacher Technology Preparation**

<table>
<thead>
<tr>
<th>LBD Steps</th>
<th>Sample Instructional Activities</th>
<th>Application in the Context</th>
</tr>
</thead>
</table>
| Understand challenges | - Frame project in context of classroom applicability/course goals.  
                      - Reading discussion.  
                      - Model technology integrated lessons (preservice teachers take on student role). | - Instructors model or demonstrate effective use of technology in classroom contexts, reflecting aloud on teacher’s planning/implementation process.  
                      - Students experience lessons from PreK-12 student point of view.                                                   |
| Plan design        | - Discussion with group members during mini-project planning/creation.  
                      - Feedback from peers and instructor. | - Participants engaged in solving authentic instructional tasks.  
                      - Authentic scenarios require the integration of technology and alignment with content and pedagogy. |
| Construct / design | - Design and creation of the artifact.  
                      - Collaboration with group members.  
                      - Feedback from instructor. | - Focus on technology use for instructional purpose in authentic contexts.                                      |
| Test               | - Feedback from peers and instructors.  
                      - Peer artifact testing for instructional/grade level appropriateness. | - Focus on testing artifact based on appropriateness of instructional solution.  
                      - Focus on helping participants articulate the relationship between content, pedagogy, and technology. |
| Analyze & explain  | - Written feedback from instructor.  
                      - Reflection on artifact’s application in a classroom setting and application of instructional methods. | - Focus on helping participants articulate the relationship between content, pedagogy, and technology.  
                      - Reflection helps participants connect their in-class learning experiences with their future teaching tasks. |

**Implementation of LBD**

In order to illustrate how the LBD model was applied in this context, the course activities from the first of the three technology integration courses, will be presented here. The course consisted of six classes. The operation and integration of six introductory technologies
were covered from Class 1 to Class 5: Educational websites, Microsoft Word and PowerPoint, Microsoft Excel, electronic communication tools, and assistive technologies. The instruction in each class session consisted of four key components that were representations of the LBD steps: reading discussions, model lessons, mini-projects, and reflections. The sixth class was course project presentation. Instructional activities to facilitate the completion of course project were spread out throughout the six classes. Next, using Class 3 as an example, the researcher will explain in greater details how the LBD activities were organized in the course.

In Class 3 the technology topic was Microsoft Excel. Prior to class, students read an article that provided examples of how Excel can be used in classrooms. For the reading discussion, students shared their ideas for using Excel in their own learning. In the model lessons, students took on the role of fourth graders in completing an Excel survey assignment. The assignment required them to follow step-by-step directions for setting up a spreadsheet that they used to collect, analyze, and display data that they gathered from their classmates. Prior to the model lesson, the instructors built students’ content knowledge by showing and discussing the state standards that the lesson addressed, and clearly stating the desired student outcomes with respect to the mathematical understandings involved. During the model lesson, the instructors modeled appropriate pedagogical practices that made a lesson a success, including providing the directions, using research-based instructional strategies, and managing student movement throughout the lesson. At the end of the lesson, the instructors also reflected aloud on their own practices and instructional decisions in order to help students understand the pedagogical considerations of implementing such a lesson with elementary school students.

After the model lesson, the instruction moved into the mini-project, in which students created step-by-step directions that were appropriate for fifth grade students that would guide
them through using Excel to create their own gradebook. The students must also create a sample Excel gradebook that they can use as an example to show their students as they created their own. Students worked in pairs on this activity in order to provide opportunities for peer collaboration, discussion, and feedback as they completed the assignment.

In this application of LBD, the scaffolding occurred as students began by reading about the use of the tool in classrooms, then participated in a classroom activity taking on the role of the elementary student, then moved to the teacher role in creating instructional artifacts that they can one day use in their own teaching. Students often began this class having little or no experience with Excel on any level, and left having the ability to use it in several different ways with their future students. The students also received feedback from the instructors throughout the process, as they participated in the activities, as they completed their mini-projects, and ultimately in the feedback they received after they submit their assignments. They also received feedback from their peers, as collaboration and discussion was encouraged throughout the process.

The five days of instruction in this course provided scaffolding for the students’ course project, which was to create and present a 15-minute technology-integrated lesson that could be used with elementary school students. Students worked in groups of 3-4 on this project, and were assigned a grade level and subject area. The groups then selected a state standard that they would focus on for their lesson, and wrote a preliminary plan which they submitted as their Statement of Intent before Class 3. The instructors reviewed these assignments, and provided feedback and additional scaffolding as necessary to help students complete their projects. On the final day of class, the groups presented their lessons to their classmates as model lessons, with their classmates taking on the role of the elementary school students. Each of the five days of
instruction was intended to prepare students for this presentation, as the instructors had modeled how to begin with a curriculum objective to create a lesson that used technology to enhance learning.

**Design-based research (DBR)**

Design-based research methodology was used in this study to guide the research design. Design-based research blends “empirical educational research with the theory-driven design of learning environments” (Design-Based Research Collective, 2003, p5) to understand “how, when, and why educational innovations work in practice” (p5). In design-based research, the research process is also the process to design, develop and implement a theory-driven education intervention in a local context. Figure 5 described the general process of a design-based research study illustrated by Reeves (2006). Herrington and her colleagues (Herrington, McKenney, Reeves, & Oliver, 2007) described the steps in a design-based research study in greater details. Researchers conducting design-based research normally start from a real-world practical problem. In this dissertation, the practical problem is how to help digital native preservice teachers develop knowledge and skills necessary for them to integration information and communication technology into their classroom. After identifying and defining the problem, researchers begin to develop a solution, which is informed by an existing theoretical framework. “A well-described theoretical framework provides a sound basis for the proposed solution, because theory can inform practical design guidelines” (Herrington, et al., 2007). In this dissertation, informed by the theoretical framework TPACK and the LBD instructional approach, the research team developed an LBD environment to teach preservice teachers TPACK. In the next step, researchers implement in practice and collect data in various format to evaluate the solution. According to the evaluation results, researchers refine the solution to the practical problem. In
order to provide enough evidence for refinement, this process should be iterative, which means a design-based research study normally has two or more iterative cycles of implementation, evaluation, and refinement. In this study, the LBD environment was implemented in a preservice teacher technology integration course. Considering the time frame and the large amount of data which could be collected from a design-based research study, with consent from the dissertation committee, the researcher focused on the first stage of the study, completing only one cycle of the testing and refinement. Finally, researchers are expected to make theoretical contribution by generating design principles which underline the development of the solution from the research. In this study, through the first cycle of design, development, enactment, and improvement, the design and implementation of the LBD environment was connected with the intended outcome of interest, preservice teachers’ construction of TPACK. The researcher was not only interested in revealing whether LBD was an effective approach to design technology instruction for preservice teachers, but also exploring how, when, and why LBD worked in this context. By monitoring the implementation process, this research methodology can also provide insights into the complexity involved in developing preservice teachers’ TPACK (Design-Based Research Collective, 2003).

Figure 5. Design-based Research (Reeves, 2006)
Participants

The participants included 39 preservice teachers who enrolled in this technology integration course in the 2010 spring semester. Among the 39 participants, a majority of them (92%) were female and were enrolled in teacher education programs as freshmen (82%) or sophomores (18%). Most of them had little to no teaching experience.

Data collection and analyses

To explore whether and how LBD was effective to help preservice teachers develop TPACK in a technology integration course, both quantitative and qualitative data were collected in this study. Educational technology researchers proposed to use both quantitative and qualitative data when determining the effectiveness of technology-enhanced programs (Kay, 2006; Lei, 2010). For example, after reviewing the data analysis section in 68 referred journal articles concerning technology preparation for preservice teachers, Kay (2006) concluded that qualitative data had a role in “assessing the effectiveness of specific technology strategies” (p. 387). However, the role of qualitative data was “probably best used in conjunction with quantitative data, at least at the evaluation stage” (p. 387).

To collect both quantitative and qualitative data, data collection methods include pre- and post-survey, in-class observation, document analysis, and interview. As mentioned in the last section, the following data collection methods were conducted in each implementation cycle.

Pre- and Post-survey: The pre-survey included the following sections: (1) Demographic information; (2) General technology use information, such as ownership of computer, time spent on computer and technology activities. (3) Preservice teachers' self-assessed TPACK. Section (3) use 46 items that measure TPACK in the Survey of Preservice Teachers' Knowledge of Teaching and Technology developed by Schmidt and her colleagues (2009). Respondents were asked to
rate their agreement of 46 statements about their TPACK on a five-point likert scale from “strongly disagree to strongly agree.” The post-survey was the same as the pre-survey. (See Appendix D for the complete survey.) The pre-survey was conducted before the first class. The post-survey was conducted after the participants completed all six classes.

**In-class observation**: The researcher observed all class sessions of the course and made detailed field notes. In the observation, the researcher focused on capturing the dynamics in the classroom, describing classroom teaching and learning activities and preservice teachers and instructor interactions.

**Document analysis**: Document analysis included the analysis of course materials from the courses. The course materials included syllabus, instructional materials, student assignments, and student activities in the Blackboard online course management system, and course evaluation.

**Interview**: The purpose of student participant interviews was to acquire in-depth understandings on students' responses from the survey and opinions about their learning experiences in the course. The interview included two parts: 1) students’ perceived effectiveness or ineffectiveness of the LBD learning activities and reasons for their judgment; 2) other activities that they believe to be effective or ineffective and that are not asked by the interviewer (See Appendix E for interview questions). Student interview was conducted after the participants completed all six classes.

The researcher used both quantitative and qualitative analysis techniques in the data analysis. Table 3 outlined the research questions, data collection methods, data sources, and data analysis techniques in Paper #2, #3, and #4 respectively. Data analyses were described in greater details in each specific paper.
Table 3

Research Questions, Data Collection and Data Analysis

Paper #2: Learning By Design for Preservice Teachers Technology Preparation: How Effective Is It and in What Ways?

<table>
<thead>
<tr>
<th>Research questions</th>
<th>Data collection methods</th>
<th>Data collected</th>
<th>Data analysis technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Does the preservice teachers’ TPACK change after learning technology integration in a LBD environment?</td>
<td>pre-survey and post-survey</td>
<td>preservice teachers' self-assessed TPACK before and after taking the courses</td>
<td>Paired sample t-test</td>
</tr>
<tr>
<td>2. How did the preservice teachers perceive the effectiveness of the LBD environment?</td>
<td>preservice teacher interview</td>
<td>in-depth understandings on preservice teachers’ responses from the survey and opinions about their experiences in the courses</td>
<td>Qualitative data analysis</td>
</tr>
</tbody>
</table>

Paper #3: Using Live Dual Modeling to Help Preservice Teachers Develop TPACK

<table>
<thead>
<tr>
<th>Research questions</th>
<th>Data collection methods</th>
<th>Data collected</th>
<th>Data analysis technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Can the preservice teachers transfer what they learned in the modeling to their own teaching projects?</td>
<td>document analysis</td>
<td>Preservice teachers’ course project proposals and final reports</td>
<td>Qualitative content analysis</td>
</tr>
<tr>
<td>2. What were the conditions that influenced the effectiveness of modeling?</td>
<td>in-class observation</td>
<td>Description of classroom teaching and learning activities</td>
<td>Qualitative data analysis</td>
</tr>
<tr>
<td></td>
<td>preservice teacher interview</td>
<td>Opinions about their LBD experiences in the course</td>
<td>Qualitative data analysis</td>
</tr>
</tbody>
</table>
Paper #4: Cultivating Reflective Practitioners in Technology Preparation: Constructing TPACK through Reflection

<table>
<thead>
<tr>
<th>Research questions</th>
<th>Data collection methods</th>
<th>Data collected</th>
<th>Data analysis technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How did the preservice teachers interpret their in-class technology integration experience?</td>
<td>document analysis</td>
<td>Preservice teachers’ reflection journals written after the first five classes</td>
<td>Quantitative content analysis &amp; Qualitative content analysis</td>
</tr>
<tr>
<td>2. How did reflection help the preservice teachers develop TPACK?</td>
<td>preservice teacher interview</td>
<td>Opinions about their LBD experiences in the course</td>
<td>Qualitative data analysis</td>
</tr>
</tbody>
</table>

**Implication and Significance**

This article discussed the initial efforts to design and develop a series of three technology integration courses for elementary preservice teachers. The researcher described the theoretical framework and instructional design model behind the courses and how the research team adapted the LBD model to suit the context. As the first paper in a multi-paper dissertation, the researcher also described the research purpose, research design and methods of the study. By presenting the theory and model, a picture of how TPACK and LBD can be used as the basis of technology integration courses was presented. Applying TPACK and LBD in this series of technology preparation courses can extend the understanding of the theoretical grounding for the design of teacher technology preparation. With the efforts in improving instruction in a local context and exploring the complex relationships that were bounded in the context, eventually the researcher intended to improve the development of LBD, the instructional model inherent in the context, delineated the principles that contribute to the effectiveness of the model, explained why and how this instructional model took effect in the context that it served, and informed the
mechanism of preservice teachers’ technology learning. It is with such detailed understanding that an instructional model can potentially be shared in a wider context with careful and informed adaptation. Moreover, with an in-depth insight into the theoretical grounding, the design of teacher technology preparation can be based on a solid ground. Preservice teachers will benefit from improved technology preparation experiences. Ultimately, our preK-12 school system will benefit from a workforce of technologically competent teachers who can effectively use technology to enhance student learning.

Notes:

1. A portion of this paper was published in C. D. Maddux, D. Gibson, B. Dodge, M. Koehler, P. Mishra, & C. Owens (Eds.), Research Highlights in Technology and Teacher Education 2011, Society for Information Technology and Teacher Education in 2011.

2. TPACK was previously known as TPCK (Thompson & Mishra, 2007). To be consistent, the researcher uses TPACK in this study although some references may use the term TPCK.

References


Sheffield, C. C. (2011). Navigating access and maintaining established practice: Social studies teachers’ technology integration at three Florida middle schools. *Contemporary Issues in
Technology and Teacher Education, 11(3). Retrieved April 9, 2013 from


Appendix A*

Lesson Plan Notes

<table>
<thead>
<tr>
<th>Instructional Strategies</th>
<th>Classroom Management</th>
<th>Computer Skills Curriculum</th>
<th>Core Content Curriculum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td></td>
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</tr>
</tbody>
</table>

* This document was developed by Laurene Johnson and Leigh M. Tolley.
Appendix B*

Mini Project 3: Using Excel to Create a Gradebook

This is an assignment to be done in pairs.

As a teacher, you will show your students how to keep track of their grades. You will do this by providing an example of a grading spreadsheet to them. This grading spreadsheet will allow them to keep track of their grades, calculate percentages for their grades, and allow the students to chart their progress. You will also prepare a list of written instructions for your 5th grade students to follow so that they can create their own gradebook, which will be modeled after your example.

Your example gradebook must contain the following components:

1. Two tabs, one marked **Semester 1** and the other marked **Semester 2**.
2. **Student Name First Semester Grades** and **Student Name Second Semester Grades** at the top of their respective spreadsheets in merged cells.
3. Columns on each spreadsheet for 5 assignments and one unit test (these can be done in any order), and a **Final** column at the end.
4. A row for entering the points the student earned on the assignment.
5. A row for the points possible for each assignment, which will be as follows:

<table>
<thead>
<tr>
<th>Semester 1</th>
<th>Semester 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignment 1: 15 points</td>
<td>Assignment 1: 30 points</td>
</tr>
<tr>
<td>Assignment 2: 20 points</td>
<td>Assignment 2: 5 points</td>
</tr>
<tr>
<td>Assignment 3: 15 points</td>
<td>Assignment 3: 15 points</td>
</tr>
<tr>
<td>Assignment 4: 30 points</td>
<td>Assignment 4: 20 points</td>
</tr>
<tr>
<td>Assignment 5: 10 points</td>
<td>Assignment 5: 20 points</td>
</tr>
<tr>
<td>Unit Test: 50 points</td>
<td>Unit Test: 75 points</td>
</tr>
</tbody>
</table>

6. Point values that your example student “earned” for each assignment or test (you can make these up).
7. Total points earned and total points possible are in the appropriate cells, calculated using the correct formula.
8. A row for the percentages earned for each assignment, test, and the final grade.
9. Percentages calculated for what the student earned on each assignment and their total semester grade, done using the correct formulas in the appropriate cells, and cells formatted correctly for percentages.
10. A line chart is inserted for one semester showing the student’s percentage progress.*

11. A column chart is inserted for the other semester showing the student’s percentage progress.*

12. Save the gradebook with the following name: Partner1_and_Partner2_gradebook.xlsx. For example, Leigh_and_Laurene_gradebook.xlsx. This is how we will be able to identify who is submitting this gradebook example.

*The line chart and column chart can be done for either semester. When creating the chart, delete the box that says “Series 1” from your chart.

Work together in order to create the gradebook and instructions. Students should be able to create the entire gradebook based on reading the instructions. Their gradebooks will be the same as your example gradebook. Make sure that both partners’ names are on the instructions and the spreadsheet. Each person must submit their own assignments to Blackboard. Submit your final Word file AND the Excel file to the Blackboard Assignment Dropbox by Tuesday, April 20, 2010 at 11:59 PM.

To attach multiple files in one submission in Blackboard, click on the assignment name in the Assignment Dropbox. In Section 2, “Assignment Materials,” select “Browse for Local File” and choose one of the files to upload. You must then click “Attach File” to attach it to your submission. Next, click the “Browse for Local File” button again, select the next file, and then click “Attach File” again. Both files should now be ready to be attached when you click “Submit” at the bottom of the page.

Criteria for Evaluation – Gradebook and Instructions Created in Pairs

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Points</th>
<th>Earned</th>
</tr>
</thead>
<tbody>
<tr>
<td>All components are completely created in the gradebook; information is complete</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Computation of data using correct formulas is complete and accurate</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Charts are all completed; clearly labeled and accurate</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Instructions for creating the gradebook are complete, clear, and can be easily followed by a 5th grader</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

* This document was developed by Laurene Johnson and Leigh M. Tolley.
Appendix C: Group Course Project*

Project Description:
Form a team of three students. Based on a predetermined scenario, your task is to work with your teammates and create a 15-minute session that teaches an aspect of technology to your “students.” The following steps will help you be successful in completing your project.

Step I.
Think about the following:
- Who are the learners?
- What do they need to learn?
- What are the goals and objectives?
- Are there issues/concerns that could impact the success of the learners?
- Any other questions/concerns/issues you might think of that will help you consider the best solution?

Step II.
Based on your answers to the previous questions, you will create a plan that uses strategies and activities that will best help your “students” learn. Questions you should ask yourself, but are not limited to, include the following:
- How should the content be organized?
- How should the content be delivered?
- How do you determine if/how much the learners have learned?

Step III.
Develop instructional materials that you will actually use in your lesson based on your plan. You may consider running a pilot session before you actually teach your lesson.

Step IV.
In the final class, you will teach your lesson (more on this below; see Final Presentation).

Step V.
Determine if your lesson has achieved the goals and objectives. You should address the following issues:
- Did your learners successfully learn what you taught them?
- How did you assess their learning?
- What would you have done differently?

This project includes three tasks or segments**:
1) (5 points) Submit a statement of intent regarding your project prior to the start of class on Friday, February 12, 2010 to the Blackboard assignment submission page. This statement must include the following information: Title, Team Members, Date, Scenario, and all of the information you gathered from Step 1 and the plan you developed in Step 2. This statement should be no longer than two pages in length, double-spaced.
2) (15 points) Submit a final report of your project and a brief reflection of how your team worked together by **Wednesday, March 10, 2010 at 5:00 pm EST to the Blackboard assignment submission page**. In your **final report**, you will summarize your activities and results in all the steps of this project. Your final report must include the following parts: Title, Authors, Date, Scenario, Results from each step of the project, and Reflection. The final paper should be about 4-5 pages. In your **separate individually prepared reflection of team collaboration**, summarize the strengths and/or weaknesses of the team learning experience, and write briefly about each team member’s contribution.

3) (10 Points) Final Presentation. In the final class (**Friday, March 5, 2010**), each team will implement their course project: teaching your lesson to your classmates in 15 minutes (remember, your lesson MUST be completed in 15 minutes). An activity to assess your students’ learning must be included in your training. Each team member must be assigned a role during the 15-minute training. Your students—the rest of the class—will grade you on this task.

* This document was developed by Laurene Johnson, Jing Lei, Liangyue Lu, and Leigh M. Tolley.
Appendix D

Technology Integration Self-Assessment

You will use the following questionnaire to examine your current understanding of the concept of technology integration in PreK-12 classrooms. There are FOUR sections in this questionnaire. Completing the activity will take approximately 30 minutes. This activity will help you better understand your knowledge on technology integration and help us better understand your technology use and design instructional activities that accommodate your learning needs. We also hope you enjoy the experience of using the online survey tool. You will be graded on your participation in the activity, NOT on how you answer the questions in the instrument.

Section 1: Demographic Information

1. Your first and last name:

2. What semester and year (e.g., Spring 2010) do you plan to take the following? If you are currently enrolled in or have already taken 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?
   a. Yes
   b. No

4. Year in college
   a. Freshman
   b. Sophomore
   c. Junior
   d. Senior
5. Gender
   ○ a. Female
   ○ b. Male

Section 2: Please check your responses to the following questions, or fill in the blanks where appropriate.

6. When did you start using a computer?
   ○ Before kindergarten
   ○ In kindergarten - grade 3
   ○ In grade 4 - 5
   ○ In grade 6 - 8
   ○ In grade 9 - 12
   ○ After grade 12

7. How much time do you spend on computers every day?
   ○ How much time do you spend on computers every day? Not at all
   ○ Less than one hour
   ○ About 1-2 hours
   ○ About 2-3 hours
   ○ About 3-4 hours
   ○ About 4-6 hours
   ○ More than 6 hours

8. Do you own the following devices or accounts?

<table>
<thead>
<tr>
<th>Device</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Computer</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Cell Phone</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Game Console</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>iPod (or other mp3 player)</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>PDA (Personal Digital Assistant)</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

9. If your computer does not work, how many people can you turn to for help?
10. What do you use computers for (choose all that apply)?

☐ For learning-related activities
☐ For entertainment (playing games, watching videos, etc.)
☐ For social/communication activities (chat, email, IM, Facebook comments, Twitter, etc.)
☐ For practical purposes (find info. you need)
☐ For self-expression (blogging, commenting, etc.)
☐ For constructive activities (creating web pages, uploading video/audio/music...files, etc.)
☐ Shopping
☐ Other (please specify)

11. What do you use the Internet for (choose all that apply)?

☐ Searching information for my study (e.g., preview, review, homework)
☐ Searching information for other practical purposes (e.g., weather, health, etc.)
☐ Reading news to know what's going on in this country
☐ Reading news to know what's going on in the world
☐ Sending and receiving emails
☐ Playing games
☐ Online chatting (chatrooms, Instant Messenger, ICQ, etc.)
☐ Surfing online for fun (reading novels, stories, entertainment)
☐ Downloading music, pictures, movies, etc.
☐ Blogging
☐ Social bookmarking
☐ Developing wiki
☐ Viewing or publishing digital media files online (e.g., on Flickr.com, YouTube.com, podcasting, etc.)
☐ Social networking (e.g., Facebook, MySpace, Twitter, etc.)
☐ Viewing and posting messages (e.g., on forums, discussion boards, etc.)
12. How often do you have an assignment that needs you to go to the Internet in order to finish?

- [ ] Every day
- [ ] 2-3 times a week
- [ ] Once a week
- [ ] 2-3 times a month
- [ ] Never

13. Overall, on which task do you spend most time on using the Internet every day (only choose one)?

- [ ] Searching information for my study (e.g., preview, review, homework)
- [ ] Searching information for other practical purposes (e.g., weather, health, etc.)
- [ ] Reading news to know what’s going on in this country
- [ ] Reading news to know what’s going on in the world
- [ ] Sending and receiving emails
- [ ] Playing games
- [ ] Online chatting (chatrooms, Instant Messenger, OICQ, etc.)
- [ ] Surfing online for fun (reading novels, stories, entertainment)
- [ ] Downloading music, pictures, movies, etc.
- [ ] Blogging
- [ ] Social Bookmarking
- [ ] Developing wiki
- [ ] Viewing or publishing digital media files online (e.g., on Flickr.com, YouTube.com, podcasting, etc.)
- [ ] Social networking (e.g., Facebook, MySpace, Twitter, etc.)
- [ ] Viewing and posting messages (e.g., on forums, discussion boards, etc.)
- [ ] Getting information about other places, countries, cultures and peoples in the world
- [ ] Shopping (e.g., Amazon, eBay, other online stores, etc.)

