Development of Technological Pedagogical Content Knowledge (TPACK) in PreK-6 teacher preparation programs

Wei Wang
Iowa State University

Follow this and additional works at: http://lib.dr.iastate.edu/etd
Part of the Instructional Media Design Commons, and the Teacher Education and Professional Development Commons

Recommended Citation
Wang, Wei, "Development of Technological Pedagogical Content Knowledge (TPACK) in PreK-6 teacher preparation programs" (2016). Graduate Theses and Dissertations. 15833.
http://lib.dr.iastate.edu/etd/15833

This Dissertation is brought to you for free and open access by the Iowa State University Capstones, Theses and Dissertations at Iowa State University Digital Repository. It has been accepted for inclusion in Graduate Theses and Dissertations by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
Development of Technological Pedagogical Content Knowledge (TPACK) in PreK-6 teacher preparation programs

by

Wei Wang

A dissertation submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Co-Major: Education; Human Computer Interaction

Program of Study Committee:
Denise A. Schmidt-Crawford, Co-Major Professor
Ann D. Thompson, Co-Major Professor
Ana-Paula Correia
Amy Hutchison
Volker Heigelheimer

Iowa State University

Ames, Iowa

2016

Copyright © Wei Wang, 2016. All rights reserved.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GENERAL INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>PRESERVICE TEACHERS’ TPACK DEVELOPMENT: A REVIEW OF TPACK LITERATURE</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>What is TPACK?</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Historical Development of the TPACK Framework</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Background: Literature Reviews on TPACK</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Methodology</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Results</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Discussion</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Conclusion</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>52</td>
</tr>
<tr>
<td>3</td>
<td>EXAMINATION OF PRESERVICE TEACHERS’ DEVELOPMENT OF TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) AFTER COMPLETION OF CONTENT METHODOLOGY COURSES</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>Literature Review</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Methodology</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Findings</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>Discussion</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>Future Implication and Conclusion</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>90</td>
</tr>
<tr>
<td>4</td>
<td>A PREK-6 PRESERVICE TEACHER’S JOURNEY TO DEVELOP TPACK: A CASE STUDY</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>Literature Review</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td>Methodology</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td>Findings</td>
<td>115</td>
</tr>
<tr>
<td></td>
<td>Discussion</td>
<td>127</td>
</tr>
<tr>
<td></td>
<td>Conclusion</td>
<td>131</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>133</td>
</tr>
</tbody>
</table>
CHAPTER 5  GENERAL SUMMARY ................................................................. 140
  Summary ....................................................................................................... 140
  Recommendations for Future Research ...................................................... 143
  References .................................................................................................... 144

APPENDIX A. IRB MODIFICATION LETTERS AND ORIGINAL APPROVAL LETTER ................................................................. 148

APPENDIX B. SURVEY OF PRESERVICE TEACHERS’ KNOWLEDGE OF TEACHING AND TECHNOLOGY ................................................................. 151

APPENDIX C. STUDENT FOCUS GROUP INTERVIEW PROTOCOL .............. 165

APPENDIX D. INSTRUCTOR INTERVIEW PROTOCOL ................................. 167

APPENDIX E. TPACK-IN-ACTION OBSERVATION INSTRUMENT ................ 169

APPENDIX F. PRESERVICE TEACHER INTERVIEW PROTOCOL ............... 175

APPENDIX G. CONSENT FORM FOR PARTICIPANT .................................... 177

APPENDIX H. TPACK CODEBOOK SAMPLE ............................................. 183

ACKNOWLEDGEMENTS .................................................................................. 184
CHAPTER I. GENERAL INTRODUCTION

"Teaching" has long been identified as a complicated matter (Mishra, Spiro, & Feltovich, 1996; Spiro & Jehng, 1990). Numerous measures and studies have investigated the characteristics of good teaching (Kember et al., 2001; Lee et al., 2015; Ramsden, 1991). Discussions about what a teacher education program can do to successfully prepare teachers to teach in classrooms has been an ongoing topic. The early history of teacher education was primarily focused on teachers’ knowledge of subject matter content (Shulman, 1986). However, the focus later shifted to the effectiveness of general pedagogical methods independent of subject matter content (Cochran, Deruiter, & King, 1993). It was not until the late 80’s when people started to realize the importance of both teachers’ pedagogical knowledge and teachers’ subject matter (content) knowledge and that both were necessary components to good teaching and student understanding (Doyle, 1986; Feiman-Nemser & Buchmann, 1987).

With this recognition of a teacher’s pedagogical knowledge and subject matter (content) knowledge, Shulman (1986, 1987) suggested the concept of pedagogical content knowledge. At the time, this represented a new perspective that contributed to our understanding of teaching and learning. Based on Shulman’s (1986, 1987) definition of pedagogical content knowledge, this knowledge base represents how teachers relate their pedagogical knowledge to their content knowledge for teaching specific students in a school context. Grossman (1990) also defines the knowledge bases for teaching and their interrelationships as the following: “four general areas of teacher knowledge….as the cornerstones of the emerging work on professional knowledge for teaching: general pedagogical knowledge, subject matter knowledge, pedagogical content knowledge, and knowledge of context” (p. 5). Out of the knowledge bases defined, pedagogical
content knowledge (PCK) was anticipated to have the most impact on teachers’ actions in classroom settings. While we know that effective teaching depends on flexible access to well-integrated knowledge from different domains, knowledge of technology has yet emerged as another knowledge domain that requires further attention (Koehler & Mishra, 2009).

Problem Statement

As the result of recognizing the importance of further developing technology knowledge in teachers, teacher preparation programs started to design and teach curriculum with the focus on preparing teachers to use technology in classrooms. Traditionally, most teacher preparation programs offer a stand-alone educational technology course as a part of the preservice teachers’ professional program (Kleiner, Thomas, Lewis, & Greene, 2007; Lambert & Gong, 2010) to fulfill any stated technology requirements. While these educational technology courses typically help increase preservice teachers’ confidence in using technology, they sometimes fall short in promoting the meaningful use and integration of technology integration into preservice teachers’ teaching practices (Wachira & Keengwe, 2011).

In order to address the concern of promoting meaningful technology integration within a teacher preparation program, many researchers agreed that technology training for preservice teachers should be an integrated process that occurs throughout the entire teacher education program (Angeli & Valanides, 2009; Hughes, 2013; Tondeur et al., 2012). To better facilitate the integration process, Mishra and Koehler (2006) developed a conceptual framework called Technological Pedagogical Content Knowledge (TPACK). This framework emphasizes how technology knowledge, pedagogical knowledge, and content knowledge interact to enhance discipline specific technology learning experiences. Ever since the establishment of TPACK,
numerous researchers have developed related curriculum, texts, professional development modules, and advancements that complement the framework (Archambault, 2016). Recently, research in this area has shifted its focus to using various measurement methodologies to determine teachers’ development of TPACK.

Based on research methodology categories proposed by Gall, Gall, and Borg (2007), five types of TPACK measurements were identified. These measurements include 1) self-report measures (e.g., Archambault & Crippen, 2009; Lee & Tsai, 2010; Schmidt et al., 2009) that focus on survey development, 2) performance assessment rubrics (e.g., Angeli & Valanides, 2009; Harris, Grandgenett, & Hofer, 2010) that focus on analyzing teachers’ lesson plans; 3) open-ended questionnaires (e.g. Robertshaw & Gillam, 2010; So & Kim, 2009) that gather teachers’ written responses to pre-developed questions included in a questionnaire or survey; 4) interviews (e.g., Harris et al., 2012; Mishra, Peruski, & Koehler, 2007; Ozgun-Koca, 2009) that focus on collecting information using a list of various questions; and observations (Hofer, Grandgenett, Harris, & Swan, 2011; Koehler, Mishra, & Yahya, 2007) that investigate teachers’ teaching performances during classroom settings.

While more and more researchers developed instruments to measure teachers’ TPACK development, most studies were designed to investigate a single scenario or course. Only limited studies (Bate, Day, & Macnish, 2013; Hofer & Grandgenett, 2012; Schmidt et al., 2009) addressed the intention of extending the research conducted into a longitudinal investigation in which teachers’ TPACK development could be examined while completing their preparation program. Chai, Koh and Tsai (2010) also stressed the need and the importance of research to further investigate the development of TPACK using longitudinal data over time. Therefore, it seems worthwhile to explore the potential of collecting data over a longer period of time to
specifically examine how preservice teachers are developing TPACK during their teacher preparation program.

**Organization of the Dissertation**

This dissertation investigates whether preservice teachers majoring in elementary education or early childhood education, in the context of a teacher preparation program at a higher education institution, develop technological pedagogical content knowledge (TPACK) with the goal of having the capacity to successfully integrate technology while planning instruction and teaching in PreK-6 classrooms. The dissertation is presented in a non-traditional format including an introduction, three manuscripts prepared for journal publication, and a concluding chapter.

**Chapter 1: General Introduction**

This first chapter introduces the research topic, presents the statement of the problem investigated, outlines the main purpose of the dissertation and describes the organization of the dissertation chapters.

**Chapter 2: Preservice Teachers’ TPACK Development: A Review of TPACK Literature**

This article represents the literature review section of a traditional dissertation. It includes a review and critique of 88 articles between 2006 to 2015 with a focus specifically on research related to preservice teachers’ development of TPACK. Building upon Shulman’s (1986) pedagogical content knowledge and other prior research studies, Mishra and Koehler (2006) explicitly designed a conceptual framework called TPACK that includes technology as a third domain of knowledge, along with content and pedagogy. Based on the analysis of the literature,
this article examines the development of the TPACK framework with a specific focus on assessing preservice teachers’ TPACK development via five different research methods (self-report, open-ended questionnaire, performance assessment, interview, and observation). Two themes were found from the analysis results revealing the importance of technology integration modeling and the challenges of observing integrated knowledge domains (TCK, TPK).

Chapter 3: Examination of Preservice Teachers’ Development of Technological Pedagogical Content Knowledge (TPACK) After Completion of Content Methodology Courses

This article examines preK-6 preservice teachers’ development of technological pedagogical content knowledge (TPACK) through triangulated assessments (i.e., survey, interviews and open-ended questions) after completion of a series of required content methodology courses (required in literacy, math, social studies, and science). Data were collected at multiple times during the teacher preparation program: 1) prior to taking the required instructional technology class, 2) immediately after completing the required instructional technology class, and 3) after completing the required content methodology courses. Findings suggest that the methodology courses play a critical role in developing preservice teachers’ knowledge in content and pedagogy. Yet, lack of support for technology integration in actual classrooms may result in preservice teachers’ decrease of technology knowledge (TK), technology content knowledge (TCK) and TPACK domains.

Chapter 4: A PreK-6 Preservice Teacher’s Journey to TPACK: A Case Study

This case study investigates how prepared a preservice teacher was to use technology within literacy content instruction during a practicum experience. Data were collected in Spring
semester 2015 from one preservice teacher including survey responses from three data collection points, practicum classroom observations, and a follow-up interview. Findings revealed the preservice teacher was able to successfully integrate technology in her teaching during her practicum experience that demonstrated characteristics from all seven TPACK domains. However, it was possible that modeling from course instructors or supervising teachers and course content consistency might play an important role in preservice teachers’ TPACK development.

**Chapter 5: Synthesis and Recommendations**

The final chapter of this dissertation summarizes the findings of Chapter 2, 3, and 4 and presents recommendations for research and practical implications in the field of preservice teachers’ TPACK development. Potential limitations are also addressed in applying the alternative views proposed in the articles.
References


Archambault, L. (2016). Exploring the Use of Qualitative Methods to Examine TPACK. *Handbook of Technological Pedagogical Content Knowledge (TPACK) for Educators*, 65.


Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary issues in technology and teacher education, 9*(1), 60-70.