Other (please specify)
14. To you, what's the most exciting thing about the Internet?

- Getting information I need for my study
- Getting information I need for other practical purposes
- Reading news
- Playing games
- Making new friends
- Communicating with my friends
- Chatting with strangers
- Knowing things about the world
- Shopping
- Downloading files I need
- Express my ideas freely
- Other (please specify)

Section 3: 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 indicate on a scale of 1 to 5, your responses to each of these statements. 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree. If you are uncertain of or neutral about your response you may always select "Neutral."

<table>
<thead>
<tr>
<th>Statement</th>
<th>1=strongly disagree</th>
<th>2=disagree</th>
<th>3=neutral</th>
<th>4=agree</th>
<th>5=strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I know how to solve my own technical problems.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. I can learn technology easily.</td>
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<tr>
<td>3. I keep up with important new technologies.</td>
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<tr>
<td>4. I frequently play around the technology.</td>
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<tr>
<td>5. I know about a lot of different technologies.</td>
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<tr>
<td>6. I have the technical skills I need to use technology.</td>
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<tr>
<td>7. I have sufficient knowledge about mathematics.</td>
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<td></td>
</tr>
<tr>
<td>8. I can use a mathematical way of</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1=strongly disagree</td>
<td>2=disagree</td>
<td>3=neutral</td>
<td>4=agree</td>
<td>5=strongly agree</td>
</tr>
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</tr>
<tr>
<td>9. I have various ways and strategies of developing my understanding of mathematics.</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. I have sufficient knowledge about social studies.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>11. I can use a historical way of thinking.</td>
<td></td>
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<tr>
<td>12. I have various ways and strategies of developing my understanding of social studies.</td>
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<td>13. I have sufficient knowledge about science.</td>
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<tr>
<td>14. I can use a scientific way of thinking.</td>
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<tr>
<td>15. I have various ways and strategies of developing my understanding of science.</td>
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<tr>
<td>16. I have sufficient knowledge about literacy.</td>
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<td>17. I can use a literary way of thinking.</td>
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<tr>
<td>18. I have various ways and strategies of developing my understanding of literacy.</td>
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<tr>
<td>19. I know how to assess student performance in a classroom.</td>
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<tr>
<td>20. I can adapt my teaching based-upon what students currently understand or do not understand.</td>
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<tr>
<td>21. I can adapt my teaching style to different learners.</td>
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<tr>
<td>22. I can assess student learning in multiple ways.</td>
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<tr>
<td>23. I can use a wide range of teaching approaches in a classroom setting.</td>
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<tr>
<td>24. I am familiar with common student understandings and thinking.</td>
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<tr>
<td>Question</td>
<td>1=strongly disagree</td>
<td>2=disagree</td>
<td>3=neutral</td>
<td>4=agree</td>
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<td>25. I know how to organize and maintain classroom management.</td>
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<tr>
<td>26. I can select effective teaching approaches to guide student thinking and learning in mathematics.</td>
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<td>27. I can select effective teaching approaches to guide student thinking and learning in literacy.</td>
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<tr>
<td>28. I can select effective teaching approaches to guide student thinking and learning in science.</td>
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<tr>
<td>29. I can select effective teaching approaches to guide student thinking and learning in social studies.</td>
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<tr>
<td>30. I know about technologies that I can use for understanding and doing mathematics.</td>
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<tr>
<td>31. I know about technologies that I can use for understanding and doing literacy.</td>
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<td>32. I know about technologies that I can use for understanding and doing science.</td>
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<tr>
<td>33. I know about technologies that I can use for understanding and doing social studies.</td>
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<tr>
<td>34. I can choose technologies that enhance the teaching approaches for a lesson.</td>
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<td>35. I can choose technologies that enhance students' learning for a lesson.</td>
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<td>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.</td>
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<tr>
<td>37. I am thinking critically about how to use technology in my classroom.</td>
<td>1=strongly disagree</td>
<td>2=disagree</td>
<td>3=neutral</td>
<td>4=agree</td>
<td>5=strongly agree</td>
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<tr>
<td>38. I can adapt the use of the technologies that I am learning about to different teaching activities.</td>
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<tr>
<td>39. I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn.</td>
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<tr>
<td>40. I can use strategies that combine content, technologies and teaching approaches that I learned about in my coursework in my classroom.</td>
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<tr>
<td>41. I can provide leadership in helping others to coordinate the use of content, technologies and teaching approaches at my school and/or district.</td>
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<tr>
<td>42. I can choose technologies that enhance the content for a lesson.</td>
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<tr>
<td>43. I can teach lessons that appropriately combine mathematics, technologies and teaching approaches.</td>
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<tr>
<td>44. I can teach lessons that appropriately combine literacy, technologies and teaching approaches.</td>
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<tr>
<td>45. I can teach lessons that appropriately combine science, technologies and teaching approaches.</td>
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<tr>
<td>46. I can teach lessons that appropriately combine social studies, technologies and teaching approaches.</td>
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</table>
Appendix E: Student Interview Sample Questions

- What do you think technology integration is? Compared with your definition last semester or at the beginning of the semester, what is the difference in your definition?

- Does this technology course help you understand content knowledge, pedagogy and technology? If yes, how? If not, why not?

- Is a certain course component effective in helping you understand how technology should be used in teaching and learning? Why do you think it effective or ineffective?

- What do you think is the best way for you to learn technologies as a preservice teacher?
Chapter 2

Learning By Design for Preservice Teacher Technology Preparation: How Effective Is It and in What Ways?

Abstract

Effective technology integration in teaching requires teachers to construct technological pedagogical content knowledge (TPACK). To help teachers develop TPACK, the learning environment must address the situated nature and complex interplay of technology, pedagogy and content. Learning By design (LBD) has been proposed as one promising instructional model to create such a learning environment. This empirical study examined whether an LBD environment is effective in helping preservice teachers develop TPACK, and described how the participants perceived the effectiveness of LBD. The results indicated that LBD can be an effective instructional model in guiding the design of learning environments to facilitate preservice teachers’ TPACK development. The participants generally agreed that LBD was helpful for them to learn about teaching with technology. They felt more comfortable with and confident in using technology in their teaching. Recommendations are made for future research and practices.

Keywords: preservice teacher technology preparation, digital native, TPACK, Learning By Design, effectiveness
Introduction

In the Digital Age, teacher preparation is rooted in the context that schools are being transitioned “from Industrial Age to Digital Age places of learning” (ISTE, n.d.). Highly-qualified teachers are expected to possess the competency of creating Digital Age learning experiences for their students (ISTE, 2008). However, researchers continue to find that teachers feel inadequately prepared in using technology for instructional purposes (e.g., Hew & Brush, 2007; NEA, 2008; CFTL, 2009). Even when teachers use technologies, they use technologies for teaching in a supplemental way, such as information gathering, production of lesson materials, or presentation (Graham, Tripp, & Wentworth, 2007; Sheffield, 2011). The most productive and meaningful use of technology engages students in knowledge construction, conversation, articulation, collaboration and reflection (Jonassen, 1995). According to Jonassen and his colleagues (1999), technology should be used as cognitive tools for students to learn with, not as tools to convey information or knowledge. One common reason that teachers do not use technology adequately or effectively is that they lack “specific technology knowledge and skills, technology-supported-pedagogical knowledge and skills, and technology-related-classroom management knowledge and skills” (Hew & Brush, 2007, p. 227). Teacher education programs are responsible for providing effective technology instruction to prepare technological competent teachers (NCES, 2000; NEA, 2008). One major criticism on teacher technology preparation is that those technology skill-focused courses or training workshops, the common practices in teacher technology preparation, help teachers develop only technological knowledge and skills, but fail to challenge teachers’ underlying beliefs about teaching and learning and the routines of their practices, which are more fundamental barriers to technology integration in k-12 classroom (Ertmer, 1999).
In response to this criticism, Mishra and Koehler (2006) proposed the technological pedagogical content knowledge (TPACK) framework, which identifies the essential knowledge for a teacher to effectively integrate technology in instruction. Because of its clear articulation of the complexity of the knowledge, TPACK is well received by scholars and practitioners and is adopted as the theoretical framework in their studies and practices (e.g., Brush & Saye, 2009; Bull & Bell, 2009).

To help teachers develop TPACK, Koehler and Mishra (2005a, 2005b) also proposed that Learning By Design (LBD), a project-based, learner-centered instructional theory, is promising to achieve the goal. Koehler and Mishra applied LBD in Master’s level technology courses for in-service teachers or faculty who had significant teaching experience. Is LBD also effective in helping preservice teachers, who generally have little to no teaching experiences, develop TPACK? In the quest for effective and theory-grounded technology instruction for preservice teachers, the researcher intends to examine whether LBD is effective in helping the preservice teachers develop TPACK and describe how they perceived their effectiveness of LBD through answering the following research questions:

a1. Does the preservice teachers’ TPACK change after learning technology integration in an LBD environment?

a2. How did the preservice teachers perceive the effectiveness of the LBD environment?

**Literature Review**

**Guiding Framework: TPACK**

Teaching is a complex professional practice, which is further complicated by the emergence of information technology in K-12 schools. Knowledge about “thoughtful
pedagogical uses of technology” (Mishra, & Koehler, 2006) is complex, situated, and multifaceted (Margerum-Leys, & Marx, 2003). Technology knowledge and skills alone are not sufficient for teachers to unleash the power of technology and catalyze educational changes. To unlock the power of technology, integrating information technology into classrooms requires a change in teaching and learning (e.g., Clifford, Friesen, & Lock, 2004; Kerr, 1996; Jonassen, 1995). The most productive and meaningful use of technology engages students in knowledge construction, conversation, articulation, collaboration and reflection (Jonassen, 1995). Using technology in these ways requires teachers to develop “pedagogical knowledge of effective instructional practices that incorporate meaningful uses of technology” (Ertmer, 1999, p. 48), as well as technical skills.

To capture the essence of teacher technology knowledge, Mishra and Koehler (2006) built a TPACK framework that addresses “the complex, multifaceted, and situated nature of this knowledge” (p.1017) and respects the dynamic relationship of content, pedagogy and technology. Table 1 lists the definitions of each component of the TPACK model. Figure 1 demonstrates how each component is connected in the model.
Learning By Design (LBD)

Mishra and Koehler (2006) state that to develop TPACK, teachers must have the opportunity to tackle the complex and dynamic relationships of content, pedagogy, and technology. Thus, teachers should learn TPACK in contexts that honor the dynamic relationships of the three components. Pope, Hare and Howard (2005) also suggest that “preservice teachers need opportunities to learn with the technology by being exposed to authentic, learner-centered activities that allow them to construct their own understanding of the learning outcomes.” When learners learn in an activity, the context of the activity becomes part of the knowledge and the problem that learners attempt to solve becomes their problem (Jonasson et. al., 1999). When teachers face ill-structured educational problems in authentic contexts, the contexts and the
Learning environment in which they learn TPACK, can become “a fundamental part of what is learned” (Putnam & Borko, 2000).

Learning By design (LBD) is such a learner-centered instructional theory that engages learners in the designing of an artifact for a real-world context whereby learners construct their understanding and meaning toward a topic or concept (Han & Bhattacharya, 2001). LBD offers opportunities for teachers to use technology in authentic problem solving contexts and to explore “the rich connections between technology, the subject matter (content), and the means of teaching it (the pedagogy)” (Koehler & Mishra, 2005a, p.95).

LBD has been implemented in various settings from K-12 classrooms to higher education (e.g., Fessakis, Tatsis, & Dimitracopoulou, 2008; Kolodner et al. 2003). However, using LBD for preservice teacher technology preparation entails a discussion of the affordance of the learning environment for this context. In this study, the author tailored the LBD model developed by Kolodner and her colleagues (2003) for the context of preservice teacher technology preparation, explored the effectiveness of LBD on preservice teachers’ TPACK development and identified the most effective features in LBD.

**Research Design**

**The design of an LBD environment**

The design of a LBD learning environment in this study is based on and modified from Kolodner’s LBD theory (2003) and Han and Bhattacharya’s suggestions on how to create a LBD environment (2001). In the adaptation for the context, the researcher also referenced current trends and successful strategies in preservice teacher technology preparation, such as modeling, collaboration, and reflection. Table 1 lists the LBD steps, sample instructional activities in each step and adaptation made for the context. LBD step 1, understand challenges, involved the
preservice teachers in learner-centered model lesson activities. In LBD step 2, plan design, the preservice teachers worked in teams to plan their design of the artifact. In LBD step 3, construct/design, preservice teachers created the technological artifact or develop instructional solutions to their assigned problem in project teams. In LBD step 4, test, the preservice teachers tested their technological artifacts or technology-enhanced lessons by either informally reviewing the artifacts or formally teaching the lesson. In the final LBD step, analyze and explain, the preservice teachers reflected on their LBD experiences by writing reflection journals.

The central tasks in the LBD environment were projects, including mini projects and a course project. For the mini project in each module, participants used one technology to design an instructional product or an instructional solution to a real-world teaching task. Besides the mini projects, the participants were required to conduct a course project to illustrate their ability to identify useful technology resources and develop instructional strategies to use technology effectively for a real-world teaching task. Learning activities organized around each project represent a LBD cycle. Therefore, each module was organized as one LBD cycle for a mini project and learning activities for the course project represented one LBD cycle and were spread throughout the course. More details about the rationale behind LBD and how LBD was designed and developed can be found in the paper by Lu, Johnson, Tolley, Gillard-Cook, and Lei (2011).

Research context

The research setting is a mandatory face-to-face technology integration course in a teacher preparation baccalaureate degree program in the School of Education at a large private northeastern university. This course was carefully designed as a LBD learning environment.
Participants

The participants were 39 preservice teachers enrolled in this technology integration course. A majority of them (92%) were female and were enrolled in teacher education programs as freshmen (82%) or sophomores (18%). Most of them had little to no teaching experience.

Data collection

Data were collected from participating preservice teachers in three concurrent course sections in the spring 2010 semester through pre- and post- survey and interview. The pre-survey includes the following sections: (1) Demographic information; (2) General technology use information, such as ownership of computer, time spent on computer and technology activities; (3) Preservice teachers' self-assessed TPACK. Section (3) uses 46 items that measure TPACK in the Survey of Preservice Teachers' Knowledge of Teaching and Technology developed by Schmidt and her colleagues (2009). The post-survey were the same as the pre-survey. The pre-survey was collected before the first class and the post-survey was collected after the final class was over.

The interview was conducted after the final class. The researcher asked each participant about their learning experiences in the LBD environment to understand why and how LBD was effective or ineffective for their learning. Most interviews lasted 20-35 minutes, with five interviews longer than 35 minutes and seven interviews fewer than 20 minutes. All interviews were recorded but one recording file was corrupted due to technical problems. The analyses of the interviews were based on the 38 successfully recorded ones.
Table 1
An LBD Model for Preservice Teacher Technology Preparation

<table>
<thead>
<tr>
<th>LBD Steps</th>
<th>Sample Instructional Activities</th>
<th>Application in the Context</th>
</tr>
</thead>
</table>
| Understand challenges | - Frame project in context of classroom applicability/course goals.  
- Reading discussion.  
- Model technology integrated lessons (preservice teachers take on student role). | - Instructors model or demonstrate effective use of technology in classroom contexts, reflecting aloud on teacher’s planning/implementation process.  
- Students experience lessons from PreK-12 student point of view. |
| Plan design   | - Discussion with group members during mini-project planning/creation.  
- Feedback from peers and instructor. | - Participants engaged in solving authentic instructional tasks.  
- Authentic scenarios require the integration of technology and alignment with content and pedagogy. |
| Construct / design | - Design and creation of the artifact.  
- Collaboration with group members.  
- Feedback from instructor. | - Focus on technology use for instructional purpose in authentic contexts. |
| Test          | - Feedback from peers and instructors.  
- Peer artifact testing for instructional/grade level appropriateness. | - Focus on testing artifact based on appropriateness of instructional solution.  
- Focus on helping participants articulate the relationship between content, pedagogy, and technology. |
| Analyze & explain | - Written feedback from instructor.  
- Reflection on artifact’s application in a classroom setting and application of instructional methods. | - Focus on helping participants articulate the relationship between content, pedagogy, and technology.  
- Reflection helps participants connect their in-class learning experiences with their future teaching tasks. |
Results and Discussion

1. Does preservice teachers’ TPACK change after learning technology integration in a LBD environment?

To determine the effectiveness of LBD on preservice teachers’ TPACK development, a paired-samples t-test was conducted to compare each component of the participants’ TPACK before and after taking the course. The results showed that there was a significant increase in their TPACK (M_{before}=3.45, M_{after}=4.06, t (38) = 4.13, p<0.001, SD=0.79) after they took the course. In addition, the participants’ PK, PCK, TCK, and TPK also had significant increase (Figure 2 & Table 2). The result suggests that the LBD environment has significant effect on fostering preservice teachers’ TPACK development. However, not all components of TPACK increased significantly. This may indicate that the development of each TPACK component may evolve differently. In the next section, the researcher discussed how the participants perceived the effectiveness of the LBD environment.

![Figure 2. Changes in preservice teachers’ TPACK](image)
Table 2

Changes in Preservice Teachers’ TPACK

<table>
<thead>
<tr>
<th></th>
<th>Mean difference</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
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<th>Mean</th>
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<th>Sig. (2-tailed)</th>
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<tr>
<td>TK</td>
<td>.081</td>
<td>.633</td>
<td>.101</td>
<td>.800</td>
<td>38</td>
<td>.429</td>
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<td>CK</td>
<td>.042</td>
<td>.620</td>
<td>.099</td>
<td>.431</td>
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<td>.669</td>
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<tr>
<td>PK</td>
<td>.363</td>
<td>.822</td>
<td>.132</td>
<td>2.765</td>
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<td>.009**</td>
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<tr>
<td>PCK</td>
<td>.294</td>
<td>.847</td>
<td>.136</td>
<td>2.175</td>
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<td>.036*</td>
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<tr>
<td>TCK</td>
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<td>.943</td>
<td>.151</td>
<td>4.242</td>
<td>38</td>
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<td>TPK</td>
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<tr>
<td>TPACK</td>
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<td>.147</td>
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Note: * .01<p<.05  ** p<.01  *** p<.001

2. How did the preservice teachers perceive the effectiveness of the LBD features?

Perception of effectiveness of the overall learning environment

When the preservice teachers were asked whether they thought the course was helpful for them to learn about technology integration, they generally expressed positive attitude toward the effectiveness of the course. Overall, the preservice teachers felt more confident and comfortable of using technology in their teaching. As Grace said,

I don’t think I’m someone who would use technology a lot in the classroom. But like seeing how it like really helps to take different perspectives on everything. I really think it’s a good idea and I’ll probably use it a lot more than I thought I was going to…by the time when we had to do the final project with our own lesson plan, I was thinking of all these different ways that we could like from things we learned, I was like, “Oh you can incorporate this way and this way”…

The course help the participants build up their confidence in the following ways:
a. The preservice teachers developed more confidence from a better understanding of what it meant to integrate technology into teaching. After taking the course, the preservice teachers realized that the course was more than technology, but was essentially about how to teach with technology. The preservice teachers had a taste of what technology integration was like in an elementary classroom. As Evan said, the course project was “a future taste of what lesson plans are going to be like in the future.” The course provided the preservice teachers with many ideas about how technology can be used for teaching in a classroom. As Grace said,

…[technology] allows for different ways of communication and ways of describing what you want to get across and you don’t have to do it with just like speaking or just like a handout, there is just so many different ways you can do it and it’s not necessary to have just like lecture and notes…

One of teachers’ tasks is to transfer lesson contents according to pedagogical needs (Shuman, 1986). The course helped the preservice teachers see how to use technology to achieve this goal. In her comments, Grace pointed out that technology could provide more options for teachers to represent concepts or contents for their students. The better understanding of how to use technology to facilitate teaching let the preservice teachers feel more comfortable and thus gave them more confidence in using technology to teach.

b. The preservice teachers developed more confidence also from “doing” technology in authentic classroom settings. They learned from actually integrating technology into meaningful teaching and learning contexts. For example, Mary discussed her thoughts about the course project,
I liked the course project; I think that was like a combination of everything that we have done. Because you were basically free to choose what type of technologies you wanted to incorporate in a lesson…We were able to think creatively about how we would use some of the technologies we have learned about, and apply it…And implementing the lesson doesn’t always go how you planned…So it was good to see that sometimes you need to think on your feet.

In the LBD environment, the preservice teachers didn’t learn technology integration in a context free environment. They learned how to use technology for instruction by actually constructing technological artifacts to solve an instructional problem or applying technology in authentic instructional contexts. Using technology to solve authentic classroom problems gave them the hands-on experience necessary to build up confidence, as well as knowledge and skills in technology integration. In Mary’s case, she practiced using the knowledge and skills she acquired in this course in the course project and felt good that she could teach a technology-enhanced lesson independently.

c. The preservice teachers felt confident because they believed they could apply what they did in the course to their future classroom. As Daisy said, “…if you just took this class and you went to a classroom next week, they are all things that you could definitely use like right away…” The learning tasks in LBD were carefully designed to imitate the instructional challenges in real elementary classrooms. The authenticity of the activities enabled the preservice teachers to make easy connections between what they learned in this course and the elementary classroom teaching.
LBD Step 1: Understanding challenges

In this stage, the preservice teachers actively participated in learner-centered model lessons, which were closely connected with their design tasks in the projects. In the model lessons, the participants acted as K-12 students and their instructors acted as K-12 teachers. The preservice teachers were expected to interpret their learning experiences in the model lessons by thinking about teaching with technology from both a student’s and a teacher’s standpoint. From the interview, the preservice teachers felt that the activities in this stage were “introduction to everything” and helpful for their learning.

a. The exploration helped the participants learn what technology tools resources were available to them in an elementary classroom and develop more knowledge about how to use them. The preservice teachers were, by Prensky’s definition (2001), digital natives and were familiar with some commonly used technologies, such as Microsoft Word or PowerPoint. This course introduced the preservice teachers to some general technologies, such as internet resources, Microsoft Word, Microsoft PowerPoint, Microsoft Excel, and communication technologies, which most preservice teachers had considerable knowledge about. However, they were unaware of many other technology tools and resources, especially those specifically designed for teaching purposes. Cassie talked about computer programs for teaching and learning, “I mean I used some of the programs before so I understand how they work, but I didn’t realize how many different programs there are out there like Inspiration was really good and all the other activities that we did so I definitely learned that there is a ton out there.” Tessa had similar comments on Internet resources,

I thought you could never put kids on the Internet because like there’s so many bad things they could run across but now I didn’t know there was like teacher tube and all
these little things that like little kids can be on the Internet and it can be like safe, not like, “What are you looking at?” So, I definitely think that it’s helpful in that.

Researchers found that digital native preservice teachers had a limited scope of technology use (Lei, 2009). Although they are proficient in using basic technologies, they are not familiar with more advanced technologies and classroom technologies. They use Web 2.0 technologies mainly for social networking, not realizing Web 2.0 technologies’ great potential in classroom applications. The above quotes were consistent with existing research findings. The model lessons gave the preservice teachers opportunities to use and explore a wide range of technology tools and resources. The exploration widened the preservice teachers’ scope in viewing technology tools or resources from the teaching or learning perspective. After gaining hands-on experience with using some educational programs, such as Inspiration, Cassie realized that there were many technology tools “out there” for teachers to use. After being introduced to some educational resources on the Internet, Tessa became aware of the easy access and ready availability of web educational resources.

The preservice teachers also understood better how some technology tools worked, especially those tools that they had little knowledge about. Rachel explained how Inspiration, a concept mapping tool, worked in the interview.

I thought Inspiration was definitely good. It’s definitely a way for students to organize their thoughts and kind of like be a guiding thing to maybe write a paper or like doing something more formal. It’s kind of like an informal way of starting your thought process by making the different charts or, they branch out, I don’t know what they are called, but so I thought it was good and you could do so many different things with that
program so. It’s like very free like you can make your own like whichever way you want to make it look, that’s how you make it so it’s kind of like creative in a way.

In the above quote, although Rachel cannot recall the term “concept mapping,” which was a key concept behind the design of Inspiration, she demonstrated more understanding of Inspiration by describing how it worked. In the survey, the participants did not perceive their technology knowledge increased as a result of taking this course. However, in the interviews, they mentioned that they knew more technology tools and demonstrated expanded knowledge in using technology. The apparent conflict between the survey result and the interview may result from how the participants perceived their technology knowledge gain. They knew how to use most of the technology tools introduced in this course before taking it, which may be the reason why they didn’t think their technology knowledge change. Although their technology knowledge changed to some degree, the margin of gain was not wide enough for them to perceive a difference.

b. The exploration helped the participants gained first-hand experience of technology integration. Being engaged in the model lessons, the participants experienced a wide variety of ways to use technology for teaching and began to understand how to integrate technology for instruction. As Iris said, “I knew technology could be useful, I just didn’t know like how. But now, I see that, that’s awesome.”

The activities gave the participants many ideas about how to use technology for instruction. In one class, a first grade teacher and an elementary school librarian were invited to talk about how they integrated technology into teaching in their schools through video conferencing. After watching the recorded video conference, Jaden thought she got “a lot of” ideas from the elementary school teacher and librarian.
It gave a lot of good ideas because I would have never thought of using technology in that way in the classroom, but especially when we watched that video with other teachers talking about it, there’s really just so many ways that you can use it to facilitate teaching and it kind of like opened up a creative outlook so everything it doesn’t always have to be just like lecture style and stuff like that.

After participating in one model lesson, Bailey realized that she could use the technology integration idea to teach a lesson she learned back in elementary school. In the model lesson, the participants acted as kindergarteners and used PowerPoint to learning about the life cycle of a pumpkin. They were presented with a PowerPoint file with pictures of a pumpkin’s life cycle in the wrong order. Their task was to rearrange the slides in the correct order by dragging the slides.

I actually really enjoyed it because it kind of reminded me back when I was in elementary school cause we did something similar with butterflies with like the caterpillar and like eating and then cocoon and then butterfly, so and back in elementary school, when we were doing that lesson, we didn’t really use technology or like PowerPoint to do the assess, they didn’t assess us in like using the PowerPoint doing that, and so this taught me “Oh when I teach and if we do this lesson, then I can use PowerPoint or like to put, like assess them by doing that the way she did the pumpkin.

Digital native preservice teachers have strong beliefs about the benefit of using technology for teaching and learning. As Lei (2009) reported, “[t]hey believed that technologies can help them teach better (82.8%) and help their students learn better (79.3%).” However, they have had limited opportunities observed or experienced effective technology integration (West & Graham,
Researchers also suggest that not having sufficient knowledge and skills is one of the barriers to classroom technology integration (Ertmer, 1999; Hew & Brush, 2007). Lacking the experience and knowledge, preservice teachers don’t know how to fulfill their teaching tasks with technology. The ideas presented in the course widened the participants’ scope in thinking about technology classroom use. For example, in the interview, Jaden was aware that there were a variety of ways to use technology tools in an elementary classroom. Bailey realized that she could borrow the technology integration idea to teach a similar lesson. When the preservice teachers experienced how to use different technology tools for instruction, they were stocking their toolbox with various technology integration ideas, thus expanding their repertoire in using technology to teach.

The participants developed their understanding of technology integration from having first-hand experience in using technology for instruction. Daisy commented her experience in using assistive technology in the model lesson.

I think it was very helpful because I had like take some other classes and they talk about assistive technology but you never really see it or like get to play around with it and I think it’s beneficial because then if you do have a child in your class that needs to use it, you can kind of better, like not that you fully understand it, but you kind of had some kind of experience with it so you can better plan like lessons to help incorporate their assistive technology without having to really change like the different material that they will be learning or working on.

This group of preservice teachers would be certified to teach in both elementary education and special education. From other education courses in the program, they learned that they would
have students with special needs in their classroom. As Sammy said, “You know if you have this kind of student in your class he’s going to need this.” Although they learned about the assistive technology tools in their special education courses, they had not seen or used those tools. The model lesson activities in the technology course helped them realize what assistive technology tools were available for students with special needs, gave them hands-on experience with the assistive tools, and the experience assured them that they can incorporate the tools into their lessons.

c. The experience helped the participants see the possibility of using technology to create learner-centered activities in an elementary classroom. In the model lessons, the preservice teachers participated in a variety of technology-enhanced, learner-centered activities. In the activities, they were able to see technology can be used for not only teachers’ tools, but more importantly, students’ learning tools. For example, a number of participants mentioned the activity of a pumpkin’s life cycle. In the activity, Microsoft PowerPoint was used as a sorting tool for kindergarteners to learn about a pumpkin’s life cycle. The novel use of Microsoft PowerPoint had positive impact on them, helping them see alternative ways of using technology tools. Cindy talked about what she learned from the class.

I thought that was very helpful because I didn’t know that you could even do that in PowerPoint, like I didn’t think of anything like that. Like I said I thought of it just like the teacher presents you the lesson on the PowerPoint and I didn’t think you could use it for an actual lesson, so and I didn’t really realize that you could move all the slides around and get it in the right order and write a little story about it too so that was helpful.
Mary had similar comments,

I liked that activity not so much because it made me more comfortable with PowerPoint and Word because there already was, because we use it so often. But because we were provided with that example, so in that way you could use PowerPoint not only to make a slideshow for students, but how you could drag things and then make an activity where students can actually engaging in it through the technology. So, it was interesting.

As mentioned above, this group of preservice teachers had limited opportunities to observe or experience effective classroom technology use when they were K-12 students. As a result, they may not realize teachers can use technology to engage students in productive and meaningful learning, such as knowledge construction, conversation, articulation, collaboration, and reflection (Jonassen, 1995). Research suggests that lack of knowledge about “ways to integrate technology into learner-centered instruction” (An & Reigeluth, 2011, p. 59) is one of the barriers to creating technology-enhanced, learner-centered classrooms. The model lessons in this course gave the participants opportunities to observe how to create active learning tasks with technology. After having the PowerPoint model lesson, both Cindy and Mary realized that PowerPoint was more than teachers’ presentation tool. It can be used to engage students in active learning activities. They also observed how their instructors connected PowerPoint with the learning task at hand and repurposed PowerPoint to make it a sorting tool for students. According to Zhao (2003), many technology tools are not designed as learning tools. To use technology effectively and creatively in a classroom, teachers has to understand the instructional problem, connect the problem with a technology tool, and repurpose the tool to solve their own problems. Both Cindy and Mary felt surprised to see PowerPoint can be transferred from a presentation tool to a sorting
tool in the model lesson. The experience widened their scope in thinking the potential of using general technology tools for learning.

**LBD Step 2: Plan Design**

The planning for mini projects and that for the course project were very different. In mini projects, the preservice teachers’ task was to construct technology artifacts or develop technological solutions for instructional problems. The instructional problems were normally well-defined and the instructional solutions were clearly presented to the preservice teachers. Therefore, planning for mini projects was minimum. In the interviews, the participants mainly talked about planning for their course projects, which was to teach a fifteen-minute technology-enhanced lesson to their peers according to the subject area and grade level they were assigned. During the course, to help them plan their course projects, the instructors organized several learning activities for the teams to communicate their ideas within the team and with other project teams, and receive feedback both from other teams and the instructors. Planning for the course project, according to the participants, was “difficult at the beginning.” As Daisy said, “the hardest part was just coming up with a way to teach the material and like what material you wanted to teach.” Learning activities in the planning stage helped them went through the challenges.

a. **Planning provided the participants with a basis where they began to construct ideas for their course projects.** In the second week into the course, each course project team had been assigned a grade level and a subject area to teach. They were required to submit a statement of intent to describe how they would teach the fifteen-minute class using technology. The participants said that the writing of the statement pushed the group members to sit down
and brainstorm what they would do for their project. Megan described how her team began their discussion of project ideas.

We looked at the objectives on [the City School District] and they wanted to know like content of a story like how to recall the content, predict what was going to happen next and like just like their own invention. So we were like, “Okay so we will read them a story, we can ask them during the story like what is going to happen next, what do you think about this?” That kind of stuff. Then we debated for a little while about what story we should do and then they both, Brandy and Peggy both like, “The Caterpillar Story,” and I’m like, “Oh okay perfect.” And it’s good because it had numbers in there too and uhm, we could ask them what they think was going to happen next and they were learning also about how caterpillars become butterflies so it had a lot of things going for it.

In the above quote, Megan described how her group used the city school district’s standards and gradually figured out what to teach and how to teach it, which was a key step in their project. After defining what and how to teach the lesson, they were able to identify the technology appropriate for their lesson in later discussion. Megan’s group followed their instructors modeling and used curriculum standards to define lesson objectives and develop a tentative plan to achieve the objectives. Planning provided them with the opportunity to tackle the instructional problem at hand and brainstorm solutions to solve the problem. Many participants mentioned that they each presented their ideas in the team and “bounced off each other’s ideas” till they found an idea that they all liked. The collaboration can help them construct the initial project
ideas, as well as foster “the development of critical thinking through discussion, clarification of ideas, and evaluation of others’ ideas” (Gokhale, 1995).

b. Communication with other project teams informed their own planning. During the planning stage, the participants had an opportunity to interview other teams about how they would use technology to teach the lesson. Mary described what she learned from the interview activity.

I think you learn from that activity by hearing different ideas, on how you could integrate technology, because you just have one or three people, you have three people’s ideas. And everyone has very different things. So, it’s interesting to see how people had totally different approach to it that you would have never thought if you haven’t talked to them. So, I guess, yes, you could learn in that way.

In the interview, Mary described that they learned other people’s point of views, what technology other teams would use and how they would use it. In a way, as Dani put it, the interview was like to “collaborate with the whole.” Collaborating with the whole class informed the participants’ project planning. On one hand, the communication helped each participant clarify their team’s ideas through presenting their ideas to other teams. On the other hand, the participants had the opportunity to evaluate different project ideas. For example, Callie commented, “I think one group did a lot more than I would have done in fifteen minutes, I think they did like a frog and a flower and I thought maybe for fifteen minutes for fourth graders that was a lot.” Callie was aware of the time constraint, which was an influencing factor for planning. From evaluating other team’s ideas, her team learned to narrow down their own topic for a fifteen-minute lesson.
c. **Continuous scaffolding and feedback can help the participants tackle the complexity in planning a technology-enhanced lesson.** The planning of the course project occurred early in the course. At the time when the participants were required to turn in the statement of intent, they had only experienced how to use Internet resources and Microsoft Word and PowerPoint. As Beth said, “...it was like two weeks into the class so we hadn’t really gotten into all of the technology yet, so, basically we just wrote something very general...” With the limited experience, it was difficult for them to debate which tools would work best for their lesson. Some participants noticed that many teams proposed to use similar technology tools, such as Microsoft PowerPoint and Internet resources, which were introduced to them in the first two weeks. Besides having limited technology use experience, lacking the insight to understand what factors would influence their teaching may restrict their scope in planning a technology lesson (Greenhow, Dexter, & Hughes, 2008). As a result, some teams mentioned that they had to make major revision to their original plan as they began to construct artifacts for the lesson. In this six-week one credit course, the learners had to start planning their final projects early. However, it may be helpful for the instructors to revisit their original plans and continue to give feedback as they had experience with more technology tools and were more aware of the complexity in planning a technology-enhanced lesson. For example, Amy suggested whole class discussion would be helpful for their planning.

I feel like a large class discussion would be more beneficial, ya’know? “Oh, we were thinking about doing lifecycles, we were thinking about using PowerPoint, does anyone have any other ideas of how we can enhance learning besides using PowerPoint?” I think like a large group discussion would have been more beneficial because you only got to meet with three or four other people, one from each group, and, ya’know, you
could be missing out on someone who would have been like “Oh, like, this idea would be awesome for this lesson!” So I feel like a group lesson, a group brainstorm, would have been more beneficial.

Although other participants felt they learned from interviewing other teams, Amy thought she might benefit more from a whole group discussion. She thought their team could have received more critical suggestions instead of merely knowing what other teams would do for their projects. By having this type of whole-class discussions, the instructors and the preservice teachers can work together to discuss what technology tools work for their specific instructional contexts and the reasons. In this way, the instructors can continue to address the questions the preservice teachers have in the planning, while the preservice teachers can continue to receive feedback from both their peers and instructors.

**LBD Step 3: Design and Construct**

In the mini projects, the preservice teachers constructed technological artifacts or developed technological solutions to an instructional problem. They usually completed their mini projects in-class with instant support from their peers or the instructors. In course projects, they designed and developed instructional materials, such as PowerPoint slides or worksheets they would use to teach the fifteen-minute lesson. They had to construct the materials outside of class independently with minimum support from peers or the instructors. In the interviews, the participants discussed extensively the tension they experienced from using technology tools, factors which would influence classroom technology use and the benefits of using technology for teaching.

a. **Constructing technological artifacts helped the participants further develop their technological knowledge.** Although the digital native preservice teachers were familiar with the
general technology tools introduced in this course, making technological artifacts made them realized that many features of those tools were novel to them. For example, in one class, the participants were asked to use Microsoft Word to create worksheets for a learning activity. Sammy said that using some features in Microsoft Word, such as inserting textboxes and symbols, were challenging for her.

…the only difficulties maybe I had, are using parts of word that I have never used before, just things like inserting textboxes and inserting things to make the symbols that we’re just used to seeing on worksheets kind of come true on the computer. And I think my biggest difficulty if anything, was trying to aim the textbox and this and that to get them where they could actually type on the lines. I think that was definitely challenging just cause it’s something I had never had to do before, but the more I practice with it, the more I’ll probably be fine.

Ella gave another good example about how they learned new features in Microsoft PowerPoint while they were making a PowerPoint slide for their fourth-grade math lesson about fraction. They planned to make a pie chart and asked their students to explore the chart and identify appropriate fraction in the chart.

**Ella:** Oh uhm, we were just thinking about it. We were like, “We don’t want to lecture kids, like it’s fourth grade, you know.” We don’t want to be like, “This is fractions, you know.” Like we wanted to be like they were communicating with us so we were just thinking of different ways to do it. So we were like, “Okay we’ll just type things in,” and like we were just, it just all came together well cause we were thinking like together I guess. I had a great partner.
Interviewer: It’s very interesting that you can actually double click on the pie and pull it out.

Ella: Yeh, we didn’t…..what happened was we were trying to look for things and we were giving up. We were like, “We can’t find a pie.” And then I was like, “Okay we’ll think.” So we were playing around with the Powerpoint and we found a pie that you could double click and it was fun.

Interviewer: Where did you find it?

Ella: We found it under uhm, you go to like insert graphs or something and then there’s these different graphs and you have to do the 3-D pie. It was a lot of fun.

Interviewer: Nice, so you found it by accident.

Ella: Yeh we did, we were just clicking on random things and we’re like, “It works.”

Not having sufficient technological knowledge is one of the first-order barriers in technology integration (Ertmer, 1999). Although the digital native preservice teachers were proficient in using the general technology tools, such as Microsoft office (Lei, 2009), their technology knowledge may not always be sufficient when they used the tools for teaching. The above quotes were good examples to show potential difficulties in using technology to develop instructional materials due to lack of sufficient technology knowledge. In Sammy’s case, she felt inserting textboxes and symbols was challenging because she had never used the features before. In Ella’s case, she and her teammate, Daisy, didn’t know the feature was available in PowerPoint. They almost gave up before accidentally found what was appropriate for their lesson. As Daisy said, “it was just luck actually” for them to find the appropriate feature to use for their lesson. Using technology to make instructional materials thus helped the participants further develop their general technology knowledge, which turned out to be not sufficient.
When they were dealing with technology difficulties, instant help from their peers and instructors and continuous practices were important. When Sammy was asked how she figured out how to insert textboxes and symbols, she said, “I asked a couple of questions and with some teacher help, and then after doing it once or twice with her, I was able to kind of then be able to do it on my own and got used to it and now I could probably do it again.” Sammy could have felt frustrated if she couldn’t figure out how to insert textboxes and symbols on a worksheet. Having the instant support in class solved Sammy’s technical problems, which can enable her to focus on the pedagogical aspect of technology use.

b. **The construction of instructional materials helped the participants develop awareness of the complexity in technology integration for teaching.** When the participants constructed technological artifacts, they had to consider the pedagogical constraints, such as their students’ developmental level. For example, Megan’s group planned to teach first graders *The Very Hungry Caterpillar* in their lesson. They created a Microsoft PowerPoint file to assess whether their students can retell the story. However, when her group began to make the PowerPoint file, they realized that most of their students, first graders, couldn’t read. They had to make a PowerPoint that was appropriate for first graders’ reading level. Megan said,

> But when it actually came to creating our project, that’s when we were like, “Okay now what do we do?” Because again first graders probably all can’t read, maybe like one or two of them can read, so we had a hard time thinking about what we could do…we decided we would need instead of just words we should have the pictures too to help them pick their answers, that’s what we did. We had the sentence and the blank and then different options with the pictures underneath so they could know even if they couldn’t read the word what they would be filling the blank in with...
In the planning stage, Megan and her teammates had considered that their students were first graders, most of whom could not read. However, when they actually began to make the instructional materials, they directly encounter the problem, which pushed them to think deeper about strategies to address it. Many factors would influence a teacher’s decision in technology integration. Preservice teachers have a less comprehensive picture of those influencing factors, compared to in-service teachers (Greenhow, Dexter, & Hughes, 2008). The construction of instructional materials helped the participants develop more awareness of these influencing factors and think about strategies to manage them.

In mini projects, the participants developed awareness of the similar tension. In one mini project, the participants used an instrument to assess a website for use in teaching and learning. Jaden discussed how she realized that a website wasn’t suitable for her targeted students in the project despite seemingly attractive features.

I thought that that was actually cool because I never thought about because I never thought of like technology in this way, I never thought about how a website needs to be really easy for students to maneuver and at first, when I got to the website, I thought it was a great website but then after going through the stuff, I was like “Oh a third grader would not really be able to navigate through this well.” It kind of shows how much time you have to like really think and put into it for each grade level.

Mary had similar comments on this website evaluation mini project.

…it points out things you should be looking for when you were taking a website to students. Is that something that is organized, is that something that can block them from
seeing different things, how much control do I have, how much control do they have, and what are they truly learning? Because there are plenty of websites are there for kids, but not all of them are necessarily appropriate to your lesson or your classroom.

Using the website evaluation tool helped both Jaden and Mary recognized the factors they should consider when selecting Internet resources for students. Mary were able to consider a wider range of elements besides student factors. According to Mishra and Koehler (2006), technological pedagogical knowledge includes “knowledge of the existence, components, and capabilities of various technologies as they are used in teaching and learning settings” (p. 1028). In the above quotes, the preservice teachers were able to consider the pedagogical value of technology tools and resources according to specific instructional contexts. This may be an indicator that they began to develop the awareness of technological pedagogical knowledge from making technological artifacts.

**LBD Step 4: Test**

In this course, the participants tested their projects in two ways. In mini projects, the participants pilot-tested their artifacts by reviewing each other’s work from both a student’s and teacher’s standpoint. For the final project, the participants formally taught the lesson they designed to their peers and received feedback both from their classmates and the instructors. In the lesson, the participants’ peers acted as the target learners, i.e., elementary students. Both ways of testing contributed to their understanding of teaching with technology.

a. **Testing helped the participants enrich their understanding of student learning.** In mini projects, although the participants cannot test their technological artifacts on their target students, they informally tested their products by reviewing the artifacts from both a teacher’s and a student’s perspective. Some of them reported that they “guessed” what their students may
know. The guess pushed them to consider what their students would respond to the instructional product. In one lesson, the preservice teachers used Microsoft Word to make a worksheet and then wrote instructions for their students to use the worksheet. Tessa described how she and her teammate made sure the instructions were clear enough for their target students.

Me and my partner kind of did it together and I said, “You know, does this seem appropriate,” and she said, “Yeh.” I think there was a few lines that we ended up breaking up into two parts so we just kind of took a guess and you know thought, if I was this age, would I understand? Cause you know, I’m thinking like a nineteen year old, not an eight, ten year old so that was probably the only thing that was difficult, but then we just kind of, we helped each other by checking and saying like, “Oh this is.” And I think we actually went through the directions and made sure it was a little bit easier.

In the course project, the participants got feedback from their peers, who acted as their target students. From their feedback, they learned about their students’ thoughts. For example, Bailey talked about what she learned from her peers’ feedback,

I actually like that because they are kind of like our students in a way and so it gives us to know what we can improve on later on and what they enjoyed and so if something that the students enjoyed, then it’s something you can keep doing because that gets them interactive and that gives attention to the lessons.

Compared with expert teachers, novice teachers are less incline to adapt their teaching to students’ learning needs (Westerman, 1991). Having the opportunities to test their projects, no
matter formally or informally, both Tessa and Bailey were able to consider their students’ learning more deeply. Although Tessa and her teammate felt challenging to guess what their students might know, they overcame their difficulties by constantly asking themselves questions and reviewing the directions carefully. Being able to teach their lesson formally, Bailey received richer feedback from “her students.” Although the feedback wasn’t from “real” elementary students, it gave Bailey a sense of student learning process and outcomes.

b. **The participants were more aware of classroom management issues after they taught their lesson.** After they actually taught the lesson, they had the first-hand experience of dealing with classroom management issues, especially time management. For instance, a few participants talked about how they misjudged the time needed to teach the fifteen-minute lesson. Amy’s group taught a fourth-grade science class about life cycles. They chose to teach both the life cycles of frogs and the life cycles of sunflowers. Amy said they completely misjudged the time needed to teach both a plant life cycle and an animal life cycle. They should have taught one life cycle instead of two.

   We did a practice run-through the day before, making sure it worked, the one thing I wish we would have done is actually stated everything because we, um, completely misjudged the amount of talking. I ended up talking a lot more than we expected, we just were really bad at judging the amount of time that it would take to explain the different things…we ended up going like five minutes over, so, ya’know, just managing our time, didn’t go as planned just cause, I guess, we, ourselves, weren’t keeping a stopwatch, but I guess all the other students noticed, but we, ya’know, when you’re up there teaching you don’t realize how quick the time is going.
While Amy’s team underestimated the time needed to teach the lesson, Beth’s team overestimated their time. She said, “…we were nervous that we weren’t gonna have enough time, so we wound up having, um, too much time in the end that we didn’t use.” In the course project planning stage, the participants had realized controlling the lesson in fifteen minutes was challenging. However, the awareness did not help them plan properly. This happened probably because they lacked real classroom experience. This group of participants were in their first or second year of teacher training and few of them had real classroom teaching experience. Not having the experience presented challenges to them when they made decisions in planning. As Koehler and Mishra (2005) put it, “Design is not something that can be taught by lectures and demonstrations. Design is a process that is best learned by experiencing it.” (p. 98) The participants had to experience and test their design of a lesson in the field before getting a sense of whether their design worked or not.

c. **Constructive feedback after the test was important to help the preservice teachers grow.** After teaching the lesson, the participants received feedback from both their peers and their instructors. They said constructive feedback with details was more helpful compared to general feedback without details. For example, Mary said,

…they circle the lower scores, I think there was one or two zeros. I thought that would have been more appropriate if they have provided reasons for that on the back, but theirs seems very vague and kind of unsure. So I didn’t know how to fix whatever they wanted we to fix, what really they were talking about. So, I didn’t think that was helpful, it was just kind like well you didn’t do this. Okay, what exactly were you talking about there? And if they answered this question a little bit clearer, then, I think it would have been a lot more helpful. But sometimes people who provided positive
scores and feedback on the back, provided great constructive criticism, so I think it was like the back of the worksheet where they can say like what was good and what could have been better. That was the most helpful parts of that.