CHAPTER 2. PRESERVICE TEACHERS’ TPACK DEVELOPMENT: A REVIEW OF TPACK LITERATURE

A paper to be submitted to Journal of Digital Learning in Teacher Education

Wei Wang

ABSTRACT

Building upon Shulman’s (1986) pedagogical content knowledge and other prior research studies, Mishra and Koehler (2006) explicitly designed a framework called TPACK that includes technology as a third domain of knowledge, along with content and pedagogy. This literature review examines the development of the TPACK framework with a specific focus on assessing preservice teachers’ TPACK development via five different research methods (self-report, open-ended questionnaire, performance assessment, interview, and observation). A discussion of common themes along with limitations and future directions is provided.
Introduction

While researchers state that technology has become one of the essential components of teaching (Koehler & Mishra, 2009), there are still concerns that teachers do not have enough knowledge about and opportunities to use technology in their classrooms (U.S. Department of Education, 2010). Although teacher education programs recognize the importance of technology integration, these same programs have struggled to find effective program-level and instructional-level strategies that adequately prepare preservice teachers to integrate technology in their future classrooms (Goktas, Yildirim, & Yildirim, 2008). Typically, teacher preparation programs have required preservice teachers to enroll in one course that focuses on learning about technology (Beck & Wynn, 1998; Gronseth et al., 2010), while others have attempted to infuse technology into other education courses such as educational psychology or teaching methods (Wetzel, Foulger, Buss & Lindsey, 2014; Willis & Mehlinger, 1996). Thus, preservice teachers are expected to naturally transfer the technology knowledge and skills that they acquire from courses in their preparation programs to their future classrooms (Brush et al., 2003). However, merely having preservice teachers complete these courses may not be enough for the knowledge transfer and application of technology integration into their future classrooms to occur. Evidence suggests that preservice teachers still do not feel adequately prepared to effectively use technology in their classrooms (Kay, 2006; Polly et al., 2010).

These findings suggest that: a) teacher preparation institutions still need to address how preservice teachers are being prepared to use and integrate technology into their programs; and b) teacher preparation programs must work to further develop and incorporate methods that better infuse technology throughout the entire teacher education program and across content areas. In order to address these needs, Tondeur et al. (2011) suggest that rather than focusing on
how to use technology, preservice teachers must learn about how technology can be used for teaching and learning. Niess (2005) recommends that teacher preparation programs develop a multidimensional approach, which concentrates on preservice teachers’ development in teaching a particular subject area (mathematics/science) with technology each semester. More and more, educators agree that technology can no longer be treated as a separate body of knowledge that is isolated from the pedagogical and content knowledge that teachers require. To address this issue, Mishra and Koehler (2006) designed a conceptual framework, Technological Pedagogical Content Knowledge (TPACK) that provides a common language in talking about teaching, learning, and technology. The framework emphasizes the connections, interactions, affordances, and constraints between and among content, pedagogy, and technology (Mishra & Koehler, 2006). After the conceptualization of TPACK, researchers in the field have tried to incorporate the model in teacher education program and further developed methods to measure the degree of TPACK knowledge development.

This review of literature is organized around the methods and results found using five specific research methodologies most frequently used to measure preservice teachers’ TPACK development. In the following sections four major topics are addressed. First, a brief introduction to TPACK is provided to assist readers in reviewing this conceptual framework related to teacher knowledge and context. Next, the historical development of TPACK is shared along with a synthesis of prior literature reviews around TPACK. Finally, a focused review of literature around preservice teachers’ development of TPACK is presented.

What is TPACK?

Technological Pedagogical Content Knowledge (TPACK) was introduced to the educational research field as a conceptual framework for understanding teacher knowledge that
is required for technology integration (Mishra & Koehler, 2006). TPACK evolved from Shulman’s (1986) theory of pedagogical content knowledge (PCK) and focuses on the need for teachers to skillfully demonstrate their ability to integrate technology within the constructs of content and pedagogical domains. TPACK can be perceived as a teacher’s intuitive understanding for teaching subject-specific content with appropriate pedagogical methods and selected technologies. It is well understood that teaching is a complex cognitive activity that requires teachers to draw upon several types of knowledge (Koehler & Mishra, 2009). TPACK serves as a useful conceptual framework for thinking, analyzing, and evaluating what teachers must know to integrate technology into teaching, but ultimately it must be understood as a framework for ways in which teachers might best develop this integrated knowledge (Baran et al., 2011). To date, researchers have stressed the importance of teachers having a solid conceptual understanding of the interactions that occurs among technology, pedagogy, and content when planning instruction (Harris & Hofer, 2011; Koehler & Mishra, 2005). Some even further elaborate on how this understanding can lead to more effective teaching in classrooms (Hughes, 2005; Neiss, 2005; Zhao, 2003). This framework provides a critical perspective with which to view technology integration in classroom settings. Highlighting the integrated knowledge domains (such as TCK, TPK, PCK and TPACK) provides a model that reflects the complexity of the multifaceted lens of teacher knowledge that is needed to understand and define this framework.

The TPACK framework consists of seven components (see Figure 1). Definitions for each component follow:

- Technology knowledge (TK): Knowledge about different technologies, including both low-tech and high-tech technologies.
- Content knowledge (CK): Knowledge about the actual subject matter to be taught.
- Pedagogical knowledge (PK): Methods and processes of teaching a subject matter.
- Pedagogical content knowledge (PCK): The content knowledge that deals with the teaching process (Shulman, 1986).
- Technological content knowledge (TCK): Knowledge of how technology can create new representations for specific content.
- Technological pedagogical knowledge (TPK): Knowledge of how different technologies can be used in teaching, and to understand that using technology may affect how teachers teach.
- Technological pedagogical content knowledge (TPACK): Knowledge required by teachers when integrating technology into their teaching in any content subject area (Schmidt et al., 2009b, p. 125).

Figure 1. The TPACK framework illustration is adopted from http://tpack.org. Reproduced by permission of the publisher, © 2012 by tpack.org.
Historical Development of the TPACK Framework

Historically, teacher education programs have focused on developing a teacher candidate’s content knowledge (Veal & MaKinster, 1999) and his/her general pedagogical development in classroom practices (Ball & McDiarmid, 1990). Shulman (1986) considered treating these two knowledge domains separately as a problem. He then used this as a turning point to propose the idea of pedagogical content knowledge. Shulman argued that having knowledge of subject matter and general pedagogical strategies does not adequately characterize good teachers. He suggested that a teacher needs to master pedagogical content knowledge in order to become an expert teacher in a particular content field. However, this does not just stop here. When technology became more available, teachers and researchers started to realize the importance of technology use in the educational field and its impact on content and pedagogy respectively. Thus, teachers are expected to acquire the knowledge needed to be effective technology-using educators (CEO Forum, 1997).

There have been several attempts by researchers over the years to incorporate technology with Shulman’s ideas of pedagogical content knowledge (PCK). Pierson (1999) first proposed a theoretical model of technology integration based on her synthesis to include technological knowledge with Shulman’s framework called “technological-pedagogical-content knowledge” (p. 224). Based on this model, Pierson (2001) claimed that meaningful use of technology can only happen when a teacher views technology use as an integral part of the learning process.

Later, Margerum-Leys and Marx (2002) suggested that using computer technology may help increase students’ performance. However, they also pointed out that in order to skillfully utilize instructional technology in classrooms, teachers are required to have comprehensive and multi-directional knowledge. These researchers examined the construct of teacher knowledge of
educational technology through the lens of Shulman’s model of teachers’ knowledge—content knowledge, pedagogical knowledge, and pedagogical content knowledge. Using Shulman’s model to analyze the collected observational data, a new “knowledge set” was revealed and was coupled with the practice of educational technology. Margerum-Lyes and Marx referred to this new knowledge set as “Pedagogical Content Knowledge of Technology” (p. 446).

Niess (2005) stated in her study that it has been challenging to ask teacher candidates to teach from an integrated knowledge structure when teaching content-specific matters. Niess then emphasized the importance for preservice teachers (especially future science and mathematics teachers) to develop an overarching conception of their subject matter with respect to technology and what it means to teach with technology. Niess identified this specific teachers’ knowledge base as “a technology PCK (TPCK)” (p. 510) and described it as when technology becomes an integral component of teaching.

Building upon these prior research studies, Mishra and Koehler (2006) designed a framework that includes technology as a third domain of knowledge, along with content and pedagogy; further developing these ideas into a visual conceptual framework that depicts necessary teacher knowledge. Initially, the framework was recognized as TPCK, but was later renamed TPACK for ease of pronunciation and to capture the representation of the three knowledge domains as a “Total PACKage” instead of three isolated domains (Thompson & Mishra, 2008, p. 38). Again, this framework suggests that content, pedagogy, and technology knowledge are equally important in developing meaningful teaching in a particular context. In addition, the TPACK framework emphasizes the importance of preparing teachers to make sensible choices while using technology when teaching specific content to a target group of learners. It is worth noting that this framework does not require one single pedagogical
orientation; it embraces using a variety of pedagogical approaches of teaching and learning (Harris & Hofer, 2011).

**Background: Literature Reviews on TPACK**

Four specific literature reviews focused on TPACK research were conducted and published between 2011 and 2013. The purpose of these literature reviews is to provide scholars in the field with an overview of how the framework has evolved, how can it be used in different contexts related to teachers’ development of TPACK and what are the research methods that are used in measuring TPACK (See Table 1).

One review specifically examined the development of the TPACK framework with a particular focus on assessing TPACK in the context of preservice teacher preparation programs (Abbitt, 2011). This review also provides an overview of the instruments and methods as well as the challenges and the implications of the uses of related TPACK-based evaluation.

Table 1.

*Summaries of Past TPACK Literature Reviews*

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year of Studies Included</th>
<th>Number of Studies</th>
<th>Study Focus</th>
<th>Category Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Abbitt, 2011)</td>
<td>2005-2010</td>
<td>91</td>
<td>· Highlighting emerging instruments and methods used</td>
<td>· Development of the TPACK Framework</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>· Challenges, purposes, and potential uses of the tools for TPACK-based</td>
<td>· Challenges of Measuring TPACK</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>evaluation for preservice teacher preparation experiences</td>
<td>· Developing a Self-Reporting Measure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>· Performance-Based TPACK Measures</td>
</tr>
<tr>
<td>(Koehler, Shin &amp; Mishra, 2012)</td>
<td>2006-2010</td>
<td>66</td>
<td>· Identifying empirical studies that utilized TPACK assessments</td>
<td>· Self-Report Measures</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>· Investigating how each measure address the issues of validity and reliability</td>
<td>· Open-End Questionnaire</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>· Performance-Based Assessments</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>· Interviews</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>· Observations</td>
</tr>
</tbody>
</table>
Koehler et al. (2012) further investigated 141 instruments included in 66 studies that focused on measuring TPACK knowledge development. Five major approaches (i.e., self-report measures, open-ended questionnaires, performance assessments, interviews and observation) were identified to be the commonly used measurement methods used in TPACK focused studies. In this analysis, it is clear that open-ended questions and instrumentation were used less often in TPACK-related studies given the complexity of data coding and analysis needed. Another major finding discussed at length by Koehler and others were issues related to how validity and reliability were addressed in this collection of studies.

Chai et al. (2013) agreed that various research methods employed in TPACK-focused research have generated positive results in enhancing teachers’ capability to integrate ICT (Information and Communications Technology) into instructional practice. These authors
suggest there are still many potential gaps where the TPACK framework might be used to guide deeper change in education. To be specific, they suggest more development and research of technological environments based on TPACK; more examination of students’ learning conception with technology; and cross-fertilization of TPACK with other theoretical frameworks related to the study of technology integration.

Finally, Voogt et al. (2013) in their review of literature ascertain that is difficult to locate studies related to teachers’ TPACK development in subject area domains. This review found two major categories of research and scholarly focus underpinning the literature: 1) studies discussing and refining the theoretical basis of TPACK, and 2) studies addressing practical issues of measurement and teachers’ professional development. This research group concluded that teacher knowledge about TPACK and beliefs about pedagogy and technology are intertwined.

Findings from past literature reviews focusing on TPACK provide clear evidence that the study of TPACK is extended across various contexts throughout education as researchers examine the development of teacher knowledge in specific domains. Of the four prior literature studies mentioned, three investigated TPACK in a variety of contexts including higher education and K-12 environments, and with both inservice and preservice teachers. Although Abbitt’s review (2011) highlights the instruments and methods used for specifically studying preservice teachers’ TPACK development, additional methods and instruments have since been developed and used. Therefore, it is worth investigating the current state of preservice teachers’ TPACK development in the literature. In the following sections, this review of literature provides a systematic synthesis of how preservice teachers’ development of TPACK has been measured and reported in the literature. The methodology used to conduct this review of literature focusing on the studies involving preservice teachers’ TPACK development is shared next.
Methodology

This review of literature seeks to understand what the TPACK research community has done to investigate the development of preservice teachers’ TPACK while being enrolled in their teacher preparation programs. The research questions guiding this literature review are:

What Technological Pedagogical Content Knowledge (TPACK) do preservice teachers develop while completing their teacher preparation program?