After the presentation, Mary’s group received two types of feedback for their teaching of the lesson. The first type was general feedback, giving merely a score without having details about what worked and what didn’t, and how to improve it. The second type was constructive, telling Mary and her teammate what was good about their lesson and what could have been done better. The constructive feedback, according to Mary was much more helpful. The Learning By Design process is iterative (Koehler & Mishra, 2005). “[T]o design is to redesign. That is, design is an iterative process continually cycling back to first principles and re-thinking decisions.” (Koehler & Mishra, 2005, p.98) Or as Amy put it, “[T]eaching is all about trial and error.” The constructive feedback enabled the preservice teachers to review their initial instructional decisions and make changes accordingly. Such experience would serve as a reference to them when they solve similar or more complex problems in their future classrooms.

**LBD Step 5: Analyze and Explain**

At this stage, the participants wrote reflection journals to articulate their learning in the course and connect their in-class learning experiences with their future teaching career. In the interviews, participants described that writing reflection journals helped them remember their learning and become more confident in teaching with technology. As they wrote more about their learning, their reflection became more reflective and in-depth.

a. **Reflection helped the preservice teachers describe and elaborate on what they learned in the course.**
In the reflection, the participants “summed up what exactly I learned.” More specifically, as Rachel said, they “summarized what the activity was,” expressed whether they “thought it was good or not,” and “talked about how I thought I could use it or what I thought the students would be taking away from using that piece of technology.” Although many of the participants merely repeated and described the in-class activities, repeating and describing their experiences in writing seemed to help them “stick” what was taught in their mind. Beth described this aspect in greater details.

I think the reflection was good because it was due the next day and everything was like fresh in your mind and you can get like a real statement out of it…um…I always wrote kind of a lengthy thing just so I could remember what we did, so that was good so now I have those, if I ever needed to like create a portfolio or something, go back and see what I had learned.

As Beth said, writing reflection was similar to keeping a record of what she did in class. By doing so, her in-class learning experiences were made explicit, which may have remained tacit until being reflected on. When Beth described how the instructional events unfolded in a classroom, she can deepen her understanding about teaching with technology (Sparks-Langer & Colton, 1991). The elaboration of their in-class learning experiences also may contribute to more successful transfer in their future application of the knowledge (Kolodner, 1997).

b. Reflection helped the participants develop more confidence by having constant conversations with themselves and personalizing their learning experiences. In the reflection, the participants were pushed to think about how to transfer what they learned into their future
classrooms. The preservice teachers said that it was good that the reflection drove them to start to think about what they would do in their own classroom. Bailey said,

…when I actually starting writing it I start to think “Oh I can use this, this way in my future classroom, or I could use this or I didn’t really like this, how I can change that so that it will be useful in the classroom…” so it got me really thinking like I can like integrate technology.

While Bailey started to reflect on how she would use the newly learned technology tools in her future classrooms, she seemed to be more confident in using technology to teach. Scholars have found that writing reflection journals helps preservice teachers gain more confidence in teaching (e.g., Hayden, 2010; Lee, O. 2010). The preservice teachers developed more confidence through reflection probably by having constant conversations with themselves and personalized their learning experiences. For example, Callie said,

I think it was good to look at the technology I use and see like, “Can I use this in my classroom?” “Would I want to?” “How would parents react to this?” Well then I thought about that and I thought, “How would my parents react?” That’s how I’ve grown up, you know. It’s good to make it a personal situation…

In the interviews, a few preservice teachers mentioned that they asked themselves a series of questions when writing the reflection. By having the constant conversation with themselves during reflection, they were able to dissect the complexity of teaching with technology. In Callie’s case, she thought about how parents would react to technology use in her classroom. This indicated that she began to consider boarder factors affecting classroom technology use. She
also tried to personalize what she learned by fitting the instructional events into her own contexts, through which she took ownership of her journals and developed her personal knowledge about teaching with technology (Spalding, & Wilson, 2002).

c. **Reflection helped the preservice teachers be more reflective and open-minded in teaching with technology.** The preservice teachers’ reflection was more and more reflective and in-depth as the course went on. Frank said,

I definitely noticed as the weeks went on the much more reflections I actually like. When I first started writing reflections, I just said like this is what we did in class, this is the technology we used. But towards the end of the semester, toward the end of the course, I was actually writing about what we did in class and reflecting on it and what is actually good about the technology, so I was being more elaborate on the class and my reflections were just a lot more better, a lot more accurate.

Grace also said,

…for the first time I was like, “Oh yeh, I liked that we did this, it will be helpful doing this.” But then by the last one, I was like writing a lot more and I was like, “Oh yeh I could use it for this, I can do this, like maybe this could be used for this subject,” so it was good that I was like, I was kind of like opening my mind to it not just thinking technology is just like internet you can use it to research things, there was so much more to it than that and I like would begin to write about that…

In the above quotes, both Frank and Grace described how they grew in their thoughts through writing the reflection journals. Frank was more elaborate and reflective towards the end of the
semester. Grace was more open-minded, thinking boarder and considering more possibility in using technology to teach. Their growth in reflective thoughts seems to be consistent with the developmental process of becoming a reflective teacher as described by Hatton and Smith (1995). To understand how preservice teachers articulate, analyze, and make sense of their experience, Hatton and Smith (1995) identified three types of reflection in a developmental sequence: technical rationality, reflection-on-action, and reflection-in-action. According to Hatton and Smith, technical rationality is description of events that happen and is not reflective in essence. Reflection-on-action consists of three stages: descriptive, dialogic, and critical reflection. In descriptive reflection, preservice teachers enact reasoning often based on personal judgment or on literature; in dialogic reflection, preservice teachers explore rationale for their choices by having a discourse with themselves; in critical reflection, preservice teachers survey the broader contexts, historical, social, and/or political to explain reasons for their decisions or actions. Reflection-in-action is the desired end-point of reflection in the developmental sequence. It requires teachers to consciously think about their teaching while it is happening. In this study, although the participants started from technical rationality and enacted mostly descriptive reflection, going through these stages in reflection was necessary to prepare neophytes to enter the professional context (Hatton, & Smith, 1995).

Conclusions

This study evaluated whether a LBD environment was effective in helping a group of preservice teachers develop TPACK and described how the preservice teachers perceived the effectiveness of LBD. The results showed that preservice teachers’ TPACK, PK, PCK, TCK, and TPK increased significantly after learning technology integration in an LBD environment. The
participants generally agreed that LBD was helpful for them to learning about teaching with technology. They felt more comfortable with and confident in using in their teaching.

The interviews with the participants showed that they had developed an awareness of the complexity in technology integration for instruction, which can be viewed as evidence of their TPACK development. This finding was generally consistent with the participants’ self-assessment of their TPACK development. The participants were more aware of the influencing factors when making technology integration decisions. Their understanding of student learning was enriched. They were more aware of classroom management issues after teaching the technology-enhanced lesson. Although it is hard to isolate their knowledge development into different TPACK components from the interviews, these are probably evidence of their development of overall TPACK. Furthermore, if we see the essence of TPACK lies in the complex and dynamic interplay of content, pedagogy, and technology, their awareness of the complexity in technology integration can be viewed as a piece of evidence to support their development in TPACK.

Although the participants did not perceived their technology knowledge grow, the interview showed that they extended their existing technology knowledge in the course. In the course, the participants learned what technology tools and resources were available to them in an elementary classroom and developed more knowledge about how to use them. They also acquired more knowledge of the features in the technology tools that they had been familiar with. These can be viewed as evidence of their technology knowledge. Despite of the evidence, they did not perceive their technology knowledge increased as a result of taking this course. This discrepancy was probably due to the fact that they thought they were familiar with most of the technology tools taught in the course. Johnson (2012) used the same survey to measure the
TPACK development of another group of preservice teachers after they took a more advanced level course in this series of three technology integration courses. The participants did not perceive their technology knowledge increased as a result of taking the course, either. However, when measured with other instruments, the participants’ technology knowledge had significant increase. Therefore, another possible explanation for the discrepancy could be the TPACK survey used in this study was not sensitive enough to detect the change in technology knowledge. However, further evidence should be collected to prove this supposition.

_The preservice teachers did not perceive their content knowledge grow as a result of taking the course, which may indicate a challenge to teacher educators about how to enhance preservice teachers’ content knowledge in a technology integration course._ The preservice teachers did not perceive their content knowledge grow as a result of taking the course. This finding was not surprising because content knowledge was not taught directly to the participants. Instead, content knowledge was taught in the contexts of instructional events. However, this presents challenges to teacher educators that how the C component of TPACK should be taught in technology integration courses. Can collaboration between instructors of technology integration courses and content knowledge course solve this problem? Or can simply pointing out the content elements in technology courses enhance preservice teachers’ awareness of the content aspects? Or should technology teachers invest more time in developing preservice teachers’ content knowledge? These can be future directions for researchers to explore.
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Chapter 3
Using Live Dual Modeling to Help Preservice Teachers Develop TPACK

Abstract
Preservice teachers’ lack of teaching experience presents challenges to them when they use technology to solve instructional problems in authentic settings. Modeling is a viable way to compensate for preservice teachers’ lack of teaching experience and help them learn about teaching with technology, more specifically, technological pedagogical content knowledge (TPACK). In this study, to help preservice teachers develop TPACK, a Live Dual Modeling strategy, which involved both live behavior modeling and cognitive modeling, was designed and implemented. The researcher investigated whether the Live Dual Modeling strategy was effective in helping preservice teachers develop TPACK in a technology integration course and what conditions influenced the use of this strategy. The findings showed that the preservice teachers demonstrated the initial ability to transfer what they learned in the modeling to real-world classroom teaching. When Live Dual Modeling is used, attention should be paid to the conditions that influence the effectiveness of the strategy due to preservice teachers’ limitations in their overall knowledge base, practical experience, and ability to transfer learning to other contexts.

Keywords: preservice teacher technology preparation, TPACK, Live Dual Modeling
Introduction

With technologies being integrated into schools in the last few decades, teachers are expected to grasp the knowledge and skills to use technology effectively for teaching. However, researchers continue to find that teachers feel inadequately prepared in using technology for instructional purposes (e.g., Hew & Brush, 2007; National Education Association [NEA], 2008). Many teacher educators have been exploring effective strategies to prepare technologically competent teachers (e.g., Basham, Palla, & Pianfetti, 2005; Fulton, Glenn, & Valdez, 2003; Groth, Dunlap, & Kidd, 2007; Pope, Hare, & Howard, 2005; Smith, 2001). In recent years, Mishra and Koehler (2006) introduced a technological pedagogical content knowledge (TPACK) framework to identify the essential knowledge that helps a teacher use technology effectively for instruction. At the center of the TPACK framework is the complex and dynamic relationships among content, pedagogy, and technology. With increasing interest in the framework, scholars have proposed many instructional strategies to help preservice teachers develop TPACK (e.g., Jaipal & Figg, 2010; Jang & Chen, 2010).

Many current instructional strategies to develop TPACK have at least one component that involves preservice teachers using technology to practice teaching in real-world setting (e.g., Koh & Divaharan, 2011; Niess, 2005). However, the ability for a teacher to solve authentic instructional problems is mediated by their prior knowledge and experience (Hughes, 2005). Therefore, when these strategies are used for preservice teachers, attention must be paid to the limitations in their prior knowledge and experience.

The first limitation is that preservice teachers have little to no real-world teaching experience in their initial stage of training. The level of teaching experience is often found to be a crucial factor influencing a teacher’s classroom practices (Lederman, 1999). Student teachers
are often frustrated and stressed with the complex nature of classroom teaching (Bolton, 1997). When making instructional decisions, novice teachers pay less attention to classroom constraints and are less likely to base their teaching on a comprehensive view of the classroom compared to expert teachers (Westerman, 1991). Similarly, when making technology integration decisions, preservice teachers consider a narrower range of school- and classroom-level factors in contrast to in-service teachers (Greenhow, Dexter, & Hughes, 2008). For example, in Greenhow, Dexter and Hughes’s study (2008), when asked to use technology to solve complex instructional problems, the preservice teacher participants primary focused on classroom-level factors, such as “student demographics, student performance data, instructional sequence, and content area standards” (p. 21). Compared with their counterparts, the in-service teacher participants were able to consider not only classroom-level factors, but also school-level factors, such as “technology support staff, technology plan and budget, and family involvement” (p. 21). Therefore, preservice teachers’ lack of teaching experience presents challenges to them when they use technology to solve instructional problems in authentic settings.

The second limitation is that preservice teachers also have limited opportunities to observe effective technology use models in K-12 schools (West & Graham, 2007). According to a report by the National Education Association (2008), although technology is used regularly in school for administrative tasks, substantially less technology use is related to instructional tasks. When technology is used for instruction-related activities, instead of integrating it into the curriculum, many teachers use technology to assist teaching in a supplemental way, such as production of lesson materials and preparation for content (Graham, Tripp, & Wentworth, 2007). Even “tech-savvy” teachers do not use technology as a teaching or learning tool on a consistent basis (Bauer & Kenton, 2005). Teachers’ modeling in their school years has a strong influence
on preservice teachers’ attitudes on teaching (Virta, 2002). Lacking the experience of seeing effective technology integration in classroom, preservice teachers may perceive their K-12 teachers’ supplemental use of technology as the norm, but fail to realize the most productive and meaningful use of technology engages students in knowledge construction, conversation, articulation, collaboration, and reflection (Jonassen, 1995).

To compensate for preservice teachers’ lack of empirical teaching experience, especially experience of teaching with technology, scholars recommend that teacher educators model effective use of technology in classroom (Faison, 1996). Modeling is a strategy found to be effective when implemented in preservice teacher technology programs (e.g., Brush & Saye, 2009). West and Graham (2007) designed a live modeling strategy and implemented it at Brigham Young University. In their version of the live modeling, instructors demonstrated live examples of effective technology use for teaching, while preservice teachers acted as K-12 students in the demonstration. The live modeling strategy was perceived by most preservice teachers as effective.

However, the live modeling strategy in current literature (Brush, et al., 2003; Doering, Hughes, & Huffman, 2003; West & Graham, 2007) includes only behavior modeling, but does not have a cognitive modeling component. Cognitive modeling, a strategy to make the covert mental process perceivable, has been used to help preservice teachers to understand complex problem solving in teaching and learning (e.g., Gorrell & Capron, 1989, 1990). Cognitive modeling can be a critical component to preservice teachers’ technology preparation. Effective teaching with technology requires teachers to have a sound understanding of the complex and dynamic relationship among content, pedagogy, and technology. Teachers make many instructional decisions both in preparation and during teaching according to their understanding
of such relationship. Understanding the relationship and making instructional decisions accordingly is a covert process. When preservice teachers are showed how to integrate technology into teaching, it is also important to demonstrate the decision making process behind the “how tos.”

According to Koehler and Mishra's suggestion on how to teach TPACK (Koehler & Mishra, 2005a, 2005b), teachers should learn about teaching with technology by designing technological artifacts to solve instructional problems. To help preservice teachers develop TPACK in a learner-centered, project-based learning environment, a Live Dual Modeling (LDM) strategy, which involves both live behavior modeling and cognitive modeling, was proposed. In this study, LDM was designed as an integral component in a Learning By Design (LBD) environment (Lu, Johnson, Tolley, Gillard-Cook, & Lei, 2011) and implemented in a technology integration course for preservice teachers. This paper investigated whether LDM was effective in helping preservice teachers learn how to teach with technology and discussed the conditions that influenced the effectiveness of LDM.

**Why Live Dual Modeling?**

Teaching involves intensive human interactions. When learning how to teach, preservice teachers can learn from models. “[H]uman minds develop in social situations” (Lave & Wenger, 1991, p.11). Based on the belief that previous learning theories neglected social factors and could not satisfactorily explain human social learning behaviors, Bandura (1977) proposed the social learning theory to explain human learning. Bandura’s theory argues that people learn from observing others’ behaviors. In the acquisition of social behaviors, imitation of models is “an indispensable aspect of learning” (Bandura, 1977, p.3). Therefore the provision of social models
is necessary in learning. Modeling can affect preservice teacher’s attitude and skill levels. Allinder (2001) modeled instructional strategies in an introductory course for preservice special education teachers. She found that the modeling strategy positively affected the participants’ attitudes and perceptions. In another study, Fleming, Motamedi, and May (2007) found that the more extensively their professors and practicum teachers modeled computer technology use, the more competent the preservice teachers felt in their computer skills.

Modeling, especially live modeling can provide more authentic teaching experience to preservice teachers, thus compensating for their lack of real-world teaching experience. The mode of modeling affects the rate and level of learning (Bandura & Walters, 1963). Effective technology use models can be delivered through three types of modeling: text-based, video, and live modeling (West & Graham, 2007). Compared with live modeling, text-based and video modeling present more challenges to learners due to the situated nature of knowledge. “[K]nowledge is situated, being in part a product of the activity, context and culture in which it is developed and used” (Brown, Collins, & Duguid, 1989, p. 32). Text-based modeling requires learners to exert extra cognitive load to visualize the situation described in the text (West & Graham, 2007). While video modeling may provide the visuals necessary for understanding, preservice teachers are still detached from the authenticity of the problem and their own empirical experience which can contribute to active learning (West & Graham, 2007). Nevertheless, in live modeling, a live performance can provide “substantially more relevant cues with greater clarity than are conveyed by a verbal description” (Bandura & Walters, 1963, p. 50). When teaching is being modeled in an authentic setting by a master teacher, the particulars of the teaching process are demonstrated. When being engaged as students in the demonstration, the observers not only see how the teaching process is being laid out, but also understand the
appropriate context in which a strategy or a teaching behavior is executed. When provided with live models, preservice teachers learn how to teach by being immersed in the interaction between the teacher and the students, with more contextual cues that help their understanding of teaching.

Live modeling also provides opportunities for preservice teachers to think from both a student’s and a teacher’s perspective. When Brush et al. (2003) implemented their version of live modeling for preservice teacher at Arizona State University, the preservice teachers first acted as K-12 students in the model lesson and then were required to critique whether the lesson was effective, discuss issues related to the lesson implementation, and propose possible changes to make the lesson more effective after the model lesson. In live modeling, preservice teachers’ being an active participant and their dual roles not only enable them to experience learning and observe the learning results from a K-12 student’s angle, but also push them to consider a teacher’s point of view in and after the observation.

The cognitive modeling component in the dual modeling can further help preservice teachers identify the complexity inherent in the teaching process. Teaching is an “ill-structured” profession and is further complicated by the integration of technology (Koehler & Mishra, 2009, p. 61). Reasoning and decision making are the hidden parts of the teaching process. When covert cognitive skills are heavily involved in a skill set, cognitive modeling, a strategy to make the covert mental process perceivable, is an alternative instructional strategy to use (Harmon & Evans, 1984). Teacher educators have often used cognitive modeling in their practices. Loughran (1997) used cognitive modeling to teach his student teachers to reflect on teaching. He went through with his students the process that he reflected on his teaching. He “thought aloud” (p. 23) about what he was doing, and the decisions he was making and reasons for making those decisions. He also shared his teaching journals with his students which outlined his thoughts
about teaching and learning. Gorrell and Capron (1990) found that when preservice teachers were trained to teach a child to find out the main idea of a paragraph, cognitive modeling helped them achieve higher levels of recall and application of relevant concepts compared with direct instruction. They also found (Gorrell & Capron, 1989) that cognitive modeling can influence preservice teachers’ expectation of success. A model can do cognitive modeling by verbally delineating the cognitive process. Sarason (1973) found that a model’s verbalizing the cognitive tactics to reach a solution while solving difficult problems had positive effects on students’ performance and helped students reduce their test anxiety.

Live behavior modeling coupled with cognitive modeling can be a viable way to teach preservice teachers how to teach. In the next section, the researcher will discuss why LDM was used to help preservice teachers develop knowledge about teaching with technology, i.e. TPACK.

Using Live Dual Modeling to Teach TPACK

“[T]houghtful pedagogical uses of technology require the development of a complex, situated form of knowledge,” which Mishra and Koehler (2006) called “technological pedagogical content knowledge (TPACK)” (p.1017). TPACK describes teacher knowledge for technology integration by adding knowledge about technology into the construct, pedagogical content knowledge (PCK, Shulman, 1987). The TPACK framework consists of three main bodies of knowledge, content, pedagogy, and technology. It emphasizes the complex interplay of the three components, which forms four additional types of knowledge: Pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK) (Mishra & Koehler, 2006). Because of its clear articulation of the types of teacher knowledge essential for
effective technology integration and their complex, dynamic nature, TPACK provides a guide for designing teacher technology training programs. Koehler and Mishra (2005a, 2005b) argued that, for teachers to understand and develop TPACK, teachers should be trained by designing technological artifacts to solve real-world instructional problems in a Learning By Design environment that honors the complex and dynamic relationships of the three components in TPACK. LDM situates technology use in rich teaching and learning contexts, which is consistent with the essence of a Learning By Design environment. LDM can be an effective strategy for preservice teachers to develop TPACK.

The live behavior modeling of effective technology use in K-12 classrooms provides the initial experience necessary for preservice teachers to understand what it means to integrate technology into teaching and how to teach with technology. In a Learning By Design environment, teachers are expected to solve instructional problems with technology and reason their solution. When solving a new problem, people often rely on their previous experience of solving a similar problem. They retrieve information about the previous problem and solution from their memory, interpret the new problem and find similarity between the new and old problem, adapt the old solution, and contemplate the possible effects of the new solution by scrutinizing the effects of the old solution (Kolodner, Gray, & Fasse, 2003). Expert teachers can rely on their classroom experience to solve new problem. However, even when experienced teachers use technology to solve instructional problems in a Learning By Design environment, they often encounter “contradictions and tensions” (Koehler & Mishra, 2005a, p. 97) among content, pedagogy, and technology. Preservice teachers, especially those who are in their first or second year of college training, have little or no full-time classroom teaching experience. They also have limited experience observing meaningful and productive technology use in classroom.
Besides technology, preservice teachers need help in developing both content knowledge and pedagogical knowledge (Borko, Livingston, McCaleb, & Mauro, 1988). As novice teachers still struggle to pedagogically transform and represent subject matter (Feiman-Nemser & Parker, 1990), adding one more variable, technology, into the teaching context can be challenging. For preservice teachers to wrestle with the complex nature of those instructional problems, some previous experience of technology integration is necessary. Instead of isolating technology use from content and pedagogy, the live modeling of how a teacher uses technology to tackle complex instructional problems is a viable way to compensate for their lack of experience in teaching with technology.

The cognitive component in the LDM helps preservice teachers articulate the complex relationship among content, pedagogy and technology in the TPACK development. To articulate the complex relationship in TPACK requires preservice teachers to be a “reasoner” when using technology to teach, reasoning their instructional choices and predicting the possible outcomes (Kolodner, et al., 2003, p. 502). The modeling of overt teaching behaviors doesn’t necessarily direct the observers’ attention to the complex decision making process behind the acts. The demonstration of how-tos doesn’t unfold how an effective instructor tactfully analyze the content in order to represent it using technology, how she chooses one or a few technologies to teach the content in constructive ways, and how she understands students’ prior knowledge and uses technology to develop students’ new knowledge by building on the old, etc. (Mishra & Koehler, 2006). Cognitive modeling is a way to make explicit the decision making process inherent in teaching and help preservice teachers disentangle the complexity among content, pedagogy and technology behind the instructional activities. On one hand, cognitive modeling helps preservice teachers “index” (Kolodner, et al., 2003, p. 502) their experience. To successfully retrieve
previous experience when solving new problems, a previous problem situation must be labeled “according to its applicability conditions” (Kolodner, et al., 2003, p. 502). When the master teacher verbalizes her reasoning and decision making, the preservice teachers index their experience by interpreting the instructional problem using the TPACK framework, recognizing relevant technology and instructional strategy that are suitable for the situation, and evaluating the effects of the solution according to the students’ learning results. On the other hand, cognitive modeling helps develop the problem solver’s ability to predict the results according to the proposed solution and to explain the reasons of the prediction (Kolodner, et al., 2003). In the behavior modeling, preservice teachers observe the teaching and its results. When modeling the instructional decision making process, the master teacher clarifies the causal relationship between the model teaching and its results. From the cognitive modeling, preservice teachers learn how to predict students’ learning outcomes and explain how to use technology to achieve those ends.

**Design and Implementation of LDM in a Preservice Teacher Technology Preparation Program**

In this study, to help preservice teachers develop TPACK, a modeling strategy called LDM was designed, which expanded West and Graham’s live modeling strategy (2007) by adding a cognitive modeling component (see Figure 1). It consists of three components: Preparation, behavior modeling and cognitive modeling. In preparation, instructors give preservice teachers a cognitive tool that is designed to help preservice teachers identify key TPACK elements in the modeling activities. Instructors then discuss the contents to be taught and state the desired student learning outcomes so that preservice teachers know the lesson
content and what learning outcomes to expect in the modeling activities. In the behavior modeling that follows, instructors demonstrate live examples of effective technology use in a K-12 classroom, while preservice teachers act as K-12 students in the demonstration. Following the behavior modeling, instructors conduct the cognitive modeling by verbally explaining the instructional decision making process behind the live example, while preservice teachers reflect on their observation from a teacher’s perspective.

**Figure 1. Live Dual Modeling**
Research Methods

Research Setting

This LDM strategy was implemented in a mandatory entry level technology integration course at a large university in the northeast in the spring semester of 2010. As the first in a series of three technology integration courses, this course was designed for preservice teachers who are in their initial stage of teacher training and have little practical teaching experience, especially with integrating technology into teaching. The course covered general information technologies for teaching purposes, including: Educational websites, Microsoft Word and PowerPoint, Microsoft Excel, electronic communication tools, and assistive technologies. The course consisted of six classes. Designed as a Learning By Design environment, the first five classes included four routine instructional components: Reading discussions, model lessons, mini-projects, and reflections. In the final class, the preservice teachers conducted the group course project, teaching their fellow preservice teachers a fifteen-minute lesson. The LDM strategy discussed in this paper was implemented in the model lesson section in the first five classes. In other class components, the instructors also demonstrated effective pedagogical strategies, such as classroom management strategies, through both behavior and cognitive modeling.

To conduct LDM in a model lesson, a worksheet was provided prior to the model lesson in order to help preservice teachers identify the audience, technology, content, and pedagogy involved in the lesson. To draw preservice teachers’ attention to the contents, the instructors started by first showing and discussing the state standards that the lesson addresses. They then clearly stated the desired student learning outcomes so that preservice teachers knew what to expect. During the model lesson, the instructors modeled appropriate pedagogical practices that integrated a chosen technology to teach the lesson. Preservice teachers took on the role of the
targeted students in the lesson. After the lesson, the instructors verbally reflected on their own practices, instructional decisions and reasoning in order to help the preservice teachers understand the technological pedagogical content considerations of implementing such a lesson with K-12 students. After the model lesson, preservice teachers were given time to reflect on the activities from a teacher’s perspective by filling out the worksheet or discussing with their classmates.

“[I]nability of faculty to provide meaningful and effective technology examples” and “preservice teachers not being given the opportunity to construct their own technology-based lessons” (Kay 2006, p. 389) were found to be two disadvantages of modeling. To overcome the identified disadvantages, in the modeling section, technology integration examples used in modeling had been implemented in elementary schools and proved to be effective. In these examples, technologies were used as learning tools to engage students in knowledge construction, conversation, articulation, collaboration and reflection (Jonassen, 1995). After the modeling, students were required to construct technological artifacts or design technological solutions as their class project. Students also conducted a group course project, which required them to teach their fellow preservice teachers a fifteen-minute lesson in class while their fellows acted as K-12 students. In the projects, they were required to use the accumulated skills from previous classes, including what they had learned in the LDM; analyze the instructional problems; identify useful technology resources; select appropriate instructional strategies; and use technology effectively to enhance learning.

To explore whether LDM was effective in helping the preservice teachers learn how to teach with technology, the following two questions were investigated:
1. Can the preservice teachers transfer what they learned in the LDM to their own teaching projects?

2. What were the conditions that influenced the effectiveness of LDM?

**Data Collection**

Thirty-nine preservice teachers, who enrolled in three sections of the technology integration course in spring 2010, participated in this study. A majority of them (92%) were female and were enrolled in teacher education programs as freshmen (82%) or sophomores (18%). Most of them had little to no teaching experience.

The data sources include observation on the participants’ in-class implementation of their final project, the project reports, and student interviews. The researcher observed the implementation of all group projects and made detailed field notes. Twelve reports yielded by the project groups were collected. In the reports, preservice teachers recapped the analysis, design, development, implementation and evaluation of their projects. In the interview, the researcher first helped the preservice teachers review the model lesson activities and then asked whether the model lessons were helpful for them to understand teaching with technology and the reasons behind their thoughts. The interview was conducted on all participants individually. Most interviews lasted 20-35 minutes, with five interviews that were longer than 35 minutes and seven interviews that were fewer than 20 minutes. All interviews were recorded but one recording file was corrupted due to technical problems. The analyses of the interviews were based on the 38 successfully recorded ones.

**Data Analysis**

NVivo 8 was used to conduct the qualitative analysis. From the observation field notes and the project reports, the researcher identified strategies and pedagogical practices in the
course projects that had been modeled in the LDM. From the interview, using constant comparative method, the researcher identified themes about what the preservice teachers learned from the LDM strategy and the issues associated with the use of this modeling strategy in the technology integration course.

TPACK offers an analytical lens for the researcher to understand teachers' practices in teaching with technology. The researcher reviewed their experience from three major angles, i.e., the three main components of TPACK: Content, pedagogy, and technology. Although the researcher did not precisely isolate the preservice teachers’ experiences by fitting them into the seven TPACK components, the researcher were able to discern some themes on how they process content knowledge to be taught, what teaching strategies they used, and what technologies they used to teach and how they used them. Results of the analyses will be presented in the following section.

**Results and Discussion**

This section described what this group of preservice teachers learned about teaching with technology from the LDM strategy. In general, the preservice teachers were able to imitate the pedagogical strategies and technology integration examples in the LDM. When using technology to teach their fellow preservice teachers a fifteen-minute lesson, the preservice teachers were able to imitate the pedagogical strategies and the technology integration examples in the model lessons. Although their imitation of the models was superficial and rigid, the preservice teachers were more aware of the key factors, i.e., content, pedagogy, and technology, which would influence the decision making in a classroom regarding technology use. Using the TPACK framework, the researcher identified themes about how the LDM influenced preservice teachers’
Learning from the LDM, the preservice teachers began to bridge their content knowledge and pedagogical knowledge. In other words, they showed the initial ability to consider content knowledge from a pedagogical perspective.

The preservice teachers were found to have difficulties in bridging their content knowledge and pedagogical knowledge in the teaching projects. Although the participants in this study did not raise issues about their content knowledge, they had difficulties in understanding what lessons were appropriate for their students’ grade level. As Sammy put it, “we didn’t really know what we were doing at first just in terms of it being too hard or too easy.” A team proposed to teach Ellis Island in their second grade social studies lesson. Their choice of topic was deemed too difficult for second graders by the instructor. The preservice teachers also had difficulty in tailoring contents to their lesson. One group originally proposed to teach ancient civilization in the fifteen-minute lesson which was too broad to teach in fifteen minutes.

To overcome the problem of choosing appropriate contents for their lessons, the participants adopted the strategy their instructors used in the LDM. They used state and local school district standards to identify the contents that were appropriate to their students’ developmental levels. In the model lessons, their instructors discussed the state standards that a lesson addressed prior to teaching. This gave an opportunity for the preservice teachers to see how expert teachers interpreted the lesson content and represented it in an age-appropriate level for their students. When beginning their projects, the participants started from recalling what they had learned in a certain grade. They used their prior knowledge of being a student to
“imagine” or “guess” what contents may be appropriate to their students’ age level. However, they relied on the state or local school district curriculum standards to help them narrow down or identify the grade-level appropriate topics. Rose said,

It was kind of hard cause we had to think back. So like, ‘Okay, what do we do in sixth grade and what kind of stuff did we learn?’ And all of us had read *Holes* that year. So we took that book and went through the standards that were set up for the City School District and one of them was vocabulary. So we actually just focused our lesson around that.

Rose’s teammate, Sammy, also commented on how they used the standards to identify students’ knowledge of the topic,

I think we looked at the standards really closely to see exactly kind of where they are supposed to be in terms of their learning and then we just kind of stacked our ideas together I guess and figured that vocabulary was an excellent place to start and that we could build off of that with games and with worksheets and other ways.

Besides modeling instructors’ use of standards, some teams chose appropriate contents for their lesson by imitating what had been taught in the model lessons. For example, one team taught the life cycles of a frog and a sunflower in a fourth grade science class. The choice of content was a direct imitation of the life cycle of a pumpkin taught in one model lesson.
Inexperienced teachers are often found to have “incomplete and superficial” level of pedagogical content knowledge (Cochran, DeRuiter, & King, 1993). Choosing appropriate content for their projects requires preservice teachers to link their content knowledge with their understanding of the learners’ abilities (Shulman, 1986). Learning from LDM, the preservice teachers began to think about content knowledge from the learners’ angle, which may indicate that the preservice teachers were developing the initial sense of pedagogical content knowledge.

2. **LDM helped preservice teachers expend their understanding in the pedagogical knowledge.**

The instructors’ modeling of using a variety of instructional strategies enriched the preservice teachers’ repertoire in instructional strategies, which was especially important because novice teachers often knew fewer instructional strategies or alternatives compared to expert teachers (Westerman, 1991). In their course projects, the participants were able to imitate many of the pedagogical strategies they observed. Table 1 shows the instructional strategies one project team imitated in a sixth grade social studies lesson about ancient Egyptian tools. The team imitated eight instructional strategies from their instructors’ modeling from posting an agenda at the beginning of the lesson to using whole class discussion to summarize the lesson.
### Instructional Strategies Learned from LDM by a Project Team

<table>
<thead>
<tr>
<th>Instructional strategies in the model lesson</th>
<th>Instructional strategies in a project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting expectations</td>
<td>Show the lesson agenda on a PowerPoint slide.</td>
</tr>
<tr>
<td>Note-taking</td>
<td>Have students research the ancient Egyptian tools on a website and take notes of the information.</td>
</tr>
<tr>
<td>Using graphic organizers</td>
<td>Ask students distinguish ancient and modern tools on a Venn Diagram.</td>
</tr>
<tr>
<td>Providing clear instructions</td>
<td>Give step by step explanation of each activity. Post activity directions on the screen.</td>
</tr>
<tr>
<td>Group collaborative learning</td>
<td>Divide students into small groups for activities.</td>
</tr>
<tr>
<td>Controlling the pace of a lesson</td>
<td>Check whether every student was on the same page before getting to the next step of an activity.</td>
</tr>
<tr>
<td>Providing immediate feedback and assistance</td>
<td>Go around the classroom to make sure the students who needed help were receiving assistance.</td>
</tr>
<tr>
<td>Whole class discussion</td>
<td>Use whole group discussion to summarize the lesson.</td>
</tr>
</tbody>
</table>

*Note: The lesson described in this table is a sixth grade social studies lesson about ancient Egyptian tools.*

In the interview, preservice teachers mentioned many instructional strategies that had been demonstrated by the instructors in the modeling, especially classroom management strategies. The organization and management of instruction are often challenging for new teachers (Lederman, 1999). When preservice teachers closely observed and reflected on the modeling from a teacher’s angle, the instructors’ purposeful use of various classroom management strategies had an impact on them. Callie said,

> I think it was kind of interesting to see how sometimes they’d give us some of the instructions at the beginning, sometimes they would give us a handout with the instructions, sometimes they would give us some and then wait for us and then give us
the next set. So I thought it was really interesting to see how many different ways you can just ask someone to do something.

The instructors’ cognitive modeling helped preservice teachers further understand why such strategies can help their students learn. In the interview, they tried to articulate what they had learned from those instructional strategies modeled in class. For example, Mary talked about why a teacher should talk to the student who sat farthest to her in a classroom,

I mean you know to speak aloud, but talking to the back of the room is a good suggestion to the person far from you, and you moving around the room, so the students have to talk louder, too. And also, keeps their attention.

3. **In their course projects, the preservice teachers were able to imitate the technology integration ideas in the modeling, especially when they found similarities between their own teaching contexts and those in the LDM.**

In their course project, preservice teachers imitated the technology use examples in the modeling. The technologies chosen by the preservice teachers in the course projects included: Microsoft Word, Microsoft PowerPoint, Kidspiration, websites, online video clips, and online games. All these technologies were previously integrated into the model lessons by the instructors. All the technology integration ideas in their projects can be traced back to the examples in the model lessons. Table 2 lists some examples of how preservice teachers used technologies in their lesson and the corresponding model lesson examples which they transferred their ideas from. For example, in a model lesson, the instructors asked preservice teachers to
research information about Colonial life on a website and then used a Venn diagram to compare the Colonial life and modern life. Team Two (Table 2) transferred this idea to their sixth grade social studies lesson about ancient Egyptian tools, whose audience and subject were the same as those of the model lesson. Team Two asked students to research information about ancient Egyptian tools on a website and then use a Venn diagram to categorize ancient Egyptian tools and modern tools.

In their teaching, the preservice teachers used the technologies as cognitive tools for their students to learn with. For example, Microsoft PowerPoint is often used in a classroom as a teacher’s presentation tool. In one model lesson, acting as kindergarteners, the preservice teachers rearranged the PowerPoint slides in the order of a pumpkin’s life cycle by dragging each slide into a correct place. In this way, PowerPoint was used as a sorting tool for kindergarten students to learn about a pumpkin’s life cycle. Students were active in the sorting activity instead of passive learners listening to a PowerPoint presentation. Team One (Table 2) transferred this idea to their fifth grade math lesson about the order of operation. They used Microsoft Word to create a worksheet with a math problem and steps to solve the problem in individual textboxes. They asked their students to arrange the textboxes in the order that the problem should be solved. In Team One’s project, Microsoft Word was not used as a text editing tool, but a cognitive tool to manipulate their thinking about the order of operation.
### Technology Integration Ideas in Preservice Teachers’ Course Projects and the Sources of the Ideas in the LDM

<table>
<thead>
<tr>
<th>Team #</th>
<th>Technology integration ideas</th>
<th>Technology integration in preservice teachers’ projects</th>
<th>Sources of ideas in the model lessons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Solving problems by moving objects on a Microsoft Word, Microsoft PowerPoint, or Kidspiration worksheet.</td>
<td>In a fifth grade math class about the order of operations, teachers used Microsoft Word to create a worksheet with math problems and steps to solve the problems in individual textboxes. Students arranged the textboxes in the order that the problem should be solved.</td>
<td>In a kindergarten class about the life cycle of a pumpkin, teachers created a Microsoft PowerPoint file with pictures of different stages in a pumpkin’s life cycle in the wrong order. Students rearranged the slides in the order of a pumpkin’s life cycle by dragging each slide into a correct place.</td>
</tr>
<tr>
<td>2</td>
<td>Researching information on a website and use graphic organizer to summarize the information</td>
<td>In a sixth grade social studies class, students researched information about ancient Egyptian tools on a website and took notes of their research. On a Venn diagram that was created in a Microsoft Word document, students made distinction between ancient tools and modern tools by moving some pictures of tools to different parts of the Venn Diagram.</td>
<td>In a sixth grade social studies class, students researched information about Colonial life on a website. While they were researching, they completed a Venn Diagram comparing the Colonial life to modern life.</td>
</tr>
<tr>
<td>3</td>
<td>Using Kidspiration to create a concept map</td>
<td>In a second grade science class about phases of matter, students used Kidspiration to create a concept map of phases of matter.</td>
<td>In a first grade English language arts class, students used Kidspiration to create an idea map before writing a short essay.</td>
</tr>
<tr>
<td>4</td>
<td>Using Microsoft PowerPoint to create a picture book</td>
<td>In a third grade social studies class about different lifestyles in urban and rural living settings, students used Microsoft PowerPoint to create a picture book. On each slide, students copied and pasted a picture to match the description on the slide. They then created a title to complete the slide.</td>
<td>In a kindergarten class, students used Microsoft PowerPoint to create a picture book, describing a pumpkin’s life cycle. They first rearranged slides to reflect the correct life cycle of a pumpkin. Then on each slide, they created a title and briefly described the stage of the life cycle.</td>
</tr>
</tbody>
</table>
When solving the instructional problems in their teaching projects, the preservice teachers were able to identify the similarities between the problems at hand and what they had experienced in the modeling. As discussed before, live behavior modeling gave the preservice teachers the initial experience and cognitive modeling further helped them index their experience in the behavior modeling. By indexing their experience, they were able to transfer their experience to new situations by recognizing its applicable conditions. When designing their lessons, the participants often referred back to similar situations in the live modeling, picked up technology integration ideas, and modified the activity for their own lesson. Grace said, “[F]or our projects, we really took what they did in the classroom and kind of did it on our own the same way.” For instance, Team One’s project was a fifth grade math class about the order of operations (See Table 2). When brainstorming ideas to teach the lesson, the team remembered in a model lesson where they learned about a pumpkin’s life cycle by rearranging PowerPoint slides into the correct order of the plant’s life cycle. Fay in Team One said, “So then I remember back to the pumpkin lesson, where they had them put the life cycle in order. So we would doing all of the operation, so why don’t we have them to put the problem in order?” After referring back to the pumpkin model lesson, the team decided to have their students practice doing operation by putting the problem solving steps in order. Lexie also commented on how their group imitated the pumpkin life cycle model lesson,

I actually used that type of example for my own presentation. So you read a story and then you are able to not just like have them discuss it or memorize it but you can interact through technology and PowerPoint and have them do that, so that was really nice.
While the preservice teachers were able to teach with technology in their projects, many of their technology uses were directly transferred from the examples in the LDM. West and Graham (2007) found that when the preservice teachers’ teaching context matched that in the modeling, transfer was easy for them. In our study, the examples in the LDM were purposefully designed to represent the teaching contexts in elementary classrooms, which also matched those of the course projects. From the interview, the preservice teachers’ successful imitation of the examples seemed to be based on their superficial understanding of the high similarities between the contexts, not on a thorough analysis of the influencing factors in their own teaching context. While the LDM have provided those inexperienced teachers with the initial technology integration experience, more help is probably needed to transfer such experience into more substantial TPACK development.

4. **Attention should be paid to the conditions that influence the effective use of LDM in preservice teacher technology preparation.**

Although LDM was generally effective in helping the preservice teachers develop the initial awareness of TPACK, some conditions may influence the effectiveness of the strategy due to limitations in preservice teachers’ overall knowledge base, practical experience, and ability to transfer learning to other contexts.

   a) **In LDM, instructors should help preservice teachers develop awareness of the school- and classroom-level factors that are related to technology integration decisions.**

   The live behavior modeling is vivid and can provide more relevant contextual cues about teaching. The cognitive modeling can give preservice teachers more background knowledge about the decision making process. However, the brief demonstration and explanation cannot fully compensate for preservice teachers’ lack of a big picture or cover all factors that a teacher
should consider in a classroom. As Zhao and Frank (2003) point out, teachers’ use of technology in classrooms is a complicated process that involves factors at different levels. However, when making technology integration decisions, new teachers often attend to fewer classroom- and school-level factors that influence teaching compared to expert teachers (Greenhow et al., 2008). In the course projects, some preservice teachers made their technology integration decisions before a careful analysis of lesson content, pedagogical needs and the affordance of the technology. In the interview, when preservice teachers were asked about the reasons why they chose to use the technology in the lesson, responses such as “we knew right from the start that we wanted to use PowerPoint” or “the first thing that came to our heads was getting a slide on each community” were common. The preservice teachers’ rush decision making without performing careful instructional analysis seemed to reflect their less comprehensive view of these factors.

A more comprehensive view of influencing factors in a classroom has to come from other education courses or experience in their program, especially their field teaching practice (Greenhow et al., 2008). For example, in the lesson about assistive technology, those preservice teachers who had learned about assistive technologies in their special education courses or who had experience working with students with disability had a better understanding of why and how assistive technology should be used in a classroom. Therefore, the role of LDM in a technology integration course is to connect preservice teachers’ knowledge and experience in the context of technology integration and provide a foundation for them to think about all the factors that influence a teacher’s decision making about technology integration.

b) **LDM must be coupled with practical teaching experience even in preservice teachers’ course training stage.**
Although the LDM provides some authenticity about real-classroom teaching, modeling is not a replacement, but only an enhancement of preservice teachers’ practical experience. Compared with in-service teachers, preservice teachers are found to have less practical and pedagogical content knowledge about technology integration (Greenhow et al., 2008). Modeling gives preservice teachers the initial experience and scaffolding about how to teach with technology. However, preservice teachers have to gain their practical knowledge and in-depth pedagogical content knowledge related to technology integration through real classroom teaching. One preservice teacher, Amy, had more teaching experience in the field than her classmates. Her perception about teaching was very different from her peers who had not. For example, when she observed her peers teach a second-grade lesson, she thought the contents in that lesson were too difficult because the second graders in her classroom would not be able to do the activities. Expert teachers tend to think about learning from their students’ perspective (Westerman, 1991). Being engaged in field teaching, this preservice teacher can think about learning from her students’ perspective and understand more about her students’ developmental stages.

Preservice teachers cannot gain such in-depth and practical experiences from live modeling, but can only gain them from real classroom teaching. Therefore, LDM must be coupled with practical teaching experience even in preservice teachers’ course training stage. Teaching projects such as the course projects preservice teachers did in this study can be helpful. Although some teaching conditions are artificial or hypothetical (such as “fake” students), instructors’ feedback on their performance is crucial to help them understand what real teaching would be like.
c) The technology use in the LDM is highly contextual. Instructors should help preservice teachers develop flexible understanding of the technology integration contexts in the LDM and transfer their learning to other contexts.

When transferring their learning to a new context, if preservice teachers cannot move beyond the specific contexts in the modeling, “contextual breakdown” (West & Graham, 2007, p. 137) may happen. “Contextual breakdown” means that the contexts in the modeling do not match the preservice teachers’ teaching context. West and Graham (2007) found that contextual breakdown was the major reason why some preservice teachers benefited the least from their live modeling. In our study, the preservice teachers expressed some concerns that were similar to those “contextual breakdown” concerns in West and Graham’s study (2007).

Some preservice teachers felt it unrealistic to teach with technology as the instructors had demonstrated because they felt lacking sufficient technology resources in their classroom. For example, Iris said, “I also feel like…kind of unrealistic, because I mean most of the schools have only one computer in the classroom. You can’t get up to every single computer.”

The reserved attitude toward using technology to teach was more obvious when the preservice teachers observed discrepancy between the targeted grade level in the modeling and the grade level they would like to teach. They inclined to think the technology integration was not helpful to their intended audience. For example, in one model lesson, the preservice teachers pretended to be fourth graders and use Microsoft Excel to create a mini survey, collect data and analyze data. Many preservice teachers in the interview said they wouldn’t use Excel because they thought Excel was only appropriate for older students. While they wanted to teach Kindergarteners and first graders, Excel would be too “difficult” for their students.
The contextual breakdown may result from preservice teachers’ rigid understanding of the technology integration contexts. Teachers’ technology integration developmental models indicate that the less advance that teachers are in the developmental stage, the less confident and creative they are in using technology for instruction and the less likely they transfer technology use into new contexts (e.g., Russell, 1995; Sandholtz, Ringstaff, & Dwyer, 1997). The preservice teachers in this study were still in their early developmental stage of technology integration. They tended to directly imitate their instructors’ technology integration ideas and believe technology didn’t fit when the contexts were different. While instructors can provide technology integration examples that represent various teaching contexts in the LDM, it is unrealistic to provide examples that address all K-12 teaching contexts. Thus, helping preservice teachers to develop flexible understanding of the technology integration contexts in the LDM is important. Discussions following the LDM about how to make variation or adaption to accommodate students’ different needs or classroom environments can be helpful. It would also be helpful to discuss preservice teachers’ concerns about applying technology integration ideas to their own teaching contexts.