What research methodologies have been used to measure preservice teachers’ development of TPACK?

In order to help identify articles that address these research questions, an explanation of the search procedures used to locate the articles and the inclusion criteria are described next.

Search Procedures

The search for articles was conducted in three scientific databases (i.e. Education Resources Information Center (ERIC), PsycINFO and Mendeley TPACK Research Group) during September 2015 and was limited to peer-reviewed articles published between (January) 2006 and (September) 2015. The keywords employed were “technological pedagogical content knowledge” and “TPACK or TPCK”. After cross-checking the reference lists in these data sources, a master reference list of articles addressing specifically preservice teachers’ development of TPACK was created. A total of 501 articles were identified after the initial search process.

Once all of the manuscripts using the sampling procedures described above were collected, the following inclusion criteria items were utilized to evaluate each research study:

a. The purpose of the study was to measure TPACK (teacher’s knowledge);
b. The study involved preservice teachers;
c. The study is empirical research (quantitative and/or qualitative);
d. The study is written in English;
e. The study is published between 2006 and (September) 2015.

Out of the 501 articles identified during the initial search process, a total of 88 studies met the inclusion criteria stated above (see Table 2). Thus, 413 studies were excluded from the analysis for the following reasons:

a. The study was grounded in the TPACK framework but did not measure teachers’ development of TPACK;
b. The participants of the study were not preservice teachers;
c. The article only described conceptual/theoretical understanding around TPACK;
d. The author could not retrieve the actual text due to lack of access to both electronic and/or hard copies of the article.

Table 2.

**Characteristics of the (N=88) studies in the review**

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of Studies</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source of the studies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journal articles</td>
<td>85</td>
<td>96.6%</td>
</tr>
<tr>
<td>Conference proceedings</td>
<td>3</td>
<td>3.4%</td>
</tr>
<tr>
<td>Year of publication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>2008</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>2009</td>
<td>7</td>
<td>8%</td>
</tr>
<tr>
<td>2010</td>
<td>7</td>
<td>8%</td>
</tr>
<tr>
<td>2011</td>
<td>15</td>
<td>17%</td>
</tr>
<tr>
<td>2012</td>
<td>16</td>
<td>18%</td>
</tr>
<tr>
<td>2013</td>
<td>29</td>
<td>33%</td>
</tr>
<tr>
<td>2014</td>
<td>12</td>
<td>14%</td>
</tr>
</tbody>
</table>
While many TPACK studies have utilized research methods that include collecting self-report data from preservice teachers using surveys (Chai, Koh, & Tsai, 2010; Koehler & Mishra, 2005; Sahin, 2011; Schmidt et al., 2009), other research methodologies have emerged and are used to systematically examine the development of preservice teachers’ TPACK. Adapted from a recent synthesis of the research literature around TPACK (Gall, Gall, & Borg, 2007; Koehler, Shin, & Mishra, 2012), a total of five categories of research methods were identified as being used to document preservice teachers’ TPACK development (see Figure 2): 1) self-report measures (i.e., Likert scale), 2) open-ended questionnaires (i.e., written responses from questionnaire questions), 3) performance assessments (i.e. rubric, performance task, create artifact, lesson plan, content analysis, and reflections), 4) interviews (i.e., oral responses), and 5) observations (i.e., taking field notes, video recording a lesson). Moreover, the researcher focused on finding recurring patterns or keywords from the articles from each category. After identifying the recurring patterns and keywords, the researcher categorized them as themes. Each category has a least one to three themes identified. It is also worth noting that over time, researchers interested in investigating TPACK began to utilize more than one research methodology to understand how preservice teachers develop their TPACK. When conducting research that involves mixed methods measurement for TPACK development, researchers typically use two or more data sources for data analysis. Thus, some studies included in this review were conducted using both quantitative (i.e. survey) and qualitative methodology (i.e. observation, open-ended questions, interview, performance rubric or artifacts). It was typical in these studies that the data gathered using multiple measures were collected to triangulate the results. Since many of the studies the author reviewed implemented multiple measures to assess TPACK, the author double-counted or triple-counted each study if two or more types of TPACK measures were
used. As a result, there are five studies that utilized the mixed method in self-report measurement; twenty-three studies that utilized the mixed method in performance assessment measurement; three studies that utilized open-ended questionnaire measurement; eight studies that utilized the mixed method in interview measurement, and eight studies that utilized the mixed method in observation measurement.

In the following section, a synopsis of these five research methodologies categories follows.

![Summary of measures for preservice teachers’ TPACK development](image)

*Figure 2. Articles in each measurement category used to document preservice teachers’ TPACK development.*

**Results**

In this section, a synopsis of the five research methodologies categories (self-report measure, open-ended questionnaire, performance assessment, interview, and observation) is provided. In addition, a summary of the result of preservice teachers’ TPACK development is also provided for each category.
Self-report Measures

Self-report measures typically use instruments with questions where participants rate their self-perceived knowledge related to the technology, pedagogy, and technology domains and the interplay between each domain. In most studies, specific groups of preservice teachers are surveyed and the selected self-report measures usually include multiple sub-scales aligned to some or each TPACK domain (e.g., TK, PK, CK, PCK, TPK, TCK, TPACK). Based on the analysis, there are 42 studies identified in this literature review that used the self-report measure as a method to measure preservice teachers’ development of TPACK (see Table 3). Effect size is considered to be important method used in Meta-analyses with quantitative measures (Fritz, Morris, & Richler, 2012). Self-report measures typically utilize a survey instrument as the method for measuring the outcomes. And, the survey is one the most used quantitative instruments in educational research. Therefore, there is a need to include effect size to ensure the same method can allow researchers to develop a more generally interpretable, quantitative description of the size of an effect. An effect size describes the size of observed effects that is independent of the possibly misleading influences of sample size. Studies with different sample sizes but the same basic descriptive characteristics (e.g., distributions, means, standard deviations) will differ in their statistical significance values but not in their effect size estimates. Effect sizes can also allow the comparison of effects in a single study and across studies in either formal or informal meta-analyses. It was worth noting that in 42 studies examined for this review, only 9 studies contain information about effect size calculation for quantifying the effectiveness of particular interventions.
Table 3.

**Major themes in self-report measure category**

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Number of Studies</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Chai et al., 2011; Chai et al., 2013; Han et al., 2013; Horzuma, 2013; Hughes, 2013; Pamuk, 2012; Semiz &amp; Ince, 2012; Tokmak et al., 2013; Young et al., 2013)</td>
<td>9</td>
<td>Effective modeling from teacher education program can enhance preservice teachers’ TPACK development.</td>
</tr>
<tr>
<td>(Kaya et al, 2013; Rohaan et al., 2012; Zhan et al., 2013)</td>
<td>3</td>
<td>Teaching experience may impact preservice teachers’ TPACK development.</td>
</tr>
<tr>
<td>(Kabakci Yurdakul et al., 2014; Koh et al., 2013; Meriç, 2013)</td>
<td>3</td>
<td>Technological Knowledge (TK) has strong correlation with TPACK development.</td>
</tr>
</tbody>
</table>

Note. 1) The asterisk (*) represents studies that utilize more than one method. 2) Only included some major studies that represented each finding.

While first generation TPACK research focused on defining the seven constructs of TPACK, the second generation of studies have shifted to focusing on using the framework to examine teachers’ knowledge of integrating technology, hence, TPACK, to facilitate and enhance their teaching and whether such knowledge develops through technology interventions. Building on the history of using survey methodology to examine teachers’ knowledge with regards to technology integration, researchers began designing survey instruments to assess teachers’ TPACK. Although several survey instruments were developed to examine inservice and preservice teachers’ TPACK (Archambault & Crippen, 2009; Jamieson-Proctor et al., 2007; Lee & Tsai, 2010), Schmidt et al. (2009) followed with a validation study for a survey (Survey of Preservice Teachers’ Knowledge of Teaching and Technology) specifically designed for...
preservice teachers who were majoring in elementary or early childhood education. The internal consistency reliability (coefficient alpha) for this survey ranged from .75 to .92 for the seven TPACK subscales. Within a pre- and post-survey design, Schmidt et al. (2009) reported that after completing an introductory instructional technology course statistically significant gains were found in all seven knowledge domains among 87 preservice teachers, with the largest growth in the areas of TK, TCK, and TPACK.

Further article analysis for this review revealed that the original Schmidt et al.’s (2009) TPACK survey instrument underwent numerous adaptations by researchers based on the nature of phenomena on which each study focused. Descriptive information concerning those changes was given and categorized with respect to retained items, added items, removed items, adapted items or subject focus, Likert scale used, and the final number of items covered by the adapted surveys. For example, in the Chai et al.'s study (2010), the Schmidt et al. survey was changed from a 5-point Likert scale to a 7-point scale. And the CK related questions were changed to incorporate subject matter that Singapore preservice teachers would typically be required to teach. The Chai et al. survey was validated using factor analyses and the preservice teachers’ TPACK perceptions before and after their ICT course were examined. The results reveal statistically significant gains with good effect sizes larger than 0.60 (Cohen, 1969). Regression analysis further revealed that technological knowledge, pedagogical knowledge, and content knowledge were all significant predictors of preservice teachers’ development of TPACK, with pedagogical knowledge having the largest impact. Another study, Kaya & Dag, 2013, translated the Schmidt et al. TPACK Survey (2009) into Turkish language and then investigated its factor structure through exploratory and confirmatory factor analysis. The participants were 352 elementary preservice teachers from three large universities in northwestern Turkey. Cronbach
Alpha reliability coefficients of subscales ranged between 0.77 and 0.88. Exploratory factor analysis results showed that the factor structure of the Turkish version of the survey was similar to the original version. According to the confirmatory factor analysis results, the goodness of fit indices indicated a good model fit. Based on the results, it was concluded that the Schmidt et al. TPACK Survey is a reliable and valid measure for use with Turkish preservice teachers.

While some studies continued to adapt existing instruments, some researchers designed additional survey instruments to further investigate TPACK. Sahin (2011) developed a survey consisting of seven subscales representing the TPACK model’s seven knowledge constructs. The instrument initially included 60 items but was reduced to 47 items after expert evaluation. Then, exploratory factor analysis (EFA) was conducted to examine the construct validity and the factor structure of the survey. The EFA results show the survey items for each subscale successfully measure each TPACK knowledge construct. The internal consistency scores for each subscale calculated are determined as 0.93 for TK, 0.90 for PK, 0.86 for CK, 0.88 for TPK, 0.88 for TCK, 0.92 for PCK, and 0.92 for TPACK. Results demonstrated Sahin’s TPACK survey is a valid and reliable measure.

With the overarching goal of helping Australian Education Institutions to implement the national Teaching Teachers for the Future (TTF) intervention to all preservice teacher education programs, Jamieson-Proctor et al. (2013) developed and validated a survey instrument related to TPACK. The TTF TPACK Survey instrument developed for the TTF Project was informed by earlier work on the measurement of TPACK and ICT integration in classrooms (Jamieson-Proctor & Finger, 2009; Jamieson-Proctor, Watson, Finger, Grimbeek & Burnett, 2007). The development of this particular instrument was guided by the TTF Research and Evaluation Working Group and incorporated additional items with the intent to extend an earlier developed
TPACK Confidence Survey (TCS) (Albion, Jamieson-Proctor & Finger, 2010), in order to meet the particular needs of the TTF project. The data collected were subject to a battery of complementary analysis procedures using both the pre (N=12,881) and post (N=5,809) preservice teacher data. In this study, exploratory factor analysis was conducted to examine how the twenty-four items were measured. Two factor loadings (confidence and usefulness) were identified with Cronbach's Reliability Coefficient of .99 and .98. It was recommended by the developers that this instrument would help explore current theoretical frameworks with respect to the teacher knowledge bases required when using ICT in the curriculum.