Conclusions

In this study, an LDM strategy was designed and implemented to help preservice teachers develop TPACK. In the course-training stage of their teacher preparation program, this strategy was in general effective for providing the initial experience essential to helping preservice teachers understand how to teach with technology. The LDM helped the preservice teachers bridge their content knowledge and their pedagogical knowledge, expand their understanding in pedagogical knowledge, and transfer the technology integration ideas from the modeling to real-world classroom teaching, although in a superficial and rigid way. As a result, the preservice
teachers were more aware and sensitive to the major factors that would influence a teacher’s decision to integrating technology for teaching. However, more research is needed to explore whether developing inexperienced preservice teachers’ awareness and sensitivity to these major factors should be the focus of their initial TPACK development. Moreover, although LDM provides the initial technology integration experience needed for inexperienced preservice teachers, LDM alone is not sufficient to enhance their TPACK development. Preservice teachers have to gain practical and pedagogical content knowledge from other educational courses in their program and from classroom teaching opportunities. The role of LDM is to help connect their overall knowledge base about teaching in the context of technology integration. In addition, when LDM is used, discussing adaptations of technology integration in various contexts and preservice teachers’ concerns of classroom application may help them develop flexible understanding of the technology use contexts in the modeling and transfer their learning to new contexts.

The understanding of the LDM strategy in this study can help teacher educators adopt and adapt this strategy in their technology preparation programs. However, more research is needed to understand how preservice teachers learn from this LDM strategy, especially from cognitive modeling. From this study, although cognitive modeling seemed helpful for the preservice teachers to transfer knowledge and skills learned in the behavior modeling, the evidence was not strong. Furthermore, it was not clear how the behavior modeling had impact on preservice teachers’ decision making process and how preservice teachers imitated the decision making process modeled by the instructors. Future research can focus on identifying preservice teachers’ decision making process in technology integration and how such a process is influenced by both behavior and cognitive modeling. Understanding their decision making process can give teacher
educators insight into designing more effective modeling strategies for preservice teacher technology preparation.

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References


Chapter 4

Cultivating Reflective Practitioners in Technology Preparation: Constructing TPACK through Reflection

Abstract: Teaching is a complex profession, which is further complicated by the integration of technology into classrooms. Reflection can help teachers unpack the complexity in their practice. Reflection can be an effective instructional strategy in helping preservice teachers develop technological pedagogical content knowledge (TPACK), the complex and dynamic knowledge necessary for effective technology integration into instruction. In this study, reflective activities were integrated into a Learning By Design (LBD) environment, which was created to help preservice teachers develop TPACK. This paper investigated the participants’ TPACK development and examined how reflection helped them construct TPACK. Through content analysis of the participants’ reflective journals, the researcher found that the preservice teachers developed initial TPACK awareness. However, their reflection in technology knowledge and the content aspects of TPACK were limited and superficial. Interviews with the participants showed reflection helped the preservice teachers remember what they learned by describing and elaborating on their in-class experiences, pushed them to think about how to apply what they learned in their future classrooms, and helped them become more reflective and open-minded about using technology in classrooms. Finally, the researcher discussed this study’s implications for teacher educators and researchers.

Keywords: TPACK; preservice teachers; reflection; technology preparation
1. Introduction

Teaching is a complex profession that is full of “uncertainty, instability, uniqueness, and value conflict” (Schön, 1983, p. 49). Teachers often deal with ill-defined problems in classrooms and solving those problems often requires artistry and intuition, as well as technical expertise (Schön, 1983). In the Digital Age, teaching is further complicated by the integration of information and communication technology in classrooms. More and more scholars have acknowledged that the knowledge essential for effective technology integration in instruction, which is also known as technological pedagogical content knowledge (TPACK), is “complex, multifaceted, and situated” (Mishra & Koehler, 2006, p. 1017). Similar to the development of other teacher knowledge, the development of TPACK in preservice teachers requires opportunities for them to grapple with its inherent complexity. Since reflection is essential for preservice teachers to identify, analyze, manage and solve the many complex teaching problems (Spalding & Wilson, 2002), the researcher suggested reflection can be a potential strategy to help preservice teachers disentangle the complex and dynamic relationship to and the intricacies of integrating content, pedagogy, and technology in TPACK development.

Scholars have discussed using reflection to facilitate preservice teachers’ knowledge development (e.g., Dieker & Monda-Amaya, 1995; Sutherland, Howard, & Markauskaite, 2009) or using technology to foster preservice teachers’ reflection (e.g., Lord & Lomicka, 2007; Shoffner, 2009a, 2009b). However, fewer studies have discussed whether and how reflection can help preservice teachers develop knowledge about teaching with technology. In this study, reflective activities were integrated into a Learning By Design (LBD) environment, which was created to help teachers develop TPACK based on suggestions from the literature (Koehler & Mishra, 2005a, 2005b). In the learning environment, the preservice teachers used reflection to
interpret their technology integration experience in the classroom and foster their TPACK construction. The researcher investigated the preservice teachers’ TPACK development as manifested in the reflection on their technology integration experience and interviewed them about their opinions on the reflective activities. Through content analysis of the preservice teachers’ reflective journals and thematic analysis on the interviews, two questions were explored in this study:

a. How did the preservice teachers interpret their in-class technology integration experience?

b. How did reflection help the preservice teachers develop TPACK?

2. Literature review

2.1. Reflection in Teacher Preparation

Following Schön’s seminal work in 1983, researchers have established the role of reflection as an important strategy in teacher knowledge development (Hatton & Smith, 1995). This section discusses the definition of reflection, the result of reflection, and teaching reflection through journal writing.

The ideas behind many reflective practices in today’s teacher education can be traced back to the “key originator” (Hatton & Smith, 1995. p. 33), John Dewey. Dewey holds that a reflective thought is the “[a]ctive, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends” (Dewey, 1933, p. 9). Schön (1983) extended Dewey’s idea by describing reflection in two categories: reflection-in-action and reflection-on-action. Reflection-in-action requires practitioners to construct a new understanding toward an uncertain and unique situation that will guide action while the situation is unfolding during action. Reflection-on-action is an afterthought about
actions taken in a situation. By definition, reflection is inseparably connected with action, and scholars tend to be more concerned with reflection leading to a “modified action” (Hatton & Smith, 1995, p.34). Thus, one benefit of reflection in relation to teaching is that it helps teachers “think about how to apply the knowledge they received in their training programs and past experiences to make changes in their instruction” (Dieker & Monda-Amaya, 1995, p. 241).

Although a “modified action” is the desired result of reflective practices, reconstructed practical theory about teaching and learning is often the result of reflection (Francis, 1995). Reflection may not lead to immediate action or problem solving (Canning, 1991). Its essential nature is “thinking about action” (Hatton & Smith, 1995, p. 34). As Dewey (1998) put it, “[t]o reflect is to look back over what has been done so as to extract the net meanings which are the capital stock for intelligent dealing with further experiences” (p. 110). Central to reflective practices are personal and professional experiences, which lead to the construction of practical knowledge (Griffiths & Tann, 1992; Sparks-Langer & Colton, 1991). Practical theory, the strongest determining factor in a teacher’s educational practice, is established through a series of diverse events, such as practice experience, reading, listening, and looking at other people’s practices (Handal & Lauvas, 1987). Practical theory is often tacit (Griffiths & Tann, 1992; Schön, 1983, 1987). The role of reflection is to help preservice teachers make their practical theory explicit by clarifying and extending it (Griffiths & Tann, 1992; Francis, 1995). Reflection can help preservice teachers “to unpack their own experiences, beliefs, knowledge and philosophies and to help them understand how these shape their identities and actions as teachers” (Ovens & Tinning, 2009, p. 1125).

When describing, analyzing, and making inferences about classroom events, teachers are constructing their own theory about teaching (Sparks-Langer & Colton, 1991). However,
teachers need to learn analytical thinking skills involved in reflective activities (Dewey, 1933; Francis, 1995; Spalding & Wilson, 2002). Journal writing is a popular pedagogical strategy to elicit reflective thoughts from preservice teachers (e.g., Francis, 1995; Spalding & Wilson, 2002). Research found that reflective journal writing can contribute to the development of teachers’ reflective thinking (Francis, 1995; Spalding & Wilson, 2002). Through construction and reconstruction of their experiences and stories, teachers can raise their voices [13] and develop deeper understanding of their own experiences (Sparks-Langer & Colton, 1991).

As a strategy for teacher knowledge development, reflection engages teachers to think about their teaching practices. These reflective practices often lead to teachers’ reconstructed practical theory about teaching and learning. Reflective thinking needs to be taught and can be taught through journal writing (Dewey, 1933; Francis, 1995; Spalding & Wilson, 2002). The next section discusses why reflection can be a potentially effective strategy to help preservice teachers develop TPACK.

2.2. Reflection in TPACK Development

As an inseparable component of a teacher’s overall knowledge base, teachers’ knowledge about technology integration is also complex, situated, and multifaceted (Mishra & Koehler, 2006). The TPACK framework proposed by Mishra and Koehler (2006) captures the essential knowledge for effective technology integration in classrooms. Mishra and Koehler argued that the essence of teachers’ knowledge about technology integration lies at the center of the framework, the interplay of content knowledge, pedagogical knowledge and technology knowledge. Mishra and Koehler defined the meaning of each TPACK component by describing the key questions and concerns in each (see Table 1).
Table 1

**Definition of TPACK (Adapted from Mishra & Koehler, 2006)**

<table>
<thead>
<tr>
<th>TPACK</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Technology knowledge (TK)</td>
<td>Knowledge about standard technologies and more advanced technologies.</td>
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<tr>
<td>Pedagogical knowledge (PK)</td>
<td>Deep knowledge about the processes and practices or methods of teaching and learning and how this knowledge encompasses overall educational purposes, values, and aims.</td>
</tr>
<tr>
<td>Content knowledge (CK)</td>
<td>Knowledge about the actual subject matter being taught.</td>
</tr>
<tr>
<td>Technology pedagogical knowledge (TPK)</td>
<td>Knowledge of the various technologies used in teaching and learning settings, and how teaching and learning might change as the result of using particular technologies.</td>
</tr>
<tr>
<td>Technology content knowledge (TCK)</td>
<td>Knowledge about the manner in which the subject matter can be changed by the application of technology.</td>
</tr>
<tr>
<td>Pedagogical content knowledge (PCK)</td>
<td>Knowledge of what teaching approaches fit the content and how elements of the content can be arranged for better teaching.</td>
</tr>
<tr>
<td>Technological pedagogical content knowledge (TPACK)</td>
<td>Knowledge of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of how technology can help redress the difficulties that students face in learning; knowledge of students’ prior knowledge and theories of epistemology, how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones.</td>
</tr>
</tbody>
</table>

Note: The table is adapted from Mishra and Koehler’s paper, *Technological pedagogical content knowledge: A framework for teacher knowledge* (Mishra & Koehler, 2006).

To help teachers develop TPACK, Learning By Design has been proposed as a promising instructional approach (Koehler & Mishra, 2005a, 2005b). It is a project-based, learner-centered instructional model that engages learners in designing artifacts for a real-world context, whereby learners construct their understanding and meaning toward a topic or concept (Han & Bhattacharya, 2001). Learners in an LBD environment should be given opportunities to develop and implement their ideas, receive feedback, articulate their reasoning, reflect on their
experiences, refine their ideas, and relate to their prior experiences in order to solve new problems (Kolodner, et al., 2003). When used for technology integration training, LBD offers opportunities for teachers to use technology in authentic problem-solving contexts and to explore “the rich connections between technology, the subject matter (content), and the means of teaching it (the pedagogy)” (Koehler & Mishra, 2005a, p.95). These learning experiences, addressing the situated nature and complex interplay of technology, pedagogy, and content, are deemed essential to the development of TPACK.

LBD entails using strategies to help learners construct understanding of their own work, through which they develop the knowledge integral to the problem-solving process, which, in this case, is TPACK. LBD acknowledges the importance of experience in knowledge development and emphasizes the connection of new and old experience (Kolodner, Gray, & Fasse, 2003). A person’s knowledge is extended when old experience is reinterpreted and re-indexed to interpret and solve new problem, and thus incorporated into new experience. Therefore, learning in LBD is “a natural consequence of applying knowledge to new situations, noticing and analyzing the results, and inserting the experience into memory” (Kolodner, 1997, p. 60).

Reflection can provide opportunities necessary for preservice teachers to articulate their LBD experiences, through which they can further interpret their technology use experience and construct their practical theory about using technology for instruction. The ultimate goal of learning is that learners can apply what they have learned in new situations. Successful transfer of knowledge to new situations depends on two conditions “(a) the extent to which the old situation was interpreted and its lessons learned were articulated and recorded and (b) the accessibility of the old situation when the new one is encountered” (Kolodner, 1997, p. 63). The
better a piece of old experience is indexed, the more accessible it is when encountering new situations. Indexing is key to reusing what has been learned in one’s experience (Kolodner, et al., 2003). Therefore, for preservice teachers to use TPACK in new contexts, having experiences in teaching with technology is not sufficient. Teachers must be given opportunities to reflect on those experiences so that they can “extract and clearly articulate what they have learned,” “make those articulations rich in the right ways,” and “index their experiences well” (Kolodner, 1997, p. 63). When articulating what they have learned in LBD, preservice teachers also have to encounter the complexity of technology use in authentic teaching contexts, thus developing a deeper understanding of the complex and dynamic relationship of content, pedagogy, and technology in TPACK.

Thus, based on the above review of the literature, the researcher suggests that in order to construct their own understanding of TPACK, preservice teachers can use reflection in LBD to interpret and analyze their technology integration experience, and integrate it into their overall knowledge base.

3. Research Design

3.1. Research Setting

The research setting was a mandatory face-to-face technology integration course in a teacher preparation baccalaureate degree program in the School of Education at a large private northeastern university in the United States. Designed for preservice teachers who were in their initial stage of teacher training and who had little practical experience with classroom technology use, the course covered some general information technologies for teaching purposes, including educational websites, Microsoft Word and PowerPoint, Microsoft Excel, electronic communication tools, and assistive technologies. This course was carefully designed as an LBD
environment, which was described in detail in another paper by the design and teaching team (Lu, Johnson, Tolley, Gillard-Cook, & Lei, 2011). The course consisted of six classes. The first five classes included four routine instructional components: Reading discussions, model lessons, mini-projects, and reflections. In the first five classes, instructors first demonstrated live examples of effective technology use for teaching, while preservice teachers acted as K-12 students in the demonstration (Lu & Lei, 2012). Then in the project section, preservice teachers used one technology to design an instructional product or an instructional solution to a real-world teaching task. After each of the first five classes, the preservice teachers were required to write a minimum of one-paragraph journal, reflecting on their in-class learning experience within 24 hours of the class. In the final class, preservice teachers conducted a group course project, teaching their fellow preservice teachers a fifteen-minute lesson using technology. The reflective activity in this paper refers to the writing of the reflective journals after the first five classes.

The overall goal of having the preservice teachers write reflective journals was to help them construct their own understanding of TPACK. To achieve this goal, each of their reflective journals was guided by the following questions: (1) What did you learn today about technology integration? (2) What instructional and classroom management strategies did you observe? (3) How did what you learned apply to what you already knew or are learning in other courses? (4) How might you apply what we did in class today for your future students? (5) What other questions or related thoughts would you like to ask or share?

Questions (1) and (2) were intended to help the preservice teachers interpret and analyze their technology integration experience in LBD. In the course, the instructors demonstrated many instructional strategies, especially classroom management strategies during their modeling.
Therefore, the instructors asked the preservice teachers to also focus on reflecting on those strategies. Question (3) was intended to urge the preservice teachers to connect their technology integration experience to their previously acquired knowledge about teaching. Question (4) asked the preservice teachers to use their reconstructed experience to contemplate on how to solve teaching problems in their future classrooms. The final question gave the preservice teachers an opportunity to ask questions after taking the classes.

3.2. Data Collection

Data were collected from 39 preservice teachers who enrolled in this technology integration course. They were enrolled in teacher education programs as freshmen (82%) or sophomores (18%), and a majority of them (92%) were female. Most of them had little to no teaching experience. The participants yielded 39 sets of reflective journal entries, of which 31 sets were complete, each having five journal entries. The remaining eight sets each had four journal entries. The researcher also interviewed the participants individually. She asked the participants about their opinions on the Learning By Design environment. One of the questions was whether reflection was helpful for them to understand teaching with technology and why they thought so. The analyses of the interviews were based on the 38 successfully recorded ones. In this study, the researcher only analyzed the participants’ responses to the question about the reflective activities.

3.3. Data Analysis

To answer the first question, how the participants interpreted their in-class technology integration experiences, content analysis was conducted on the 39 sets of reflective journals using NVivo 8, qualitative analysis software. Content analysis is “a research technique for the
objective, systematic, and quantitative description of the manifest content of communication” (Berelson, 1971, p. 18). It involves “comparing, contrasting, and categorizing a corpus of data” (Schwandt, 2007, p. 40). Content analysis has been used to analyze teachers’ technology integration experiences (e.g., Koehler, Mishra, & Yahya, 2007; Koh & Divaharan, 2011). For example, Koehler and his colleagues used content analysis to analyze the participants’ activities and experiences in a faculty development design seminar to investigate their TPACK development (Koehler, Mishra, & Yahya, 2007).

Content analysis has three essential steps (Koehler, Mishra, & Yahya, 2007; Riff, Lacy, & Fico, 1998). Firstly, researchers identify samples of textual materials, such as field notes, interview transcripts, and observation. In this study, the samples were all the preservice teachers’ reflective journals about their learning experiences in the technology integration course. Secondly, researchers develop a protocol and train coders to use the protocol to identify and categorize the target variable. In this study, the target constructs were TPACK and its subsets. The researcher used Mishra and Koehler’s definition of TPACK as the protocol. Thirdly, after coding the samples, researchers analyze and describe the target variable. As Schwandt (2007) explains, “[c]ontemporary forms of content analysis include both numeric and interpretive means of analyzing data” (p. 40). In this study, in order to draw a comprehensive picture of the preservice teachers’ current TPACK development, the author used both quantitative and qualitative analyses to interpret the preservice teachers’ reflection on their technology integration experiences (Koehler, Mishra, & Yahya, 2007).

To investigate the preservice teachers’ TPACK development, the researcher followed the three steps of content analysis to dissect the participants’ technology integration experiences in their reflective journals. The TPACK framework was adopted as an analytical lens. The
definition of TPACK constructs defined by Mishra and Koehler (2006, see Table 1) was used as the protocol to categorize the participants’ experiences. The researcher and a coder first used two sets of reflective journals to develop coding examples for identifying the TPACK constructs (see Table 2). The category of content knowledge did not emerge in this study. Therefore, the coding examples presented here consist of only six categories. To ensure coding validity, the researcher and the coder coded each reflective journal independently. They then compared their codings until most coding differences were resolved through discussions. The final inter-rater agreement between the researcher and the coder was calculated using Nvivo. Table 3 lists the Cohen’s Kappa values on the seven constructs, all of which are above 0.90. In each TPACK construct, the researcher used the constant comparative method to identify themes about how the participants interpreted their technology integration experiences. By doing so, the researcher could detect themes about the participants’ TPACK development from different angles by grouping their experiences into the seven TPACK components.
Table 2

TPACK Coding Categories

| TPACK construct | Coding example |  
|-----------------|----------------|--------|
| TK              | Today in class we learned about creating spreadsheets on excel to use as a tool to collect data and create charts. |  
| PK              | She also explained about a Jigsaw activity in which students are responsible for different parts of an assignment and they all have to come together to make the whole. I have learned about this strategy in Block 1 and have seen it done in my 2nd grade field experience this semester. |  
| TPK             | I think that using centers at the computers could definitely be an effective strategy when you want students to develop a large range of knowledge about a particular topic. After using all the different websites, I now know to look for interactional websites that have instructions in multiple forms such as audio, pictures, and words. |  
| TCK             | Today I learned that technology can be integrated in the classroom for a variety of subjects such as spelling, history, and mathematics. In my previous classroom experiences, I only experienced using technology for teaching literacy and language arts. |  
| PCK             | This seems like a good idea for a station in a class and then I would have another station that would be drawing or creating your own pumpkin. What I remember from my younger grades was a lot of coloring and creating things that of course were all sloppy but it was a lot of fun. |  
| TPACK           | All of the websites that we explored used a variety of teaching strategies such as using text, sound, and visuals which accommodates a variety of learners. Each activity used different instructional strategies to teach the content of the lesson. I found the Brainpop Jr. Movie lesson had a lot of useful methods that individual lessons should possess. The Brainpop Jr lesson about bar graphs and tallies was taught in the format of a movie. During the movie the visuals were clear and the “instructor” would ask the students questions about the material, pause, and then answer the answer correctly. I think it is important to ask questions throughout the lesson to see if the student comprehends the material. After the movie was over the student was able to take a quiz to check their understanding of bar graphs and tallies as well as try a problem on their own. |  

Table 3

Inter-rater Agreement

<table>
<thead>
<tr>
<th>Construct</th>
<th>CK</th>
<th>PK</th>
<th>TK</th>
<th>TPK</th>
<th>PCK</th>
<th>TCK</th>
<th>TPACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>1</td>
<td>0.95</td>
<td>0.98</td>
<td>0.91</td>
<td>0.97</td>
<td>0.92</td>
<td>1</td>
</tr>
</tbody>
</table>

To answer the second question, how reflection helped the participants develop TPACK, the researcher used thematic analysis to investigate the data from the interviews with the preservice teachers. According to Braun and Clarke (2006), thematic analysis is “a method for identifying, analyzing and reporting patterns (themes) within data. It minimally organizes and describes your
data set in (rich) detail” (p. 79). It has six phases: (1) Becoming familiar with the data; (2) generating initial codes; (3) searching for themes; (4) reviewing themes; (5) defining and naming themes; (6) producing the report. The essential step is to identify a theme which “captures something important about the data in relation to the research question and represents some level of partnered response or meaning within the data set” (Braun & Clarke, 2006, p. 82). Following the six phases of thematic analysis, the researcher identified themes to interpret and explain the participants’ narratives of their opinions on the reflective activity, that is, whether and why they thought reflection helped them develop a deeper understanding of their learning.

4. Results and Discussion

This section presents and discusses the findings from analyzing the participants’ reflective journals and interviews. The analyses of reflective journals focused on how the preservice teachers interpreted their in-class technology integration experiences. The analyses of the interviews focused on determining how reflection helped the participants construct TPACK.

4.1. Evidence of TPACK Growth

To analyze the participants’ interpretation of their technology integration experience, the researcher dissected their reflection using the TPACK framework and identified the coverage of each TPACK construct in their reflective journals. Coverage of a TPACK construct referred to the percentage of that construct coded in the 39 sets of the reflective journals, as shown in Figure 1. TPK (57.4%), PK (14.64%), and TPACK (12.8%) were covered the most. The total coverage of TPK, PK, and TPACK was 84.84%. The coverage of TK, 3.56%, ranked fourth; TCK (1.35%), PCK (0.71%), and CK (0%) had very low coverage.
If the coverage of each TPACK construct is viewed as an indicator of the preservice teachers’ knowledge growth, these results are generally consistent with the participants’ self-assessment of their TPACK growth in another study (Lu & Lei, 2011). In that study, the same group of participants’ TPACK growth was measured by pre- and post- TPACK surveys before and after the participants had taken the same course. The results showed the participants’ TPK, PK, TPACK, PCK, and TCK increased significantly after they had taken the course. As the participants felt their TPK, PK, TPACK increased, they reflected more on them in their reflective journals. Therefore, coverage of each TPACK construct in the participants’ reflective journals can be a good indicator of their TPACK growth. In the following sections, how the preservice teachers articulated their understanding of technology integration in each TPACK construct is described, and a picture of their initially developed TPACK is sketched.