Various existing survey instruments provide a straightforward and useful self-reporting measure of TPACK for use with preservice teachers. However, another trend from the analysis shows an additional focus for investigating specific subject matter in preservice teachers’ TPACK development. For example, Lin et al. (2013) explored science teachers' perceptions of technological pedagogical content knowledge (TPACK) addressing their perceptions of the affordances of technology application in instruction. A total of 222 preservice and inservice science teachers in Singapore were surveyed. Structural equation model analysis was utilized to examine the TPACK model involving the seven domains. The result of this study confirmed all the correlations between the latent variables of the seven-factor TPACK model were identified as significant. Besides, the science teachers’ TPACK was highly correlated with their TCK (.83), TPK (.76), and TK (.70). The results may suggest that science teachers who perceive self-confidence in the synthesized knowledge of technology, pedagogy, and content possess a similar level of confidence in the knowledge involved with emerging technologies.

Analysis of the results from the TPACK studies that used the self-report measure as a research methodology revealed three major themes. The first theme is about how effective
modeling from teacher educators can enhance preservice teachers’ TPACK development. It was understood that with various opportunities to observe how to use technology in the courses offered by the teaching in teacher preparation program can enhance TK-related knowledge (Horzuma, 2013; Tokmak et al., 2013; Young et al., 2013). On the other hand, Semiz and Ince (2012) specified the risks of negatively impacting preservice teachers’ TPACK development if teacher educators provided poor technology integration modeling. It was also revealed in both the studies of Chai et al. (2013) and Pamuk (2012) that although preservice teachers all showed development in their core knowledge domains (TK, CK, and PK), without sufficient teaching experience, preservice teachers had difficulties developing integrated knowledge domains. It was recommended by the authors that teacher preparation programs will need to provide opportunities to demonstrate how to integrate technology effectively in teaching.

The second theme that emerged from the analysis is how teaching experience may impact preservice teachers’ TPACK development. Rohaan et al. (2012) indicated that more experience in teaching technology related knowledge during classes will stimulate the development of preservice teachers’ PCK, which will again lead to more confidence in teaching and more positive attitudes. Both Kaya et al. (2013) and Zhan et al. (2013) confirmed the same hypothesis, but also pointed out that lack of teaching experience may greatly affect preservice teachers’ overall TPACK development. Specifically, with sufficient amount of teaching experience, preservice teachers’ will enhance their PCK and TPACK development.

The third theme that emerged from the analysis is that TK has a strong correlation with TPACK development. The research results from Meriç’s study (2013) are parallel to what Chuang and Ho (2011) say in that TK knowledge is necessary for TPACK knowledge, but it does not guarantee TPACK. Kabakci Yurdakul et al. (2014) specified similar research findings;
the structural regression model demonstrated that technology usage (TK) had direct influence on TPACK competencies. In the other words, the technology usage phase and level were significant predictors of TPACK competency.

**Open-ended Questionnaires**

Open-Ended Questionnaires typically ask preservice teachers to respond to different types of questions (prompts) regarding their overall experiences in instructional technology courses with an emphasis on TPACK development or their teaching experiences. There are 8 research studies reviewed that used an open-ended questionnaire format for gathering data from preservice teachers (see Table 4).

Table 4.

**Major themes in open-ended questionnaire category**

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Number of Studies</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Valtonen et al., 2011)</td>
<td>1</td>
<td>There was limited TK, PK and TPK development from first-year preservice teachers.</td>
</tr>
<tr>
<td>2 (Mouza et al., 2014)</td>
<td>1</td>
<td>Positive TCK development helps situate preservice teachers to teach in specific discipline.</td>
</tr>
<tr>
<td>3 (Calik et al., 2013; Kennedey-Clark, 2011; Tokmak, 2013*)</td>
<td>3</td>
<td>There was positive preservice teachers’ TPACK development due to proper modeling.</td>
</tr>
<tr>
<td>4 (Robertshaw &amp; Gillam, 2010)</td>
<td>1</td>
<td>Preservice teachers improved in TK, TCK, PCK and TPACK knowledge development.</td>
</tr>
</tbody>
</table>
Table 4. (continued)

<table>
<thead>
<tr>
<th></th>
<th>(Ozgun-Koca, 2009*)</th>
<th>1</th>
<th>TK knowledge increased significantly and has positive impact on TPACK development.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>(So &amp; Kim, 2009*)</td>
<td>1</td>
<td>Preservice teachers understood the importance of TK and PK, but they did not translate it into TPACK development.</td>
</tr>
</tbody>
</table>

Note. The asterisk (*) represents studies that utilize more than one method.

A typical example can be found in So and Kim’s (2009) study about the relationship between TPACK and practice in a study with preservice teachers. The questionnaire they used for this study contains five demographic items (gender, age, teaching experience, types of teaching subject and school, and Problem-Based Learning (PBL) exposure) and five open-ended items on perceptions of PBL (pedagogy) and ICT (technology). The questionnaire was developed to identify participants’ understandings, misconceptions, and difficulties in integrating both ICT and PBL in classrooms. For example, one of the research questions states, “What do you see as the main strength and weakness of integrating ICT tools into your PBL lessons?” Thus, in the creation and development process of open-ended questionnaires, questions should be created for assessing the overall experience of the respondents. Two coders identified types and frequencies of common themes that emerged from preservice teachers’ responses to the five open-ended items in this survey. For the purpose of this study, the representations of content knowledge were evaluated in relationship to the pedagogical and technological designs in the rubric.

Similar to the previous study, Tokmak et al. (2013) focused on preservice teachers’ opinions about their communication experience via e-mail and chat programs. The open-ended questions included in the questionnaires for this study focused on what the preservice teacher took into account while communicating both synchronously and asynchronously; whether there
was a change in terms of procedure while communicating on the Internet and face-to-face; what difficulties they met during communicating on the Internet versus face-to-face; and what they gained from this activity. The study revealed that preservice teachers gained essential competencies in instructional material design. Moreover, the results expressed that preservice teachers gained experience in incorporating TPACK into their future teaching practices.

Analysis of the results from the TPACK studies that used open-ended questionnaires as a research methodology revealed one major theme: modeling by course instructor contributed to preservice teachers’ TPACK development. By following proper guidelines or demonstrations from course instructors, preservice teachers learned how they could effectively integrate educational technologies into coursework or teaching with specific content related ideas. In Calik et al.’s study (2013), constant demonstrations of how to use technology in content from the content-specific course instructor (in chemistry) significantly enhanced senior science preservice teachers’ TPACK in a chemistry elective course and practicum. Kennedy-Clark (2011) also stated the need for establishing a proper modeling structure for preservice teachers who are typically inexperienced in pedagogy and content area knowledge, so that it can promote effective technology integration in actual classrooms.

Preservice teachers from other individual studies showed various growth in TPACK development. For instance, preservice teachers showed improvement in TK, PCK, TCK and TPACK (Robertshaw & Gillam, 2010), while another study reported that when preservice teachers showed a significant increase in TK that may contribute to the overall development of TPACK (Ozgun-Koca, 2009). However, it was also understood that despite the fact most preservice teachers were recognized as being digital natives (Prensky, 2001), they may not be able to recognize the connection between technology and teaching right away (Voltonen et al.,
2011). Even though preservice teachers acknowledge the importance of using technology and effective pedagogical approaches, most still have difficulty developing pedagogically sound, and content-specific teaching approaches with effective technology integration (So & Kim, 2009). Based on the written responses from preservice teachers, researchers were able to see initial responses regarding technology integration in teaching. However, more in-depth written reflections and artifacts are needed to monitor the changes.

Performance Assessments

Performance-based measures are another popular research method used in studies focusing on preservice teachers’ TPACK development (Koehler, Shin & Mishra, 2012). This specific method typically develops ways to assess TPACK by using artifacts (Abbitt, 2011), or by completing a task, or a product resulting from some type of performance (Gall et al., 2007). Some TPACK performance assessments consist of scenario or problem-based questions that require a solution (Graham, Tripp & Wentworth, 2009). There are 35 studies identified in this literature review that used performance assessment as a method to measure preservice teachers’ development of TPACK (see Table 5).

Table 5.

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Number of Studies</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Angeli &amp; Valanides, 2013; Agyei &amp; Voogt, 2012; Graham et al., 2009; Jang &amp; Chen, 2010; Kramarski et al., 2010; Meagher et al., 2011; Mouza &amp; Karchmer-Klein, 2013*)</td>
<td>14</td>
<td>Scaffolding or modeling can foster preservice teachers’ TPACK knowledge development.</td>
</tr>
</tbody>
</table>
Three major rubric tools have been developed to date to assess teachers’ TPACK development and technology integration. Harris, Grandgenett, and Hofer (2010) adapted a rubric from the Technology Integration Assessment Instrument (Britten & Cassady, 2005) to assess preservice teachers’ TPACK. In a validation study, experienced educators each had rated fifteen lesson plan documents that targeted various content areas and grade levels from the same course for a two-year period using an adapted rubric instrument. The raters provided ratings ranging from one to four (four being the best) for the specified categories such as “Curriculum Goals & Technologies,” “Instructional Strategies & Technologies,” “Technology Selections,” and “Fit.” Based on the acknowledgment of the instrument being validated and reliable with Cronbach’s Alpha calculated as .91 and internal consistency calculated as .90, it was later widely used in other studies with different contexts as well (Hofer & Grandgenett, 2012; Kopcha et al., 2014). Typically, this validated rubric is used for evaluating such performance-based activities such as designing a project plan, writing a lesson plan or creating a portfolio. In Hofer and Grandgenett’s (2012) study, the rubric was used to assess the lesson plans developed by 17 preservice teachers enrolled in an eleven-month secondary Masters of Arts Education program. Results revealed that with lesson-related scaffolding during the classes, preservice teachers demonstrated significant knowledge in technological pedagogical knowledge (TPK) and technological pedagogical content knowledge (TPACK) in their developed lesson plans, but only limited growth in technological content knowledge.
In 2012, another performance-based assessment was designed to assess teachers’ integration of self-regulated learning (SRL) while infusing technology into a TPACK classroom context. The tool reflects all three knowledge components’ dynamic interactions with SRL and test instrument's validity and reliability as a practical tool for measuring effects of teacher education (Kohen & Kramarski, 2012). The TPCK-SRL scheme was used to assess nine preservice teachers’ lesson design, collected before and after taking a course on TPCK Teaching and Learning Methods. Results from the posttest lesson designs revealed specific, qualitative TPCK-SRL descriptions that referenced TPACK components and SRL considerations (what, how, when, and why to infuse technology), thus providing content validity for the scheme.

Koh (2013) later shared a validated rubric to analyze 55 Singaporean preservice teachers’ lesson activities to determine the strengths and weaknesses of the preservice teachers’ TPACK for meaningful learning with ICT in practice. The study describes the conception, validation, and implementation of a rubric for assessing ICT lesson activities with respect to the dimensions of meaningful learning with ICT. Findings suggest that the ICT module was successful in developing the preservice teachers' TPACK for meaningful learning with ICT for the active dimension. However, other dimensions (constructive, authentic, intentional, and cooperative) were rated at lower levels of development. This result could be connected to insufficient exposure to such kinds of advanced learning experiences (e.g., utilized specific approach for subject matter with technology) as preservice teachers, given that Singaporean classroom practices are largely teacher-centric and focused on information acquisition for exam preparation (Gao, et al., 2009; Hogan & Gopinathan, 2008; Lim & Chai, 2008).

Some TPACK studies reviewed used performance assessments such as reflections to assess teachers’ TPACK development. Norton (1994) emphasized the importance of including
reflective journals and reflective experiences as part of a preservice teacher’s professional development during a teacher preparation program. By writing reflective journals, preservice teachers could then identify teaching problems and improve their teaching skills (Ekiz, 2006). When reflecting upon one’s experiences becomes a habit of mind, conscious teaching occurs (Freese, 1999; Kincheloe et al., 1999; Larrivee, 2000). Koh and Divaharan (2011) assessed 74 preservice teachers’ individual course reflections. The results revealed that these preservice teachers predominantly developed Technological Knowledge (TK) and Technological Pedagogical Knowledge (TPK). The authors suggest more emphasis on subject-focused pedagogical modeling, product critique, and peer sharing may better develop preservice teachers’ Technological Content Knowledge (TCK) and TPACK. Maeng et al. (2013) utilized a similar research design to investigate preservice secondary science teachers’ technology-enhanced inquiry instruction and their developing TPACK. A reflective paper was used to investigate whether preservice teachers’ TPACK changed at all during this intervention. Results from preservice teachers’ reflection journals revealed that participants perceived the value of using technologies and believed educational technology can support and facilitate non-experimental and experimental inquiry experiences. Participants developing TPACK was evidenced by their selective and appropriate use of technology.