![Coverage of each TPACK construct in the reflection journals](image)

*Figure 1. Coverage of each TPACK construct in the reflection journals*

### 4.2. Rich Reflection in TPK, PK, and TPACK

As was found in the literature, preservice teachers can interpret their experience and construct their practical knowledge by articulating their experience in reflection (Griffiths & Tann, 1992; Sparks-Langer & Colton, 1991). Likewise, content analyses of the participants’ journals in the current study showed they were able to articulate their understanding of TPACK with great detail.
by vividly describing their in-class technology integration experiences, especially in their reflection of TPK, PK, and TPACK. The participants’ rich reflection may indicate that the preservice teachers have developed initial awareness in these three areas. As one preservice teacher stated, “If you can retell it, you have learned it!”

TPK

According to Mishra and Koehler (2006), TPK is the knowledge of the various technologies used in teaching and learning settings, and how teaching and learning might change as a result of using particular technologies. The researcher and the coder coded TPK whenever the preservice teachers described their in-class experiences about how to use a technology tool for a learning activity, or when they envisioned how they would use technology for learning activities in their future classrooms. In the journals, TPK was reported to have the highest coverage among all the TPACK constructs. All 39 participants covered TPK in their journals. They described the impact of technology on teaching and learning, and explained how technology helped their students learn. Although the preservice teachers demonstrated positive attitudes toward using technology for teaching, they began to understand the complexity of technology integration in a K-12 classroom.

First, the participants began to understand how technology use influenced instruction. In the model lessons, the participants developed a positive attitude about using technologies in K-12 classrooms when they acted as K-12 students and observed the impacts of technology use on them. For example, Beth reflected on the class in which the class had a live video conference with a first-grade teacher and an elementary school librarian and wrote about how video conferencing can have an impact on classroom teaching.
Today we had an interactive web chat with teachers who told us about their technology integration. It was cool because it brought the teachers in our classroom because they couldn’t physically be present. It was also a great way to show that even if you can’t get a hold of a speaker, or be able to go on a field trip that you can still bring it into the classroom.

When the preservice teachers participated in the technology-integrated activities, they experienced the impact that technology use can have on teaching and learning. In her reflection, Beth understood that video conferencing can broaden students’ learning resources by bringing in speakers who cannot physically be present in a classroom or by virtually bringing students to places where they cannot physically go. The awareness of technology’s positive impact on teaching and learning was a sign of her beginning construction of TPK. According to Mishra and Koehler (2006), TPK is the knowing of how teaching and learning might change as the result of technology use.

Second, the preservice teachers tried to explain from a teacher’s perspective why using technology tools can be effective in a classroom. Evan discussed using web resources with students in different age groups.

The first IDE class was very interesting and made me more aware of how technology is and should be used with different aged kids. I learned that little kids in elementary school need more interactive activities such as games on computers…establishing a lesson with engaging activities on, for example, the alphabet [game], will make learning fun. I realize
older kids can deal more with research-based activities such as the one we did in class with comparing and contrasting modern versus colonial life.

Knowing why and how one type of technology is effective for learning can not only help preservice teachers choose appropriate technology tools in a learning scenario, but can also help them choose proper instructional strategies consistent with a tool’s affordance (Mishra & Koehler, 2006). In Evan’s case, he was able to explain from a teacher’s perspective why using Internet resources in a classroom can be effective. As Evan reflected in his journal, after he experienced using Internet resources to learn as a K-12 student, he tried to show how Internet resources helped his students learn. He recognized that teachers could choose from a wide range of Internet resources for students in different age groups.

Third, although the preservice teachers were generally positive about technology use in classrooms, they started to understand the complexity of technology integration in a K-12 classroom. For example, Tracy was concerned that elementary students may be too young for some computer activities. She reflected on a model lesson, in which the students were asked to recreate a PowerPoint storybook after listening to a story.

It was also different to see a book being brought into a more active lesson. This feels like it could be tricky though because the book we read was for a younger demographic that might not be very good at typing quite yet…I know I didn’t learn how to type well until I was around 11 so if I was that young child I would have gotten very frustrated.
Although she had experienced effective technology use in model lessons, Tracy was concerned, based on her own technology use experience, that younger students may not be able to handle the tools. Like Evan in the previous example, Tracy associated students’ developmental level with technology use when she considered whether a tool was appropriate for a specific teaching task. This consideration may indicate that the participants began to take into account student characteristics, which is one of the influencing factors for classroom technology use. If their concerns are addressed appropriately by teacher educators, such concerns can ignite more in-depth thinking in preservice teachers about how to choose appropriate technology tools for different learning tasks.

PK

The preservice teachers’ reflection on PK had the second highest coverage of all TPACK constructs. According to Mishra and Koehler, PK is “deep knowledge about the processes and practices or methods of teaching and learning and how it encompasses, among other things, overall educational purposes, values, and aims” (Mishra & Koehler, 2006, p. 1026). The construct PK was coded in the journals whenever the preservice teachers described the use and the impact of a specific instructional strategy or technique. Thirty-three out of 39 participants (92%) covered PK in their reflective journals. They showed some in-depth recognition of the teaching techniques, especially classrooms management skills. They began to interpret the effectiveness of a specific instructional strategy by explaining how it helped students learn. They not only described what they observed, but also tried to explain why some teaching methods would work in a classroom.
Firstly, the participants reflected extensively on classroom management skills, demonstrating deeper understanding of how and why a classroom management strategy should be used. They reflected on classroom management skills, such as learning centers, techniques to keep students focused, grouping, and providing instructions. For example, Marie discussed what she learned from her instructors about how to divide students into small groups.

For instructional strategies I learned different ways to group students together. The most obvious way is to let the students pick their own group. Another way is to assign numbers and let the students find their partners by what number complete the set. Classroom management is important to have all the activities ready and to keep the class flowing from one thing to the next. This also helps keep the students’ attention.

In the above example, Marie showed some awareness that classroom management was key to effective teaching. The extensive reflection on classroom management skills may indicate the participants paid more attention to the issues with which they were concerned in a classroom. New teachers are often challenged by the organization and management of instruction (Lederman, 1999). As shown in Marie’s comments, her instructors’ effective classroom management skills had considerable impact on her. The greater focus on classroom management issues may also be due to the guiding reflection question. The instructors specifically asked the preservice teachers to pay attention to classroom management strategies and reflect on them.

Secondly, the preservice teachers began to interpret the effectiveness of a specific instructional strategy by explaining how students can benefit from it. For example, Jackie talked about how students can benefit from small group discussions.
I also thought the way we shared ideas in class was a good way. Like you said, by putting kids on the spot when asking questions, a lot of kids can be worried if they are answering in the right ways or they may not know exactly how they want to answer the question when you first ask them. By sharing in groups or writing down your answers ahead of time, discussing answers are more productive. They will have had time to think about what they want to say and they will have gotten other people’s ideas. This helps with not only being able to think and answer questions but it helps with group work. A lot of kids may be afraid to share in front of the class. So sharing in a small group and becoming confident with your answer is something that is really positive for students.

In the above example, Jackie was aware that small group discussion can be effective in an elementary classroom. She also tried to explain how it would help students learn. By doing this, Jackie may begin to think more like expert teachers because compared to novice teachers, expert teachers would consider learning more from their students’ perspective (Westerman, 1991).

Thirdly, the preservice teachers described what they observed and tried to understand when and why to use those teaching techniques in the classroom. For example, Abby reflected on how to talk to students in a classroom.

Today in class [the teacher] talked about how she talks differently and moves around as students from all sides of the room talk during class discussions. She moved far away from a person because the student talks to the teacher. If the teacher is far away, the student will project their voice so the teacher can hear them. Since the student does this
then everyone else in the classroom will listen. As [the teacher] told us this, I realized it is a good strategy and I plan on using it in my own classroom in the future.

In the above reflection, besides describing her experience, Abby explained why and how the particular instructional technique would work in a classroom. Articulating and explaining her opinion helped her understand more the appropriate instructional situations when these techniques or strategies should be used. Preservice teachers’ reflection is an important step to index their learning experiences in order to reuse what they have learned (Kolodner, et al., 2003). The more “embellished” (Kolodner, 1997, p.60) their interpretation of their experiences, the more accessible the knowledge constructed through that interpretation; and the better the old experience is interpreted, the more useful the experience is in guiding reasoning in future problem-solving (Kolodner, 1997).

**TPACK**

The preservice teachers’ reflection on TPACK, the knowledge of the complex and dynamic relationship of technology, pedagogy, and content (Mishra & Koehler, 2006), had the third highest coverage of all components. The researcher and the coder coded TPACK whenever the preservice teachers described the use and impact of technology in a learning activity for teaching specific contents. Twenty-eight participants (72%) covered TPACK in their journals. Their reflection showed some evidence of their initial awareness in TPACK development.

*After observing how to effectively use technology in a model lesson, the participants were able to articulate their technology integration experiences by recounting their observation.* For
example, Fay retold how she learned about caribous by researching information on a website and then playing a computer game with information from that research.

On one of the games that I played with animals, students would have to read background information about animals and then they got to use the information and knowledge that they gained in making their own story about the travel of caribou. I thought that this game was fantastic in helping students learn how to do background information and in helping them use what they have learned in assignment. Through playing this game and many other games on the Delicious website I began to realize that technology would be a great thing to incorporate into an elementary curriculum.

After she learned about caribous using the Internet, Fay was able to recount this piece of learning experience in her reflection. Preservice teachers often have limited technology use experience in real classrooms (Greenhow, Dexter, & Hughes, 2008) or have limited opportunities to observe effective classroom technology use when they are K-12 students (West & Graham, 2007). After the participants experienced effective teaching with technology in the technology integration course, retelling the learning can help further internalize their experience. This internalization can be essential to helping preservice teachers understand how to teach with technology.

The preservice teachers not only recounted their experiences, but also tried to adapt those experiences for their own teaching contexts. For example, in a Microsoft Excel model lesson, the participants used Excel to create a mini survey, collect and analyze data, and chart the data. Amy talked about how she could adapt this activity in her classroom to teach other content.
creating the “What is your favorite kind of candy” chart and graph is an activity that different grade levels can do. The activity allows the students to move around by entering their data or collecting data from their classmates to enter into their computer. Excel is a tool students can also use to double check their findings if they wrote the numbers and graph on paper first. If when they plug in their numbers, the graph and chart look similar to the one they wrote, they know they analyzed the data correctly. Charts and graphs and Excel can be used to teach students about different habitats, sizes of animals, dates in history, or vocabulary words. Students as young as kindergarten could use Excel as long as the instructions are modified for each student’s needs.

The participants had limited field experience. They did not have many opportunities to test their ideas in real classrooms. Reflection, the “imaginative action” (Dewey, 1933, p. 107), gave them opportunities to construct their own theory about teaching with technology by explaining why and how to use the strategies in a classroom context. They firstly had to retrieve what was learned and then fit it into a context they anticipated to be appropriate. In her reflection, Amy was able to not only retell her experience, but also go one step further to apply what she had learned in the Excel lesson to her future classroom. This imaginative act gave her an opportunity to encounter an experience in multiple contexts, which could make the knowledge acquired “more accessible, flexible, deeply learned and accurate” (Kolodner, 1997, p. 63).

4.3. Limited Reflection in TK, CK, TCK, and PCK
Compared with their rich and vivid reflection in TPK, PK, and TPACK, the participants’ reflection in TK, CK, TCK, and PCK was limited and superficial. The total coverage of TK, CK, TCK, and PCK in their reflection was 5.62%, which was much less than that of TPACK, the third highest coverage of all TPACK constructs.

**TK**

The construct TK had 3.56% coverage in the reflective journals. Mishra and Koehler (2006) defined TK as “knowledge about standard technologies” (p. 1027). The researcher and the coder coded TK whenever the preservice teachers described a specific technology tool or resource. Twenty-eight participants (72%) covered TK in their journals. Although many preservice teachers talked about their TK, they merely mentioned the technology tools or briefly described them without providing more details about the tools. For example, Abby described her knowledge of two assistive technology tools. She said, “Pix Writer and Board Maker used pictures and words to help children read.” When reflecting on their technology knowledge, the participants tended to talk about the technology tools that were novel to them or with which they had little to no experience, such as Microsoft Excel, video conferencing, and assistive technologies. For example, Amy distinguished asynchronous and synchronous communication in her reflection.

Today in class we started off by brainstorming different types of communications and deciding if they were asynchronous or synchronous. Asynchronous communication occurs at different times and synchronous communication is communication that exists or occurs at the same time.
Detailed reflection on TK, such as Amy’s, was rare. However, the fact that the preservice teachers did not reflect much on their TK may not indicate that their TK did not grow. This course introduced general technologies with which the participants were mostly familiar. They did not spend time reflecting on technologies with which they were familiar, but were inclined to write about the technology tools about which they had little knowledge. Interviews with the participants confirmed this point. The preservice teachers said they chose to write about the technology tools with which they were less familiar. Therefore, TK occupied only a small portion (3.56%) of their reflection, since they knew about how to use most of the technology tools before taking the course.

**CK, TCK, and PCK**

In the journals, the preservice teachers had limited reflection on CK, PCK, and TCK. Except for TPACK, the intersections that were related to content knowledge, TCK (1.35%), PCK (0.71%) and CK (0%), were mentioned little in the preservice teachers’ reflective journals. Even when the participants described their content knowledge, most of their reflection was superficial. They only mentioned technology could be used to teach a certain subject or topic, without analyzing how and why the technology was suitable for that subject or topic. For example, although Amy had rich reflection in other TPACK constructs, her reflection on the content aspect was limited: “Today I learned that technology can be integrated in the classroom for a variety of subjects such as spelling, history, and mathematics.” Brandy wrote, “I learned that technology can be used to teach any subject: math, history, science, reading, and writing.” The above reflections were typical.

Although most participants had insufficient articulation in the content aspect of TPACK, some of them demonstrated a slightly deeper understanding about the relationship between
content and technology. In their reflection, they elaborated on how technology could help their students learn content. For instance, Tracy discussed what CoWriter could help her students learn. CoWriter is an assistive technology program for writing, which has the word prediction feature.

I enjoyed CoWriter because all kids could use it. The prompt for spelling help can let students actually work on writing structures instead of spelling which can hold a lot of children back in terms of vocabulary. This program could help students show what they are thinking beyond what they might be able to spell. I know I always brought down writing assignments because I could not spell the big words that I was thinking.

In this example, Tracy was able to point out with the word prediction feature CoWriter was more suitable for teaching “writing structures instead of spelling.” This observation showed her awareness of TCK, “the manner in which technology and content are reciprocally related” (Mishra & Koehler, 2006, p. 1028).

The participants’ superficial and limited reflection on the content aspect of TPACK may indicate they developed some understanding that technology can be used to teach different subjects. However, the participants’ content knowledge may not be strong enough for them to elaborate on how and why various technologies can be used to teach a subject or topic. This group of preservice teachers were in the beginning stage of their teacher training and were developing their CK. Based on the literature, preservice teachers need help in developing both PK and CK (Borko, Livingston, McCaleb, & Mauro, 1988). The participants learned CK mainly in courses focusing on various subject areas and learned PK mainly in method courses. In
technology courses like this one, they may focus more on the technological and pedagogical aspects, but did not direct enough attention to CK. In the abovementioned TPACK survey study (Lu & Lei, 2011), this group of preservice teachers did not perceive that their CK grew as a result of taking this course. Although the preservice teachers perceived that their TCK and PCK increased in the survey study, they did not articulate their TCK and PCK in their journals probably due to the focus and nature of this technology course.

The participants’ superficial and limited reflection on the content aspect of TPACK may also due to the design of the reflection questions. The questions did not direct the participants’ attention to reflecting on the content being taught in the model lessons and mini projects. Therefore, it was possible that the participants did not reveal their knowledge about the actual subject matter being taught in the reflective journals.

4.4. How did Reflection Help the Preservice Teachers Develop TPACK?

As an instructional strategy, reflection was designed in the LBD environment to help the preservice teachers deeply process their learning experiences, thus constructing their personal knowledge about how to integrate technology into their teaching practice, i.e., TPACK. To understand how reflection helped the participants develop TPACK, the researcher asked the participants whether and why they thought reflection was helpful for their leaning in the technology integration course. From the 38 successfully recorded interviews, 37 participants (97%) agreed that writing reflective journals was helpful. They explained reflection helped them remember what they learned in class and pushed them to think about how to apply what they learned in their future classrooms. Some also reported their reflection became more reflective and in-depth as they wrote more about their class experiences.
Reflection helped the participants remember what they learned by describing and elaborating on their in-class experiences. Eighteen participants (47%) mentioned reflection helped them remember what they learned in class. In the reflection, the participants “summed up what exactly [they] learned.” More specifically, as Rachel said, they “summarized what the activity was,” expressed whether they “thought it was good or not,” and “talked about how [they] thought [they] could use it or what [they] thought the students would be taking away from using that piece of technology.” Although many of the participants merely repeated and described the in-class activities, doing this seemed to help “stick” what was taught in their minds. Beth described this aspect with greater detail,

I think the reflection was good because it was due the next day and everything was fresh in your mind, and you can get a real statement out of it… I always wrote kind of a lengthy thing just so I could remember what we did. So that was good now I have those. If I ever need to create a portfolio or something, [I can] go back and see what I had learned.

Ella also said,

…that was very good because it’s fresh in your mind so you could really write a proper reflection… a couple weeks later when you forget, you can go back to your paper and say, “Now what did we do?” And because it is so detailed cause you remembered at the time, you were able to actually go back and understand what you did.
Keeping a record of what they did in class through reflection helped both Beth and Ella remember what they learned about teaching with technology. Their in-class learning experiences were made explicit in the reflection, which may have remained tacit otherwise. As predicted in the literature (Kolodner, 1997; Sparks-Langer & Colton, 1991), when both Beth and Ella described how the instructional events unfolded in class, they could deepen their understanding about teaching with technology. The elaboration of their in-class learning experiences could also contribute to more successful transfer in their future application of the knowledge. Based on the conversations with the participants, a couple of elements emerged that may help them articulate their experience in the reflection:

a. The instructors’ guidance directed the participants’ attention to key elements about teaching. The participants did not reflect on every activity. They were more attentive to the instructional strategies on which their instructors asked them to reflect. For example, Cindy said,

… I liked how she had us look at the instructional strategies and everything so that made me realize the little things that she is doing that I wouldn’t usually pull out of a class that I’m sitting in… just like if I was in a different class, I wouldn’t really realize that they were doing that. It makes me look at it and because I have to go and reflect on it, so I need to pick out those points and it makes me really tune into those, to what she is doing.

As it is evident from her reflection above, Cindy was more aware of the instructional strategies being modeled in class because of the instructors’ guidance. There were many aspects of teaching in one activity. The instructors’ pointing out the key elements seemed to help Cindy
sort out her experiences. Indexing one’s experience is key to reusing what has been learned (Kolodner, et al., 2003). Providing guidance can be necessary in assisting preservice teachers to dissect their experience.

b. The preservice teachers chose to discuss their learning when they felt a strong connection to the learning activities. For example, Megan said,

…normally I would be writing the reflection [by] jotting down notes on paper while the lesson was going on and the things that I thought were interesting. That was good at least to just think back because in a lot of my reflections, I actually wrote down what I personally would want to do as a teacher or things that I found particularly interesting. So yeah, it was good just to look back at everything I learned.

Personal and professional experiences are central to reflection (Griffiths & Tann, 1992). Megan reflected on the course activities based on her personal style or preference as a teacher. A few other preservice teachers also mentioned that they reflected on the activities to which they could connect. This finding indicated the importance of creating a learning environment to which preservice teachers can relate their experiences.

Reflection pushed the participants to think about how to apply what they learned in their future classrooms. From the recorded interviews, ten participants (26%) mentioned reflection was helpful for their learning in this regard. As Chris put it, “I thought that was good that we already started thinking about what we would do in our own classrooms with that.” For example, Bailey said, “When I actually start writing it, I think, ‘Oh I can use this, this way in my future
classroom, or I could use this or I didn’t really like this, how I can change that so that it will be
useful in the classroom’…so it got me really thinking like I can like integrate technology.”

Fay had similar comments:

I reflected on whether I liked the technology that we used in the class, and then how I
would change it to incorporate it into my class. So, I guess it helped me with that thinking,
thinking about what I liked, what I don’t like and then, it made me think about how I
would incorporate it into my classroom.

In their reflection, both Bailey and Fay envisioned how they would use technology to teach in
their future classrooms. In this stage of their teacher training, the preservice teachers had limited
real-classroom teaching experience. They did not have immediate opportunities to transfer what
they learned in the technology integration course to real-world teaching. Therefore, reflection,
the imaginative act, gave them the chance to test in their minds the technology integration ideas
they had acquired in the course. In addition, Bailey seemed to be more confident in using
technology to teach after experimenting with the ideas in her mind. Scholars have found that
writing reflective journals can help preservice teachers gain more confidence in teaching (e.g.,
Hayden, 2010; Lee, 2010). The participants developed more confidence through reflection
probably by having constant conversations with themselves and personalizing their learning
experiences. For example, Callie said,

I think it was good to look at the technology I use and see, “Can I use this in my
classroom?” “Would I want to?” “How would parents react to this?” Well, then I thought
about that and I thought, “How would my parents react?” That’s how I’ve grown up, you know. It’s good to make it a personal situation…

In the interviews, a few preservice teachers mentioned that they asked themselves a series of questions when writing the reflection as Callie did. By having constant conversations with themselves during reflection, they were able to dissect the complexity of teaching with technology. In Callie’s case, she thought about how parents would react to technology use in her classroom. This indicated she began to consider broader factors affecting classroom technology use. As the literature also indicated (Spalding, & Wilson, 2002), when Callie tried to personalize what she learned by fitting the instructional events into her own contexts, she could take ownership of her journals and developed her personal knowledge about teaching with technology.

Reflection helped the preservice teachers be more reflective and open-minded in teaching with technology. The preservice teachers’ reflection was more and more reflective and in-depth as the course went on. Frank said,

When I first started writing reflections, I just said this is what we did in class, this is the technology we used. But toward the end of the semester, toward the end of the course, I was actually writing about what we did in class and reflecting on it and what is actually good about the technology, so I was being more elaborate on the class and my reflections were just a lot better, a lot more accurate.

Grace also said,
…for the first time I was like, “Oh yeah, I liked that we did this, it will be helpful doing this.” But then by the last one, I was writing a lot more and I was like, “Oh yeah I could use it for this, I can do this, maybe this could be used for this subject,” so it was good that I was kind of opening my mind to it, not just thinking technology is just like the Internet you can use to research things. There was so much more to it than that and I would begin to write about that…

In the above quotes, both Frank and Grace described how they grew in their thoughts through writing the reflective journals. Frank was more elaborate and reflective toward the end of the course. In her reflection, Grace demonstrated open-mindedness, thinking broader and considering more possibilities in using technology to teach. Open-mindedness is, as Dewey (1933) put it, “an active desire to listen to more sides than one; to give heed to the facts from whatever source they come; to give full attention to alternative possibilities; to recognize the possibility of error even in the beliefs that are dearest to us” (p. 30). Grace used to think searching for information on the Internet was the primary use of technology in a classroom. After experiencing various uses of technology in the model lessons, she was willing to accept the possibility of using technology in a variety of ways in a classroom.

However, this theme was not prevalent. Only four preservice teachers mentioned that their reflection was more in-depth toward the end of the course. However, their description of the growth in reflective thoughts seemed to be consistent with the developmental process of a reflective teacher. To understand how preservice teachers articulate, analyze, and make sense of their experiences, Hatton and Smith identified three types of reflection in a developmental
sequence: Technical rationality, reflection-on-action, and reflection-in-action (Hatton & Smith, 1995). Technical rationality is description of events and is not reflective in essence. Reflection-on-action consists of three stages: descriptive, dialogic, and critical reflection. In descriptive reflection, preservice teachers enact reasoning often based on personal judgment or on literature; in dialogic reflection, they explore rationale for their choices by having a discourse with themselves; and in critical reflection, they survey the broader contexts to explain reasons for their decisions or actions. Reflection-in-action requires teachers to consciously think about their teaching while it is happening. Based on Hatton and Smith (1995), although the participants in this study started from technical rationality and enacted mostly descriptive reflection, going through these stages in reflection was necessary to prepare neophytes to enter the professional context.