Analysis of the results from the TPACK studies that used performance assessment measures as a research methodology revealed two major themes. The first theme is scaffolding or modeling can foster preservice teachers’ TPACK knowledge development. Kramarski et al. (2010) described the complexity for preservice teachers to develop their understanding about TPACK. Therefore, it was recommended that a focus on teaching about the interactions among technology, content, and pedagogy is needed. Mouza and Karchmer-Klein (2013) also shared
that preservice teachers may not have a deep understanding of pedagogy when they first started the program. As a result, they may need to acquire more classroom experiences with technology integration modeling or teaching tryouts (Agyei & Voogt, 2012) or instructional design tasks (Angeli & Valanides, 2013) before they can exhibit a more sophisticated integration of TPACK.

Not only can modeling from instructors of the teacher preparation program be influential, there are also studies indicating peer mentor feedback and field instructors can play a major role. In Jang and Chen’s study (2010), it was revealed that through peer coaching and online discussion, preservice teachers could exchange their ideas and opinions when they had questions about the course. These strategies provided preservice teachers with an avenue to receive instant feedback and learn related pedagogical content knowledge with technology. The mentors’ approach and involvement indicated their potentially strong impact on the development of preservice teachers’ TPACK. Then, it was important that preservice teachers were provided with authentic opportunities to experiment with teaching approaches. On the other hand, both Graham et al. (2009) and Meagher et al. (2011) stated the impact field experience and field instructor can have. Graham et al. (2009) further explained the negative impact when field instructors do not have the concept of TPACK, preservice teachers could potentially be discouraged to use technology because of the experience. The finding highlighted the importance of providing good models of technology use to the field instructors as well as to the teacher candidates.

The second theme emerged from the analysis is the challenge to identify the development in integrated knowledge domains. Pamuk (2011) pointed out that while preservice teachers may have demonstrated some degree of knowledge in technology, pedagogy, and content, their ability to use knowledge bases and their attempts to create new knowledge bases, like TPK, were limited. This finding may be principally due to lack of teaching experience. Hosseini and Tee
(2012) revealed in the results of their study that developing integrated knowledge bases based on different teaching components can be difficult for preservice teachers because it requires a deep understanding of core knowledge and interpretation of the teaching context and its dynamics. Kopcha et al. (2014) also revealed that while many of the preservice teachers were able to clearly articulate their understanding of TPACK in their end-of-course portfolio written reflections, they struggled to create planning documents that used technologies that were appropriate for their given audience and supported the content standards. It was worth noting that the results from the written reflections contradict their survey responses. This may indicate that scores on the Schmidt et al. survey better reflect what teachers' think they know about TPACK rather than what they actually know or can do with that knowledge. Even though preservice teachers may demonstrate some integrated knowledge (i.e. TPK) through course assessments, they sometimes focused on technology as ‘motivating’ or ‘engaging’ the students in ‘active learning’ rather than connecting directly to content-specific pedagogies (Graham et al., 2012).

**Interviews**

Another measurement method found was interview. When conducting interviews, the overall process is typically audio-recorded for coding later. There are 12 studies identified in this literature review that used interview as a method to measure preservice teachers’ development of TPACK (see Table 6). Ozgun-Koca (2009) asked 27 preservice secondary mathematics teachers during group interviews (fourth- and fifth-year students separately) the advantages and disadvantages of using calculators in a math classroom. Results revealed that preservice teachers' perception of TK increased, as they knew more about what the handheld technology tool can offer. There was a great change in TPACK knowledge, too. Fourteen (52%) of the preservice
teachers mentioned that when graphing calculators are used, they facilitate students’ participation in class and promote active learning processes. Preservice teachers also indicated that the importance of having both the technical (technology) knowledge and pedagogical knowledge about how to use these devices in mathematics classrooms is necessary to create an effective learning and teaching environment (TPACK).

Table 6.

Major themes in interview category

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Number of Studies</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Maeng, 2013*; Trudle &amp; Dell, 2010)</td>
<td>2</td>
<td>Close connection between educational technology and pedagogy was identified.</td>
</tr>
<tr>
<td>2 (Hosseini &amp; Tee, 2012*)</td>
<td>1</td>
<td>Deficiency in basic knowledge domains lowers the development of TPACK.</td>
</tr>
<tr>
<td>3 (Hsu, 2012*)</td>
<td>1</td>
<td>Development of TK and TPK was identified, but TCK was completely missing.</td>
</tr>
<tr>
<td>4 (Tondeur et al., 2012)</td>
<td>1</td>
<td>Preservice teachers devoted efforts in connecting TK to PK and CK, but they only showed improvement in TCK.</td>
</tr>
<tr>
<td>5 (Jaipal &amp; Figg, 2010*)</td>
<td>1</td>
<td>Lack of TPK has a negative impact on teaching in classroom.</td>
</tr>
<tr>
<td>6 (Figg &amp; Jamani, 2011*; Jaipal &amp; Figg, 2010*; Jang &amp; Chen, 2010*; Schnittka &amp; Bell, 2009)</td>
<td>4</td>
<td>There were positive preservice teachers’ TPACK development due to proper modeling.</td>
</tr>
<tr>
<td>7 (Ozgun-Koca, 2009*; Chien et al., 2012)</td>
<td>2</td>
<td>Significant increase in TK has positive impact on preservice teachers’ TPACK development.</td>
</tr>
</tbody>
</table>

Note. The asterisk (*) represents studies that utilize more than one method.

In addition to the advantages and disadvantages of using technological tools, researchers in some studies conducted interviews with participants to evaluate their TPACK domain development or their perceptions of TPACK. A semi-structured interview consists of several key
questions that help to define the areas to be explored but also allows the interviewer and/or the interviewee to elaborate in order to pursue an idea or response in more detail. Many studies focus on investigating preservice teachers’ teaching experience. Jaipal and Figg (2010) investigated how four preservice teachers planned and taught technology-enhanced lessons during a seven-week, practice-teaching block at two K-8 schools. Findings from this study actually propose a framework that outlines particular characteristics for supporting preservice teachers’ effective integration of technology into classroom practice.

Analysis of the results from the TPACK studies that used interviews as a research methodology revealed three themes: 1) modeling by course instructors and/or inservice teachers, 2) teacher preparation programs have a great impact on preservice teachers’ teaching with technology, and 3) preservice teachers’ knowledge increase in TK and TPACK. Four of the studies revealed that when instructors or inservice teachers provide proper modeling to facilitate technology integration in content-specific situations, preservice teachers are inspired and show growth in their TPACK development. In these interviews, preservice teachers expressed that they were better able to select the appropriate technology tools and integrate them with their content ideas when they were able to see specific ideas modeled by their course instructors and inservice teachers.

A second theme was found in two other studies. The researchers found from interview results that preservice teachers’ development of TPACK was apparent in the way that they applied the general model of technology-enhanced inquiry instruction they learned in the science teacher preparation program to their own classroom context. The authors noted the most variation in participants’ use of technology to support students’ in their observing, inferring, and
experimenting with the aid of a variety of technologies. These results emphasize the close connection between educational technology and pedagogy (Maeng, 2013; Trundle & Bell, 2010).

The third and final theme identified in TPACK studies that included conducting interviews with preservice teachers was an increase in their TK and TPACK. Two of the studies explicitly acknowledged that there might be a direct correlation between the development of two TPACK domains, TK and TPACK. In Chien, Chang, Yeh and Chang’s study (2012), drawing on Collins et al.’s model (1989) to scale up a 4-phase cyclic MAGDAIRE framework, it was found that guided development provides critical aids to develop online science instructional materials. In addition, articulated implementation helps preservice teachers think about the process of implementing the developed project around those online science materials. It is interesting to note that reflected evaluation from peers also assists science teacher educators in closing the gap between instructional design and technology design while teaching technology integration. Ozgun-Koca (2009) also confirmed that by introducing the graphic calculator with careful guidance and providing examples to showcase how to implement the tool to secondary mathematics preservice teachers, they expressed their positive attitude toward the tool and could see it enhance learning outcomes. These findings suggest that detailed guidance and planning with technology integration not only improved the preservice teachers’ technology knowledge (Flash proficiency, as an example of a particular technology competency), but also helped them use technology skills with teaching methods and subject matter (TPACK) (Chien, Chang, Yeh & Chang, 2012; Ozgun-Koca, 2009). However, not all studies showed positive changes in the knowledge development. In the study of Tondeur et al. (2012), while making the attempt to connect TK to PK and CK, preservice teachers only showed improvement in TCK and not an improvement in TPK and TPACK. Interestingly, Jaipal and Figg (2010) suggest in their study
that having TK and TCK increase may not still be enough for a successful technology integration instruction. Without TPK development, there was a negative impact for preservice teachers implementing their lesson plan in practice.

**Observations**

There are 13 studies identified in this literature review that used observation as a method to measure preservice teachers’ development of TPACK (see Table 7). Researchers began to examine how the knowledge level of TPACK changed over time by using note taking and/or video recording during an observation (Koehler, Shin & Mishra, 2012). It is known that direct observation in classrooms can yield abundant information about the nature of effective teaching (Good & Brophy, 2000) and “successful integration of technology requires not only knowledge of the technology and its potential use but also the skill to plan and execute a good lesson” (Painter, 2001, p. 23). When conducting the observation, researchers typically observe the study participant in a classroom setting and take field notes about how he/she integrates technology into the process of teaching the lesson. Understanding the importance of enacted instruction, Hofer, Grandgenett, Harris and Swan (2011) developed and validated a TPACK-based rubric that has been used to assess observed evidence of TPACK during classroom instruction.

Table 7.

**Major themes in observation category**

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Number of Studies</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Hubbard &amp; Price, 2013*; Lee &amp; Kim, 2014)</td>
<td>2</td>
<td>Basic knowledge domains (TK, CK and PK) showed great development while integrated knowledge domains (TCK, TPK and TPACK) showed no improvement.</td>
</tr>
</tbody>
</table>
Table 7. (continued)

<table>
<thead>
<tr>
<th></th>
<th>Study Reference</th>
<th>Method</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>(Hosseini &amp; Tee, 2012*)</td>
<td>1</td>
<td>Deficiency of TPK impacted overall development of TPACK.</td>
</tr>
<tr>
<td>3</td>
<td>(Hubbard &amp; Price, 2013*; Pamuk, 2011)</td>
<td>2</td>
<td>Lack of PK contributed to the decrease of TPK, PCK and TPACK.</td>
</tr>
<tr>
<td>4</td>
<td>(Hsu, 2012*)</td>
<td>1</td>
<td>Preservice teachers developed TK and TPK in educational technology course.</td>
</tr>
<tr>
<td>5</td>
<td>(Swan &amp; Hofer, 2011)</td>
<td>1</td>
<td>Preservice teachers showed strong TPK in lesson implementation while TCK was completely missing.</td>
</tr>
<tr>
<td>6</td>
<td>(Figg &amp; Jamani, 2011*; Haciomeroglu et al., 2011; Jaipal &amp; Figg, 2010*; Maeng et al, 2013*; Tokmak et al., 2013*)</td>
<td>6</td>
<td>There were positive preservice teachers’ TPACK development due to proper modeling.</td>
</tr>
</tbody>
</table>

Note. The asterisk (*) represents studies that utilize more than one method.

Figg and Jamani (2011) also investigated two separate approaches for teaching with technology that highlighted practice-based teacher knowledge and actions for teaching technologically enhanced lessons. Participants were two elementary preservice teachers teaching during a practicum experience and classroom observations were used for collecting data. Cross-case analysis revealed that content-centric pedagogy-focusing lesson design on a specific content learning outcome, rather than technical skill-promoted student engagement and learning of both content and technical skill. Observations were also used in Tokmak et al.’s study (2013) while observing whether preservice teachers develop TPACK skills while enrolled in an instructional technology and material design course. Five activities based on TPACK were designed by the instructors to provide students with specific teaching experiences. The study revealed that the pre-service teachers’ perception of instructional technology (IT) was changed. It was changed from only focusing on technology (TK) to including both instructional implications (PK) and
teaching. It also showed that preservice teachers’ perceptions about using technology, pedagogy, and content (TPACK) for teaching purposes were enhanced through these activities.

From the studies identified for using observation as a method to measure preservice teachers’ TPACK development, one major theme repeatedly was reported from six out of the twelve studies examined. It was revealed that by following the guidelines and/or modeling by inservice teachers or course instructors, preservice teachers were much more successful in integrating technology with content-specific ideas and views into their coursework/teaching. Researchers also noted that preservice teachers’ TPACK knowledge increased during the class observations those studies.

Two other themes were evident from TPACK studies involving observations, the lack of preservice teachers’ pedagogical knowledge and the difficulty in observing the “integrated” knowledge domains (like TCK, PCK, TPK, TPACK). Both Pamuk (2011) and Hubbard and Price (2013) documented that preservice teachers typically had insufficient knowledge of teaching in general (i.e., lack of pedagogical knowledge). Thus, this lack of PK negatively impacted the preservice teachers’ knowledge development in TPK, PCK and TPACK as a result. For example, Hosseini and Tee (2012) revealed that if preservice teachers had a “deficiency” in TPK, their TPACK was also lower or not as evident.

Finally, researchers could typically observe preservice teachers’ basic level TPACK domains (TK, CK, and/or PK), but it was more difficult to observe any of the integrated knowledge domains, such as TCK, TPK and TPACK (Hubbard & Price, 2013; Lee & Kim, 2014). It is worth noting that TCK seems to be a knowledge domain that is the most difficult to observe in teaching situations. For example, Swan and Hofer (2011) observed strong TPK development when preservice teachers implemented their podcasting projects in social studies.
(mostly history), but did not observe TCK during any of the preservice teachers’ observations. And, Hsu (2012) was also able to observe preservice teachers’ obvious knowledge development in the areas of TK and TPK during their student teaching period, but TCK was absent from the observations.

**Discussion**

Based on the analysis provided above, one to three themes related to preservice teachers’ TPACK development were identified from each TPACK research method category (see Figure 3). There are two overarching themes that emerged from most of the categories. The first theme is modeling can promote and enhance preservice teachers’ development of TPACK. Preservice teachers need more scaffolding to help them better integrate technology in different teaching environments (Chai et al., 2013, Pamuk, 2012). The scaffolding can come from teacher preparation program instructors (Meagher et al., 2011), field teachers and even peer mentors (Koh & Divaharan, 2011). On the other hand, if the instructors or field teachers did not have a full understanding about TPACK, preservice teachers could get discouraged with technology integration or even show no improvement in the related TPACK knowledge domains as a result (Semiz & Ince, 2012). It was also confirmed that preservice teachers tend to repeat the same type of technology integration activity they learned from their past experiences in their own classrooms (Figg & Jamani, 2011).
The second overarching theme is the challenge associated with observing integrated TPACK knowledge domains (TCK, TPK). While it was easy to identify the core knowledge domains (TK, CK, and PK) in different measurements, the integrated knowledge domains either showed no improvement or could not be identified in some studies (Hosseini & Tee, 2012; Lux et al., 2011). In order to understand the rationale of the results and investigate the best approach...
to observing these domains, further follow-up data collection method may be needed to provide the whole picture of preservice teachers’ TPACK development.

Regarding the TPACK research methods, despite the fact that the teacher education community continues to investigate preservice teachers’ development of TPACK, the most frequently used data collection methods from the studies analyzed for this review were self-report (N=42) and performance-based (N=35) measures. However, it is worth noting that steps are being taken to continually build upon prior work of others conducted in the area. For example, researchers are using existing self-report instruments for studies being conducted in different countries or instructional contexts. Several of these self-report instruments have been through a process of validation to ensure consistency when tracking preservice teachers’ TPACK development. Several studies (Hofer & Grandgenett, 2012; Koh, 2013; Kohen & Kramarski, 2012; Kopcha et al., 2014; Schmidt et al., 2009) have documented the validation process in details. First generation examples of the TPACK survey primarily focused on “general” preservice teachers’ development of TPACK (e.g., Schmidt et al., 2009), while the second iteration of studies that use self-report surveys have focused more on subject specific (e.g., math and science) preservice teacher knowledge development related to TPACK (Lin et al., 2013, Ozgun-Koca et al., 2010).

Despite the fact that most of the studies investigated general preservice teachers’ technology integration skills using self-report measures, there is a small trend indicating there is growing interest in using more performance-based measures in order to triangulate data in order to better understand how preservice teachers are prepared to teach certain subject matter (e.g. science, math, etc.). Typical data collection tools used for TPACK performance-based measures
range from using reflection, designing a lesson plan, assessing with a rubric, and creating technology-based artifacts.

Self-reported data can still provide important findings on the topic, but researchers must be aware that “there is always the potential for error in recall” (Egbert, Paulus, & Nakamichi, 2002, p. 121) and the problematic data (errors) associated with self-report do not present solid evidence or showcase one’s ability to integrate technology in the classroom (Marquez Chisholm & Padgett, 2004). Therefore, it is important that research around TPACK begin to utilize systematic and empirical methods in order to truly measure various domains of TPACK using multiple approaches. While open-ended questionnaire (N=8), observation (N=13) and interview (N=12) methods were beginning to be used more often in studies involving preservice teachers, some researchers in the field have started to utilize more mixed method measures to confirm and verify how preservice teachers develop their knowledge for integrating technology into subject specific teaching. However, this analysis has its limitation. It is worth noting that except for three of the studies reviewed (Bate, Day, & Macnish, 2013; Hofer & Grandgenett, 2012; Schmidt et al., 2009) there was no mention of extending the research conducted into a longitudinal investigation in which preservice teachers’ knowledge development could be examined throughout one’s teacher preparation program experience. It was more typical of a study to investigate a single scenario or course at a specific moment in time related to a preservice teacher’s development of TPACK. It seems worthwhile to explore the potential of collecting data over a longer period in future studies to inform educator preparation programs how preservice teachers are developing their TPACK knowledge over the course of the entire preparation program and during student teaching.
Another limitation is that in order to focus specifically on preservice teachers’ development of TPACK, some well-known research studies that target inservice teachers were eliminated and not used in this synthesis. In addition, other seminal studies around Information and Communication Technology (ICT) and technology integration published prior to 2006 were not included in this analysis because the search focused on publications after the TPACK framework was named and introduced (Mishra & Koehler, 2006). Future studies might incorporate ICT or technology integration as part of the keyword search to widen the results that depict the historical development of technology integration situated in the TPACK framework.

Conclusion

In sum, the purpose of this literature review is to provide a thorough synthesis of prior literature around studies grounded in the conceptual framework of TPACK and conducted with preservice teachers. Thus, the focus is to synthesize and report the results from these studies to 1) identify various research methodologies used to investigate preservice teachers’ TPACK development and 2) report results of whether preservice teachers are actually developing TPACK at some point and/or during their teacher preparation program. It is hoped that this synthesis of literature can help direct future research in TPACK by building upon what researchers have already accomplished in order to keep improving how preservice teachers are prepared and how they actually use technology in a variety of teaching and learning contexts within their own teacher preparation program.
References


Robertshaw, M.B. & Gillam, R.B. (2010). Examining the validity of the TPACK framework from the ground up: Viewing technology integration through teachers’ eyes. In D. Gibson & B. Dodge (Eds.), Proceedings of Society for Information Technology & Teacher Education International Conference 2010 (pp. 3926-3931). Chesapeake, VA: AACE.


CHAPTER 3. EXAMINATION OF PRESERVICE TEACHERS’ DEVELOPMENT OF TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) AFTER COMPLETION OF CONTENT METHODOLOGY COURSES

A paper to be submitted to *Journal of Teacher Education*

Wei Wang

**ABSTRACT**

This study examines preservice teachers’ development of technological pedagogical content knowledge (TPACK) through triangulated assessments (i.e., survey, course syllabi, and interviews) after completing a series of required content methodology courses. Data were collected at multiple times during the teacher preparation program. Findings suggest that the methodology courses play a critical role in developing preservice teachers’ knowledge in content and pedagogy. Yet, lack of support in technology integration in PreK-6 classrooms may result in the decrease of TK, TCK, TPK and TPACK domains.
Introduction

Technology knowledge has become an important component of effective teaching (Koehler & Mishra, 2009). However, there are concerns that teachers lack adequate opportunities to use technology in their classrooms (U.S. Department of Education, 2010). This has led to an emphasis on providing more opportunities for preservice teachers to use technology throughout their teacher preparation programs (Pellegrino, Goldman, Bertenthal, & Lawless, 2007). Still, the relationship between having technology knowledge and the ability to integrate it is difficult to evaluate. Technological Pedagogical Content Knowledge (TPACK) has emerged as a useful conceptual framework to help us understand the complexities that PreK-12 teachers encounter when integrating technology into their curricular practices (Mishra & Koehler, 2006). This framework emphasizes that it is ineffective to instruct teachers on how to use technology without appropriate integration in the context of pedagogical and content knowledge.

Accordingly, technology must not then be treated as a separate knowledge or skill to be learned. TPACK is a valuable theoretical framework for thinking about what knowledge teachers need to have in order to integrate technology and how they can develop this knowledge. The framework contains seven domains, which are:

- content knowledge (CK),
- pedagogical knowledge (PK),
- technology knowledge (TK),
- pedagogical content knowledge (PCK),
- technological content knowledge (TCK),
- technological pedagogical knowledge (TPK),
and finally, technological pedagogical content knowledge (TPACK) (Mishra & Koehler, 2006).

Several researchers have begun to develop methods to measure TPACK and its subdomains (Archambault & Barnett, 2010; Archambault & Crippen, 2009; Harris, Grandgenett, & Hofer, 2010; Koehler, Mishra, & Yahya, 2007; Schmidt, Baran, Thompson, Kohler, Mishra, & Shin, 2009). However, further study is needed where triangulated assessments are used to measure preservice teachers’ TPACK (Hofer, Grandgenett, Harris, & Swan, 2011).

Goodlad (1990) has been critical of teacher education because he believes there is a gap between teacher preparation and actual classroom practices. Over the years, teacher preparation programs were viewed to emphasize theory instead of actual teaching practices (Barone, Berliner, Blanchard, Casanova, & McGowan, 1996). Other researchers have since suggested that there is a lack of alignment among technology related topics covered in teacher education programs (Ottenbreit-Leftwich et al., 2012). Others have argued that teachers may not be fully aware of the possibilities technology can provide in classrooms to assist students’ learning in innovative ways (Maddux & Johnson, 2006). Discussions such as these have pushed scholars in the field to reconsider what knowledge and experiences, especially those related to technology, need to be included in a teacher preparation program (Lawless & Pellegrino, 2007).

However, restructuring how technology is integrated throughout a teacher education program is complicated. Beck and Wynn (1998) indicated that the integration of technology in teacher preparation programs should be a continuous process. It usually occurs one of two ways. They explained that traditionally some teacher preparation programs offer one course about technology, and that course becomes the preservice teachers’ only experience for learning how to integrate technology. On the other hand, some programs have taken steps to integrate technology
into the overall teacher education program by infusing technology into each course. Niess (2005) documented efforts taken to include technology in math methodology courses. This approach of preparing teachers by integrating technology in all courses in the teacher preparation program appears to be promising. This type of approach may help better prepare teachers’ knowledge development in technology, pedagogy and content areas (Duhaney, 2001). However, little research has been conducted to actually examine how this continuous approach to developing preservice teachers’ TPACK throughout a preparation program can be realized.

To address these issues, the following study investigated whether preservice teachers, majoring in elementary education and early childhood education, develop TPACK over time during their teacher preparation program at a large Midwestern university. The research question for this study is, “if preservice teachers have developed their technological pedagogical content knowledge (TPACK) during their teacher preparation program, which includes the time from taking the required instructional technology course until completing all of their content methodology courses?” Thus, this study focuses on examining preservice teachers’ longitudinal development of TPACK during their teacher preparation program. Preservice teachers completed a questionnaire at different data collection points (i.e., administered before starting and after completing an instructional technology course and another one was completed after finishing all content methodology courses). In addition, other qualitative data from course artifacts and focus group interviews were used to support the findings. As a result, this study attempts to inform about how content methodology courses experience can influence preservice teachers’ development of the TPACK domains.
Literature Review

This literature review focuses on topics around preservice teachers and their development of TPACK. Based on the research question, several themes will be discussed. The first section provides a short introduction to the TPACK framework. The second section contains an overview of the approaches typically used to prepare preservice teachers to use technology in teacher education programs. The last section addresses the current understanding of preservice teachers’ TPACK development.