5. Conclusions and Implications

In this paper, the researcher explored the preservice teachers’ TPACK development as manifested in their reflective journals and how reflection helped them construct TPACK. Through content analysis of the participants’ reflective journals, the researcher provided a draft description of their TPACK development by describing how they interpreted their technology use experiences in a technology course. Evidence of their initial TPACK awareness was found. The preservice teachers had rich and vivid reflection in TPK, PK, and TPACK. However, their reflection in TK, CK, TCK, and PCK was limited and superficial. Through thematic analysis of the interviews with the preservice teachers, the researcher found reflection helped the preservice teachers remember what they learned by describing and elaborating on their in-class experiences, pushed them to think about how to apply what they learned in their future classrooms, and
helped them become more reflective and open-minded in teaching with technology. The results support the suggestion that cultivating reflective practices in an LBD environment can be a potential effective strategy to enhance preservice teachers’ TPACK development, although more evidence is needed to further prove the effectiveness of the strategy. As Spalding and Wilson put it, “we must demystify reflection if students are to take ownership of their journals and use reflection as a vehicle for personal and professional development in the preservice year and beyond” (Spalding, & Wilson, 2002).

From the results, this study also indicates a few lessons for teacher educators and researchers when they create LBD or similar project-based, learner-centered environments to help preservice teachers construct TPACK.

Firstly, guidance can help preservice teachers analyze the complex relationship among content, pedagogy, and technology knowledge in their reflection. After being engaged in a complex learning environment, learners can benefit from guidance which points their attention to the essential factors in their learning. In this study, when the instructors directed their attention to the classroom management issues, the participants yielded more detailed and thoughtful comments about classroom management strategies in their journals. While the instructors did not ask the preservice teachers to reflect on the content being taught in the model lessons and the mini projects, the participants had superficial and limited reflection on the content aspects of TPACK. Therefore, if an instructor provides more guidance on the complex relationship of content, pedagogy, and technology, preservice teachers may develop more in-depth thoughts in their reflection and may be more likely to integrate their new technology experience into their existing knowledge base, thus forming a more consolidated knowledge base and emphasizing the connection of content, pedagogy and technology. If an instructor helps preservice teachers reflect
on the content aspects of TPACK, they may steer more attention to think about their CK, TCK, and PCK. If an instructor points out the influencing factors in an instructional instance, preservice teachers may encode their experience into more explicit and retrieval knowledge, which may contribute to more successful knowledge transfer. Thus, how to provide effective guidance in a project-based learning environment for preservice teachers to reflect on their technology use experience can be a good topic for future research.

Secondly, it is important to create a learning environment that encourages learners to connect their own technology or teaching experiences. In an LBD environment, learners heavily rely on their previous experience related to the topics to be learned (Kolodner, et al., 2003). In this study, the participants reflected more on their learning when they felt they had some connection to the activities. Such connections were developed from their previous learning or teaching experiences, their own teaching style, personal preference, or their expectation of their future classrooms. To encourage the development of such connections in an LBD environment, teacher educators can introduce examples from real-world classrooms and create authentic learning tasks, with which preservice teachers may connect their previous experiences as a student or future experience as a K-12 teacher. Teacher educators can also help preservice teachers personalize their learning experiences by inspiring them to use the newly learned knowledge to solve their own instructional problems, which they have previously encountered or they anticipate they would encounter in their future classrooms. Therefore, how to create an LBD environment which helps preservice teachers connect their previous and current technology and teaching experiences can be a good topic for future exploration.

Thirdly, more research is needed to investigate preservice teachers’ TPACK development in an LBD environment. Scholars have argued that TPACK is “a unique body of knowledge that is
constructed from the interaction of its individual contributing knowledge bases” (Niess, 2011, p. 154). In this study the researcher provided a draft description of preservice teachers’ beginning TPACK by exploring the individual TPACK construct development. However, this study did not describe the trend of TPACK development in the participants. Therefore, it was not able to provide evidence on the change of the development in the seven constructs, whether or not their TPACK transformed into a more integrated set of knowledge base toward the end of the course. It was also not able to provide evidence on how the individual constructs contribute to the transformation of TPACK. Studies such as that done by Koehler and his colleagues (Koehler, Mishra, & Yahya, 2007) can shed light on future research in this regard. After tracing the TPACK development of the participants in a design seminar, Koehler and his colleagues (2007) found that at the beginning of the seminar the participants considered “technology, pedagogy and content as being independent constructs” (p. 740), while toward the end they developed “a richer conception that emphasized connections among the three knowledge bases” (p. 740). Is preservice teachers’ TPACK development pattern similar to that of experienced teachers as in Koehler’s study? And what does the TPACK development look like in senior preservice teachers who have more real-classroom experience from having done field teaching or student teaching? Future research can help address questions in these areas.

In addition, this study relied on the participants’ self-report of their own learning experiences. Their account of how they would teach with technology in their future classrooms may not translate into effective practices when they are engaged in teaching practicum in real classrooms. Therefore, it is necessary to identify the stage of preservice teachers’ TPACK development and trace in a longer term whether and how preservice teachers transform their initial TPACK into a more robust and mature knowledge base, and eventually translate their TPACK into effective
classroom teaching. Research on teachers’ TPACK developmental progression may provide insight in this regard (Niess, 2011).

Finally, it is important that teacher educators consider the role of an LBD environment in helping preservice teachers enrich their TPACK in the content areas. Although scholars have acknowledged the transformative and integrated nature that distinguishes TPACK from its subsets, they have also proposed that TPACK is constructed from the interaction of its contributing knowledge bases (Angeli & Valanides, 2009). In this study, we found the participants were able to elaborate more in the technological and pedagogical aspects of TPACK, while they demonstrated less elaborate knowledge in the content areas. The target course of this study was essentially about teaching - in particular, how to teach with technology. Content knowledge was taught in the context of various instructional events. In other words, it was intertwined with both technology knowledge and pedagogical knowledge. Although this was the purpose of the course, the teaching of content knowledge was not as explicit as it was in a subject matter course. As a result, it was not surprising that the participants had little reflection on the content intersections, while they reflected a lot on both the technological and pedagogical components.

However, the role of an LBD environment in enhancing the C component in TPACK remains unresolved. Can we assume that learners’ knowledge in the content intersections will automatically contribute to the formation of TPACK? If not, what strategies should be used to enhance learners’ knowledge in this regard? Or will the content subsets coevolve when a preservice teacher’s TPACK forms? Discussion of these questions may also lead to reflection on the TPACK framework. Koehler and Mishra (2008) acknowledged that some intersections of TPACK received less attention than others did. As they stated, “in some ways, TCK is the most
neglected aspect of the various intersections in the TPCK framework” (p. 16). Is TCK neglected because it is less clearly defined than other intersections? Or is it neglected because it is difficult to teach by nature? Can the neglect affect the overall TPACK construction? Clarifying these questions may help enhance the usability of this framework and provide more insight into teachers’ TPACK development.

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References


Chapter 5 Summary

This summary is intended to give readers a more comprehensive picture of this multi-paper dissertation. The summary includes three parts: a summary of all results in the papers, implications of this dissertation, and reflection on design-based research.

Summary of results in all papers

The overall design and investigation in this dissertation study was guided by three general research questions. Each individual paper had its specific research questions, which were derived from the three research questions. In this section, to give the readers a comprehensive overview of the research results in this dissertation, the researcher will summarize the results of all individual papers to answer the three general research questions which guided the study.

a. Is a LBD learning environment effective in helping digital native preservice teachers construct TPACK? In other words, does preservice teachers’ TPACK change after learning technology integration in a LBD environment?

The researcher found that the LBD learning environment was effective in helping the preservice teachers construct TPACK, although their TPACK development was initial and incomplete. The following evidence was found:

a) The preservice teachers’ self-assessed PK, PCK, TCK, TPK, and TPACK changed significantly after taking the course. Although their TK and CK also changed, the increase was not statistically significant.

b) The preservice teachers generally agreed that the course was helpful for them to learn about technology integration. They felt more confident and comfortable in using technology in their teaching after taking the course.
c) The preservice teachers expended their pedagogical knowledge and began to bridge their content knowledge and pedagogical knowledge. In their course projects, they were able to imitate the technology integration ideas in the model lessons, especially when they found similarities between their own teaching contexts and those in the modeling.

d) In their reflection journals, the preservice teachers had rich reflection in TPK, PK, and TPACK. However, their reflection on TK, CK, TCK, and PCK was limited.

b. How did the preservice teachers perceive the effectiveness of LBD?

The preservice teachers generally felt that LBD activities were helpful. In the interviews, they described in greater details how LBD activities helped them learn about teaching with technology. Their responses were summarized in the following table.
<table>
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<tr>
<th>#</th>
<th>LBD Steps</th>
<th>Sample Instructional Activities</th>
<th>Evidence of Effectiveness in Each Step</th>
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</table>
| 1  | Understand challenges | - Frame project in context of classroom applicability/course goals.  
- Reading discussion.  
- Model technology integrated lessons (preservice teachers take on student role). | - Participants learned what technology tools resources were available to them in an elementary classroom and developed more knowledge about how to use them.  
- Participants gained first-hand experience of technology integration.  
- Participants saw the possibility of using technology to create learned-centered activities in an elementary classroom.                                                                                      |
| 2  | Plan design     | - Discussion with group members during project planning/creation.  
- Feedback from peers and instructor. | - Provided the participants with a basis where they began to construct ideas for their course projects.  
- Communication with other project teams informed their own planning.  
- Helped the participants tackle the complexity in planning a technology-enhanced lesson.                                                                                                                                       |
| 3  | Construct / design | - Design and creation of the artifact.  
- Collaboration with group members.  
- Feedback from instructor. | - Participants further developed their technological knowledge.  
- Participants developed awareness of the complexity in technology integration for teaching.                                                                                                                                         |
| 4  | Test            | - Feedback from peers and instructors.  
- Peer artifact testing for instructional/grade level appropriateness. | - Participants enriched their understanding of student learning.  
- Participants became more aware of classroom management issues after they taught their lesson.  
- Constructive feedback after the test was important to help the preservice teachers grow.                                                                                                                                       |
| 5  | Analyze & explain | - Written feedback from instructor.  
- Reflection on artifact’s application in a classroom setting and application of instructional methods. | - Participants described and elaborated on what they learned in the course.  
- Participants developed more confidence by having constant conversation with themselves and personalizing their learning experiences.  
- Participants were more reflective and open-minded in teaching with technology.                                                                                                                                             |
c. Based on the first iteration of the DBR cycle, what improvements can be made to the LBD environment when it is used in designing technology instruction for digital native preservice teachers?

In this dissertation, besides investigating whether and how an LBD environment was effective, the researcher also generated some suggestions on refining the LBD environment in preservice teacher technology preparation:

- Teacher educators have to consider how to help preservice teachers develop complete and concrete TPACK, especially the content components. Evidence showed that preservice teachers’ content knowledge and content-related knowledge in TPACK did not increase after learning in the LBD environment. This indicates a challenge to teacher educators regarding how to enhance preservice teachers’ content knowledge in an LBD environment.

- Although the preservice teachers in the study developed initial awareness of TPACK, their TPACK development was incomplete and superficial. To help preservice teachers develop complete and concrete TPACK, on one hand, instructors should help preservice teachers develop an awareness of the school-level and the classroom-level factors that are related to technology integration decisions. On the other hand, instructors should help preservice teachers develop flexible understanding of the technology integration contexts in the modeling and transfer their learning to other contexts, such as their projects.

- When using reflection to help preservice teachers develop TPACK in LBD, teacher educators should give guidance to preservice teachers, helping them analyze the complex relationship among content, pedagogy, and technology knowledge.

- It is important for teacher educators to create a learning environment which encourages learners to relate their own technology or teaching experiences.
Implications

*On the theoretical level, this study extended current theoretical understanding of the LBD model, contributed to further understanding of preservice teachers’ TPACK development, and led to reflection on the TPACK framework.* By explaining why and how LBD took effect in the context that it served, and delineating the conditions that contributed to its effectiveness, this set of articles contributed to a deeper theoretical understanding of the LBD model. Since the continuous improvement of LBD was the ultimate goal of this research study, suggestions on the improvement of LBD provided directions for future studies. Researchers can further manipulate the LBD environment according to the suggestions and test their effectiveness.

A detailed description of the preservice teachers’ TPACK development in this article contributed to further understanding of how preservice teachers develop knowledge and skills essential to technology integration for instruction. More research is needed to confirm whether preservice teachers tend to develop incomplete and superficial TPACK in the early development stage. The result also presented new challenges to researchers and practitioners on how to help preservice teachers develop complete and concrete TPACK, especially the content intersections.

This study demonstrated how TPACK could be used as a theoretical lens to investigate teachers’ technology use experiences, which led to reflection on the TPACK framework. For example, the analyses in this study showed that TCK might be a neglected construct in the TPACK framework, which was also acknowledged by Koehler and Mishra (2008). This indicates that continuous theoretical development is needed to strengthen the TPACK framework and to clarify the construct of TCK. Another example was that the TPACK survey used in this
study did not detect the participants’ TK change, while qualitative data showed evidence of increase in their TK. This indicates that improving the measurement of TPACK is another area that can attract attention for future research.

*On the practical level, this study prescribed how TPACK and LBD can be used as the basis of technology integration courses for preservice teachers.* By providing detailed description of the LBD model, elaborating on the instructional methods used in the model, and describing how to apply the model in a technology integration course, this study can guide practitioners on creating an LBD learning environment in technology preparation programs. By providing a deeper understanding of how LBD helps preservice teachers learn TPACK and the conditions which affect the effectiveness of the strategies in the model, this study can help practitioners understand how and why LBD takes effect in a specific context. It is with such understanding that LBD can potentially be applied in a wider context with careful and informed adaptation. Practitioners can make flexible adaptations to LBD according to the needs of their local contexts. Lessons learned in this study and the suggestions on how to improve LBD can guide practitioners to develop more effective technology preparation programs for preservice teachers to develop TPACK.

**Reflection on design-based research**

To explore effective and theory-grounded learning environment for preservice teacher technology preparation, the researcher used design-based research methodologies in this dissertation. As mentioned in the first paper, a design-based research study is characterized by the iterative cycles of testing and refinement of the target program because data from one research cycle is “rarely sufficient to gather enough evidence about the success of the
intervention and its effect on the problem solution” (Herrington, McKenney, Reeves, & Oliver, 2007). In this study, considering the time and large amount of data needed to complete a complete design-based research, the researcher decided to focus on only one cycle of testing and refinement. The analyses of the rich data collected from the first research cycle have yielded meaningful results and provided solid suggestions on how to refine the LBD model. Research activities in this study provided opportunities for reflection on conducting a complete design-based research within the time frame of a doctoral program.

**Having a solid plan for quick data analyses.** Design-based research is normally conducted in authentic settings. In real practice, the time between two implementations is usually short. Practitioners cannot wait for researchers to complete data analyses before they begin another round of implementation. Therefore, the data analyses after each round of implementation should be conducted quickly enough to make recommendation for future program implementation. Having a solid plan for quick data analyses thus is very important. A solid and sufficient data analysis plan can have two layers. The first layer is initial data analyses, which should be conducted immediately and in a relatively short amount of time to provide suggestion on the refinement. The second layer is in-depth data analyses, which can be conducted after the initial data analyses and provide more in-depth evidence to support the initial analyses.

**Designating data to provide evidence for quick decision making.** Scholars have proposed using both quantitative and qualitative data in educational technology research (Kay, 2006; Lei, 2009). Although qualitative data can provide evidence to assess the effectiveness of technology strategies (Kay, 2006), qualitative data normally requires much longer time to analyze. For example, in this study, the researcher completed the paired t-test analysis of the pre-
and post-survey and the quantitative content analysis of the reflection journals in a relatively quick manner. However, at that time when the researcher finished the above analyses, the interviews were not available for analysis because they had not been completely transcribed. Most of the evidence to indicate how and why LBD was effective was found in the student interviews. Therefore, although the initial analyses indicated that the LBD environment was effective, it was not clear how and why LBD was effective. Therefore, the quantitative data could not provide solid evidence to suggest refinement on the program.

To solve this problem, it would be practical to designate a portion of the data which can be analyzed in a relative short time to inform program refinement. Using this study as an example, the researcher can add a few open-ended questions to the post-survey, asking the participants what activities they felt most and least effective and the reasons behind their thoughts. Although their answers to the open-end questions may be less in-depth than their responses in the interviews, this portion of data does not require transcription and the small amount of data can be analyzed in a quicker manner. The result of analyses can also help the researcher to sample the interview data and locate the data that may provide evidence for refinement.

**Selecting a smaller scope when deciding on a research topic.** In this study, the researcher investigated the overall LBD environment. The scope of the topic required collecting data concerning every aspect of the learning environment. This was the major reason why the amount of data was large. The large amount of data and rich data sources were one of the strengths of this study. However, to conduct a complete design-based research study within the time frame of a doctoral program, it would be more practical for a researcher to focus on a smaller scope of instructional practices. For example, if the researcher in this study focused on
one or a few aspects of LBD, such as modeling or reflection, the scope of the dissertation study would have been more appropriate. In this way, the amount of data collected would be less and the analyses on the strategies can be more focused.

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EDUCATION

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JOURNAL PUBLICATIONS


BOOK CHAPTER


PROCEEDINGS


Lu, L. (2010). What happened when preservice teachers were required to teach with technology in field placement? Proceedings of the Twenty-First Society for Information Technology & Teacher Education (SITE) annual conference, San Diego, CA.


PRESENTATIONS


Lu, L. (2010). What happened when preservice teachers were required to teach with technology in field placement? Paper presented at the Society for Information Technology & Teacher Education (SITE) annual conference, San Diego, CA.


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**Instructor**, DD&E, Syracuse University

*Integrating Technology into Teaching II (IDE 300)*  
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- Designed a student-centered, project-based learning environment to teach undergraduate preservice teachers how to integrate basic and emerging information technologies into teaching;
- Designed and developed course syllabi, course contents, instructional materials, and assignments
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*Technology Mentor (EDU 500)*  
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**Instructor**, Department of East Asian Languages and Literatures, The Ohio State University  
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- Used the Acquisition Model Instruction (AMI) to design and teach the historical evolution of Chinese languages  
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**Teaching Associate**, IDD&E, Syracuse University  
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* For more detailed information about my teaching experience, please visit my teaching portfolio website at [https://sites.google.com/site/myteachingportfoliosite/](https://sites.google.com/site/myteachingportfoliosite/)

**PROFESSIONAL DEVELOPMENT IN TEACHING**

**Certificate in University Teaching**, Syracuse University  
**2009**

**Future Professoriate Program**, Syracuse University  
**2008-2009**

**INSTRUCTIONAL DESIGN / TECHNOLOGY EXPERIENCE**

**Blackboard Course Developer**, School of Education, Syracuse University  
**6/2010 – 8/2010**  
- Consulted with faculty to identify student learning needs  
- Surveyed the faculty’s technology needs for their course  
- Created a Blackboard course site for an introductory course in exercise science  
- Provided suggestions on integrating technology into the course

**Instructional Designer**, IDD&E, Syracuse University  
**9/2009 - 12/2009**  
- Designed and developed course syllabus, course contents, instructional materials, and assignments for an undergraduate technology course, *Integrating Technology into Teaching III (IDE 400)*

**Technology Helpdesk Coordinator**, Teaching and Leadership, Syracuse Univ.  
- Coordinated Helpdesk activities  
- Supervised two graduate assistants  
- Maintained the Sakai-based course management and e-portfolio system, SyrCLE  
- Documented procedures to maintain and use SyrCLE  
- Trained students and faculty to use SyrCLE  
- Consulted with preservice teachers and faculty on technology use  
- Organized training workshops on classroom technology use
**Instructional Designer & Instructor**, IDD&E, Syracuse University 1/2006-5/2008
- Project member in the NASA-sponsored Initiative to Develop Education through Astronomy and Space Science (IDEAS) after-school computer club
- Taught various technologies to 4th- to 6th-graders in the Syracuse City School District
- Helped students develop science projects related to astronomy and space science
- End product: An after-school computer club packet that can be used to develop similarly themed computer clubs

- Evaluated eight Read Ahead initiative literacy projects funded by Central New York Community Foundation.

- Designed and developed a module for the museum to train high school student volunteers

**ADDITIONAL PROFESSIONAL EXPERIENCE**

**Guest Speaker**, Graduate School, Syracuse University 8/2010
- Organized and spoke at two sessions of *Motivating Your Students* in the University Teaching Assistant Orientation (https://sites.google.com/site/motivatingyourstudents/)

**Guest Speaker**, *Say Yes to Education* Summer Institute, Syracuse University 6/2010
- Delivered a talk jointly with Dr. Jing Lei (doctoral advisor) to about 200 Institute counselors on strategies to integrate technology into PreK-12 classroom activities

**Graduate Assistant**, IDD&E, Syracuse University 9/2004 – 12/2004
- Substituted for the program administrator to develop IDD&E’s Two-Year Course Plan (2005-2007)
- Set up course schedules for 2005 summer and fall semesters

- Project member in *Liberty and Creativity* (funded by the Ministry of Education in China)
- Translated two chapters in the *Handbook of Creativity*
- Conducted research in the knowledge and creativity section of the project
- Research was developed into my MA thesis

**Graduate Assistant**, Graduate School, CCNU 10/2001 – 12/2002
- Managed all graduate students’ academic files
- Provided administrative assistance in the Student Affairs Office
- Helped organize local graduate student job fairs

**AWARDS & GRANTS**

**AECT/NSF Early Career Symposium Participant**, (one of the nine advanced doctoral student participants, $750 reimbursement for travel, lodging, and conference registration), Association for Education Communications and Technology 2012

**School of Education Conference Travel Grant** ($700/year), Syracuse University 2005-2012

**Syracuse University Graduate Student Association Travel Grant** ($400) 2011
American Educational Research Association Division K Graduate Seminar Travel Grant ($150) [withdrawn after being awarded] 2011
School of Education Creative Research Grant ($1000), Syracuse University 2010
Teaching Mentor Alternate, Graduate School, Syracuse University 2010
Graduate School Outstanding Teaching Assistant Award Nominee, Syracuse University 2010
Future Professoriate Program Stipend ($400/year), Syracuse University 2008, 2009
Syracuse University Summer Fellowship, Syracuse University 2005
Syracuse University Fellowship, Syracuse University 2003, 2005
Hongtao K Scholarship (prestigious award given to top students at universities in Hubei Province, RMB10000), Hongtao K Corporation, Wuhan, China 1999
CCNU Scholarships (awarded to top 5% students), CCNU 1998, 1999

CONFERENCE REVIEWER

Association for Educational Communications and Technology (AECT) annual conference 2010-2013
American Educational Research Association (AERA) annual conference 2010-2011
American Evaluation Association (AEA) annual conference 2006

UNIVERSITY SERVICES

- Attended monthly department faculty meetings
- Facilitated communication between doctoral students and faculty
- Organized brown bag sessions

IDD&E Chair Search Committee Member, IDD&E, Syracuse University 10/2006-5/2007
- Served as student representative on the committee
- Reviewed candidate application materials
- Collected and summarized student feedback about the candidates

IDD&E 60th Anniversary Celebration Technology Planning Committee Member, IDD&E, Syracuse University 4/2006-9/2006
- Developed technology committee work plan
- Designed contents and structure of the anniversary website
- Provided technical support to the anniversary activities

Vice President, Syracuse University Chinese Student & Scholar Association 6/2005-4/2006
- Key organizer of all activities organized by the association
- Participated in the design of the association’s website
PROFESSIONAL MEMBERSHIPS

Association for the Advancement of Computing in Education (AACE)

Association for Educational Communications and Technology (AECT)

American Educational Research Association (AERA)

Society of International Chinese in Educational Technology (SICET)