Defining TPACK

Technological Pedagogical Content Knowledge (TPACK) was introduced to the educational research field as a conceptual framework for understanding the teacher knowledge that is required for technology integration (Mishra & Koehler, 2006; Thompson & Mishra, 2007). Expanding on Shulman’s (1986) theory of pedagogical content knowledge (PCK), TPACK focuses on situating technology knowledge within content and pedagogical knowledge (see Figure 1). While the idea of TPACK, with respect to technology integration, may not be totally new to the field, it provides researchers with a unique perspective on how to view technology integration in classroom settings. Mishra and Koehler (2006) explicitly constructed the framework visually so that it positions technology as a third and equal domain of teachers’ knowledge along with content and pedagogy. Several scholars have suggested that having a good understanding of the interplay between technology, pedagogy, and content can lead to effective teaching (Hughes, 2005; Neiss, 2005; Zhao, 2003).
Seven knowledge domains components are included in the TPACK framework. They are defined as:

- **Technology Knowledge (TK):** Knowledge about different technologies, including both low-tech and high-tech technologies.
- **Content Knowledge (CK):** Knowledge about the actual subject matter to be taught.
- **Pedagogical Knowledge (PK):** Methods and processes of teaching a subject matter.
- **Pedagogical Content Knowledge (PCK):** The content knowledge that deals with the teaching process (Shulman, 1986).
- **Technological Content Knowledge (TCK):** Knowledge of how technology can create new representations for specific content.
- Technological Pedagogical Knowledge (TPK): Knowledge of how different technologies can be used in teaching, and to understand that using technology may affect how teachers teach.

- Technological Pedagogical Content Knowledge (TPACK): Knowledge required by teachers when integrating technology into their teaching in any content subject area (Schmidt et al., 2009b).

TPACK is a useful conceptual framework for thinking about what knowledge teachers must have to integrate technology into teaching and how they might develop this knowledge. Schmidt et al. (2009b) indicated that using the TPACK framework might help when designing professional experiences, especially for preservice teachers. Therefore, researchers need to constantly reflect on the preparation practices that are being used in teacher education to better prepare future teachers.

**Preparing preservice teachers for using technology**

It is often difficult to identify the most effective approaches that can help preservice teachers develop their technology knowledge and integration skills for teaching in their future classrooms (Goktas, Yıldırım, & Yıldırım, 2008). Polly, Mims, Shepherds and Inan (2010) mentioned many programs’ initial attempt is to develop an introductory instructional technology course that is then included in the program requirements. After completing the introductory instructional technology course, preservice teachers are then expected to successfully integrate technology into their future teaching (Brush, Rutowski, Glazewski, Sutton, Hansen, & Bardsley, 2002). However, Kay (2006) reported that preservice teachers indicated that they do not feel confident integrating technology in their teaching after just completing one course. Other researchers, such as Niess (2005), have suggested that technology skills should be integrated
throughout the teacher education program’s curriculum in order to provide teachers with the skills and experiences needed to apply technology to their specific content areas. Wetzel, Buss, Foulger and Lindsey (2014) also suggested reconsidering the format of stand-alone introductory technology courses and commented that this format may not provide the most effective preparation.

However, this does not mean the stand-alone technology course is not important to preservice teachers. The stand-alone technology course still provides a critical component to preservice teachers’ development (Kleiner, Thomas, & Lewis, 2007). This course typically provides a basic foundation of technology integration and the skills developed can be transferred to methodology courses (Kleiner et al., 2007). So it appears important to examine how these foundational skills can be fostered and further enhanced in courses that preservice teachers take later in their preparation program.

**Preservice teachers’ development of TPACK**

Beginning teachers are generally confident with their level of knowledge in all seven domains of the TPACK framework (Jordan, 2011). However, Keating and Evans (2001) stated that although preservice teachers may feel comfortable with technology in their schoolwork, they are still having concerns about using technology for their future teaching. Recent research also shows that teachers often experience challenges to using their TPACK in a systematic and useful way (Hutchison, Beschorner, & Schmidt-Crawford, 2012). However, several studies have examined how preservice teachers’ TPACK knowledge was impacted after taking an instructional technology course. According to Schmidt et al. (2009), preservice teachers experienced statistically significant gains in all seven TPACK components after completing a required technology course, with the large increase in the areas of TK, TCK, and TPACK. Chai,
Koh, Tsai and Tan (2011) reported that pedagogical knowledge had a direct impact on TPACK at the beginning of the introductory technology course. In that study, the results revealed that preservice teachers made connections between their TK and PK to form TPK during the course, the direct relation between PK and TPACK became insignificant whereas the relations between PK and TPK, and TPK and TPACK became significant. The comparison between the pre- and post-course models also revealed that preservice teachers’ perceived understanding between CK and TPACK and changed from insignificant to significant. Based on Koh and Divaharan’s (2011) study, they found their participants primarily developed TK and TPK only during the ICT (Information and Communications Technology) course. Therefore, they strongly recommended the need to emphasize subject-focused pedagogical modeling, product critique, and peer sharing to help teachers’ develop their TCK and TPACK (p. 35).

Some studies have sought to explain how methodology courses or practicum experiences may change preservice teachers’ knowledge of content, pedagogy, and technology. It is already known that limited pedagogical knowledge inhibited technology integration (Pamuk, 2011). Therefore, some scholars suggest that PCK can be developed through an integrative process embedded in classroom practice (Niess et al., 2009). Thus, PCK serves as a guide for teachers to react to dealing with a specific subject matter in the classroom. Kastberg and Leatham (2005) indicate the risk of having access to technology but without essential knowledge of related curriculum materials may discourage teachers from integrating technology into their classroom instruction. While there is limited study of this area, the results from Ozgun-Koca, Meagher, and Edwards (2010) indicate that preservice teachers’ understanding of technology shifted from viewing technology as a tool for reinforcement into viewing technology as a tool for developing student understanding. Nonetheless, Ozgun-Koca et al. (2010) pointed out that preservice
teachers still were skeptical about the appropriateness of using technology to help develop subject content concepts, specifically in mathematics.

While most studies provide results on individual’s self-reported data related to his/her development of TPACK knowledge (Kereluik, Casperson, & Akcaoglu, 2010), such data are limited in measuring these individuals actual use and the integration of technology in classrooms. In other words, it is more difficult to provide concrete examples of what TPACK looks like in practice or what the characteristics are of the TPACK domains (Jaipal & Figg, 2010). As Kereluik et al. (2010) argued that in order for the measure of TPACK to be effective, researchers must observe how teachers apply their knowledge to their teaching. So and Kim (2009) also agreed that teachers may have high self-reported TPACK confidence, but pointed out that it is difficult for them to show that same level of TPACK confidence in their classrooms.

This brief synopsis of the literature related to the research topic provides a starting point for further investigation. From this literature, the investigation about preservice teachers’ TPACK development after methodology courses is still limited. In the following section, the detailed research design is discussed.

**Methodology**

This section provides information about the research methodology used for this study. Descriptions about the research context, participants, data collection and data analysis are provided.

**Research Context**

Data were collected from 171 preservice teachers majoring in elementary education from a large Midwestern university. This group of participants had completed all or most of their
content-specific methodology courses (e.g. literacy, mathematics, science and social studies). At this institution, all elementary education majors are required to take five methodology courses: 1. Teaching Reading and Language Arts for Primary Grades (PreK-3), 2. Teaching Reading and Language Arts for Intermediate Grades (4-6), 3. Teaching Children Mathematics, 4. Teaching of Science, and 5. Teaching of Social Studies. Except for social studies, each methodology course has a supervised classroom-based practicum experience.

All preservice teachers had also completed the required, introductory technology course prior to taking the methodology courses. Once they complete the introductory technology course, students typically start taking the content-specific methodology courses that are required for their area of specialization. Although it is not required, if preservice teachers are interested to learn more about technology in classroom, they can also enroll in a Learning Technologies Minor. This minor requires a minimum of 16 credits, with at least six credits taken at this Midwestern university in courses numbered 300 or above. Preservice teachers then enroll in their methodology courses, commonly called Block I and Block II, over a two-semester time frame (see Table 1). The Social Studies methodology course is treated as a course outside Block I and II. Preservice teachers attending this university typically start taking the methodology courses in the second semester of their junior year (Block I) and first semester of their senior year (Block II). Preservice teachers in Block I take the literacy for primary grades and math method classes on Monday and Wednesday for the first 9 weeks of the 15-week semester. Then, the on-campus classes stop, and the school-based practicum experiences begin. So, preservice teachers are placed with a cooperating K-3 teacher in school all day on Monday and Wednesday for 4 weeks to apply what they have learned in their two methodology classes. During the practicum experience, students are also supervised by a university supervisor to provide feedback and
evaluation. The 4-week practicum ends, and the Monday/Wednesday on-campus classes resume for 2 weeks until the end of the semester.

Block II includes methodology courses for literacy for the intermediate grades and science. The scheduling of the classes changes slightly during Block II. Students attend the courses on campus for the first 5 weeks of the semester on Tuesdays and Thursdays, and then they complete their practicum experience all day on Tuesdays and Thursdays for 4 weeks in schools. After completing the practicum, the preservice teachers return to campus and resume the method courses for 6 weeks until the end of the semester. The social studies method course has a prerequisite of Block I so it varies when students complete this course (e.g. in summer, during Block II…etc.).

Table 1

| Organization of Methodology Courses for Elementary Education/ Early Childhood Education Majors |
|---|---|---|
| **Block I** | 9 weeks in class on campus | 4 weeks in PreK-3 classrooms | 2 weeks in class on campus |
| · Teaching Reading and Language Arts for Primary Grades (PreK-3) | · Practicum for literacy method course | · Teaching Reading and Language Arts for Primary Grades (PreK-3) |
| · Teaching Children Mathematics | · Practicum for science method course | · Teaching of Science |
| **Block II** | 5 weeks in class on campus | 4 weeks in Grades 4-6 classrooms | 6 weeks in class on campus |
| · Teaching Reading and Language Arts for Intermediate Grades (4-6) | · Practicum for literacy method course for intermediate grades | · Teaching Reading and Language Arts for Primary Grades (4-6) |
| · Teaching of Science | · Practicum for mathematics method course | · Teaching Children Mathematics |
| **Additional Methodology Course** | 15 weeks of class on campus – No Practicum | |
| · Teaching of Social Studies | |

* Academic semester = 15 weeks of class and 1 week for final exams.
Participants

267 preservice teachers who completed their methodology courses (e.g., Blocks I and II) were asked to participate in the study. They were asked to complete the *Survey of Preservice Teachers’ Knowledge of Teaching and Technology* (Schmidt et al., 2009). The survey was administered during the last week of each semester in Spring 2012, Fall 2012, Spring 2013, Fall 2013, Spring 2014, Fall 2014 and Spring 2015. Of the 267 preservice teachers who were surveyed between Spring (April) 2012 to Spring (April) 2015, only the responses from participants who had also completed the surveys at the beginning (pre-test) and end of the introductory instructional technology course (post-test) were used. In order to help the researchers to keep track of preservice teachers’ three-time responses, their email addresses were used as the identifier. Using these exclusion criteria, the researchers analyzed the data from a total of 171 preservice teachers who voluntarily participated in the study and completed the surveys all three times (See Table 2). The survey was administered the first time at the first week of the semester when preservice teachers were taking their introductory technology course. It was administered the second time during the last week of introductory technology course. The preservice teachers took the survey for the third time after they finished taking their methodology courses. These data were collected to measure the preservice teachers’ perceptions about how their knowledge about TPACK had developed between taking the required instructional technology course and completing all methodology courses (approximately 2 years).

Table 2

*Administration of TPACK Survey*

<table>
<thead>
<tr>
<th>TPACK Survey Administered</th>
<th>Time 1</th>
<th>Time 2</th>
<th>Time 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Week of Introductory Technology Course</td>
<td>Last Week of Introductory Technology Course</td>
<td>Completion of Methodology Courses</td>
<td></td>
</tr>
</tbody>
</table>
Of the 171 preservice teachers who participated in the study, 154 (90.1%) were female, and 17 (9.9%) were male. In addition, 149 (87.1%) had completed the two literacy methodology courses, 155 (90.6%) had completed the science methodology course, 162 (94.7%) had completed the mathematics methodology course, but only 81 (47.4%) had completed the social studies methodology course. Nearly 54 percent (53.3%) of the respondents (n=91) were scheduled to student teach in 2013. It is worth noting that after completing the introductory instructional technology course, 66.1% of the participants had not completed any type of practicum experience. This indicates that, at this particular institution, students are encouraged to take the instructional technology course before taking Block I. Out of 171 preservice teachers, 14% (n=24) of the preservice teachers were signed up for the Learning Technologies Minor.

Preservice teachers in the elementary education major also need to have at least one specialization. The specialization list includes the following options: Art, English and Language Arts, Foreign Language, Health, History, Special Education (Instructional Strategist), Mathematics, Music, Science, Social Studies and Speech/Theater. The majority of responses could be found in three areas, including 42 students with a specialization in mathematics (24.6%), 30 responses (17.5%) were in instructional strategist endorsement and 41 (24%) respondents were in English and Language Arts specialization.

**Research Design**

This study utilized a convergent parallel research design (Creswell & Plano Clark, 2011). There are four steps to the convergent parallel design (also known as the convergent design) process. First, researchers collect both quantitative data and qualitative data about the investigated topic. The two sets of data are collected in the same time frame but are independent
of each other. In other words, one data collection does not depend on the results of the other. After data collection, the researcher analyzes the data separately using the appropriate quantitative and qualitative analysis procedures. The key is to keep both portions separate during the analysis and combine the results during the overall interpretation (see Figure 2).

Figure 2. Convergent parallel design process (Creswell & Plano Clark, 2011).

Research Procedures and Data Collection

Data were collected at the end of Spring 2012, Fall 2012, Spring 2013, Fall 2013, Spring 2014, Fall 2014, and Spring 2015 semesters from 171 preservice teachers. The data included both quantitative and qualitative measures. For this study, the Survey of Preservice Teachers’ Knowledge of Teaching and Technology (Schmidt et al., 2009) was again administered online to preservice teachers after they completed the Block II methodology courses (see Table 2). The internal consistency reliability (coefficient alpha) ranged from .75 to .92 for the seven TPACK subscales. This range is considered to be acceptable to excellent (George & Mallory, 2001). This survey was specifically developed to understand elementary education preservice teachers’ knowledge development in the areas of technology, pedagogy, and content. The survey includes 9 demographic questions, 47 5-scale Likert items, 3 multiple-choice items and 3 open-ended questions designed to measure preservice teachers’ self-perception of knowledge development in
all seven TPACK constructs. Typically, preservice teachers spend 15 to 20 minutes to complete the survey response each time.

Qualitative data were also collected during the data collection period. Four 30-minute instructor interviews were conducted with one course instructor from each of the methodology courses (mathematics, literacy, science, and social studies). The interview questions focused on topics related to the instructors’ observations of preservice teachers’ knowledge development and their course planning. In addition to instructor interviews, five preservice teachers volunteered to participate in a focus group interview. The focus group interview confirmed the preservice teachers’ thoughts about technology integration efforts during their methodology courses and practicum experiences. All interviews were recorded and then later transcribed. In addition, the course syllabus from each methods course was collected to further investigate the evidence of how technology was integrated into each course.

**Data Analysis**

Data were analyzed using both quantitative and qualitative methods. For quantitative analysis, a series of 10 1×3 repeated-measure (RM) ANOVAs with Time (Time 1, Time 2, Time 3) as a within objects factor, and composite scores on each of the seven TPACK elements as dependent measures (TK, PK, CK, TCK, PCK, TPK and TPACK). CK was separated into 4 sub-units based on the specific content areas CK Literacy (CKL), CK Mathematics (CKM), CK Science (CKS), and CK Social Studies (CKSS). Due to the need to conduct 10 independent statistical tests, the Bonferroni correction was used to control for Type II errors.

Additional data analysis involved using qualitative methodologies. Specifically, a summative content analysis was used to analyze the interview data and the course syllabi. Summative content analysis involved counting and comparisons of content, followed by the
interpretation of the underlying context. Data sources for this procedure came from the interview transcripts (instructors and focus group), and each course’s syllabus. The researcher focused on finding recurring patterns or keywords in the data. After identifying the recurring patterns and keywords, the researcher categorized them as themes (see Table 3). Then, the researcher compared the themes identified from the summative content analysis with the results from the statistical analysis (see Figure 2).

Table 3

*Data comparison table: Theme example*

<table>
<thead>
<tr>
<th>Theme</th>
<th>Quantitative Analysis</th>
<th>Qualitative Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not enough preparation for real classroom</td>
<td>Social Studies (CK_SS) dropped significantly (Time 2, Time 3):</td>
<td>“I felt I was not confident to teach social studies.” - (Student focus group interview)</td>
</tr>
<tr>
<td></td>
<td><img src="image" alt="Graph" /></td>
<td>“We didn’t have practicum for social studies.” - (Student focus group interview)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“CI 443 doesn’t have practicum like other method courses.” - (Social studies method course instructor interview)</td>
</tr>
</tbody>
</table>
Findings

In this section, the analysis of the data gathered is organized around the three foundational domains of TPACK - CK, PK, and TK.

Content Knowledge (CK) Domains

The research question that guided this study was stated as follows: If preservice teachers developed their technological pedagogical content knowledge (TPACK) during their teacher preparation program, which includes the time from taking the required instructional technology course until completing their methodology courses?

Responses from the TPACK survey and interviews were analyzed to understand the continued development of the preservice teachers’ technological pedagogical content knowledge during the methodology courses taken as part of their preparation program. From the results, preservice teachers’ literacy content knowledge (CKL) was the only content knowledge that showed a significant increase between the three-time measurements (see Figure 3). A repeated measures ANOVA with a Greenhouse-Geisser correction determined that CKL differed statistically significantly between time points ($F(1.767,300.307) = 48.76, p < 0.001$, $MSe = 7.93, h_p^2 = 0.223$). Bonferroni Post-hoc analyses revealed that the mean score for literacy content knowledge at time one ($M= 3.87$, $SD = 0.53$) was less than the mean score for time two ($M= 4.10$, $SD = 0.46$). With the increase from time one to time two, which was considered to be statistically significant ($p < 0.001$). There was also an increase in mean scores between times two and three ($M= 4.10$, $SD = 0.46$; $M= 4.27$, $SD = 0.47$, $p < 0.001$ respectively). The first theme,
inconsistent methodology course requirements on the number of courses and practica, emerged from the qualitative data provided by preservice teachers may help explain this increase. As one student stated, “For literacy, we have to take two courses. But only one for other subject areas” [Student focus group interview]. A method course instructor also commented, “Students have to take two literacy method courses and do two practica” [Course instructor interview].

Results also indicate that both mathematics and science showed only a very slight increase from time two to time three, and that social studies was the only subject area that the preservice teachers showed a significant decrease between time two and time three. A repeated measures ANOVA with a Greenhouse-Geisser correction determined that CKSS differed statistically significantly between time points ($F(1.766, 300.223) = 16.19, p < 0.001, MSe = 4.37, h_p^2 = 0.087$). Bonferroni Post-hoc analyses revealed that preservice teachers’ mean score for social studies content knowledge at time one (M= 3.57, SD = 0.64) was less than the mean score
for time two (M= 3.87, SD = 0.66). With the increase from time one to time two, which was considered to be statistically significant (p < 0.001). There was also a decrease in mean scores between times two and three (M= 3.87, SD = 0.66; M= 3.71, SD = 0.66, p = 0.03 respectively). Even with the significant decrease from time two to time three, the mean scores between time one and time three were still considered to be increased significantly (p = 0.025). During the focus group interviews, the same theme, inconsistent methodology course requirements, was categorized when preservice teachers expressed their concerns that, “We didn’t have practicum for social studies” during a student focus group interview. The social studies methodology course is the only methodology course at this institution that does not have practicum associated with it. This has led preservice teachers to realize they do not have enough practice to teach social studies in a real classroom (Theme two: Not enough preparation for the real classroom). Several preservice teachers commented during the focus group interview that “I felt I was not confident to teach social studies.”

**Pedagogical Knowledge (PK) Domains**

In the self-reported score results, all PK related domains increased in both between time one and time two and between time two and time three (see Figure 4). A main effect was found for both PK (F(1.956,332.515) = 100.02, p < 0.001, MSe = 16.74, h_p^2 = 0.370) and PCK (F(1.905,323.779) = 71.23, p < 0.001, MSe = 13.16, h_p^2 = 0.295). Bonferroni Post-hoc analyses revealed that the mean score for Pedagogical knowledge at
Figure 4. Mean differences of Preservice teachers’ pedagogical knowledge related domains during three data collection points.

time one (M= 3.68, SD = 0.51) was less than the mean score for time two (M= 4.03, SD = 0.50). Both PK and PCK’s mean scores between times two and three significantly increased (PK: M= 4.03, SD = 0.50; M= 4.30, SD = 0.43, \( p < 0.001 \) respectively) (PCK: M= 3.87, SD = 0.55; M= 4.05, SD = 0.46, \( p < 0.001 \) respectively). These findings related to pedagogical knowledge reveal that preservice teachers’ perception of their pedagogical knowledge increased steadily during the period of the study. Another theme emerged from the focus group interview was “various opportunities to interact with different learning approaches”. Preservice teachers frequently commented that different teaching approaches were introduced to them during the method courses. As one preservice teacher stated, “I learned different teaching approaches in all my method courses” [student focus group]. During the student focus group, preservice teachers also shared they had to teach mini lessons for different method courses that helped them develop their teaching skills. They commented, “Our instructors asked us to submit lesson plans and do group
or individual lesson teaching in front of the whole class.” Methodology course instructors also confirmed the preservice teachers’ statements during their interviews. As one course instructor commented, “Students have to work with their peer to plan a lesson and teach in front of the class” [course instructor interview].

**Technological Knowledge (TK) Domains**

While the entire PK related domains increased related to the TPACK frame, the TK related domains actually decreased between time two and time three (see Figure 5). A repeated measures ANOVA with a Greenhouse-Geisser correction determined that TK differed statistically significantly between time points \( F(1.829,310.929) = 38.69, p < 0.001, \text{MSe} = 8.67, \eta_p^2 = 0.185 \). Bonferroni Post-hoc analyses revealed that the mean score for Technology knowledge at time two (M= 3.86, SD = 0.53) is significantly higher than time one (M= 3.43, SD = 0.66) with the \( p \)-value less than 0.001. But, there was a decrease in mean scores between time two and three (M= 3.86, SD = 0.53; M= 3.68, SD = 0.63, \( p = 0.001 \) respectively). Even with the significant decrease from time two to time three, the mean scores between time one and time three were still considered to be significantly increased (\( p < 0.001 \)). A main effect was found for TCK \( F(1.916,325.652) = 92.79, p < 0.001, \text{MSe} = 35.55, \eta_p^2 = 0.353 \). Bonferroni Post-hoc analyses revealed that the mean score for Technological Content Knowledge at time two (M= 4.06, SD = 0.57) was significantly higher than the mean score for time one (M= 3.18, SD = 0.74) with the \( p \)-value less than 0.001. However, there was a decrease in mean scores between times two and three (M= 4.06, SD = 0.57; M= 3.77, SD = 0.66, \( p < 0.001 \) respectively). Even
Figure 5. Mean differences of preservice teachers’ technology knowledge related domains during three data collection points.

with the significant decrease from time two to time three, the mean scores between time one and time three were still considered to be significantly increased ($p < 0.001$).

A main effect was also found for TPK ($F(1.873,318.442) = 47.31, p < 0.001, \text{MSe} = 9.79, h_p^2 = 0.218$). Bonferroni Post-hoc analyses revealed that the mean score for Technological Pedagogical Knowledge at time two ($M= 4.35, SD = 0.43$) was significantly higher than the mean score for time one ($M= 3.88, SD = 0.50$) with the $p$-value less than 0.001. There was another slight decrease in mean scores between times two and three ($M= 4.35, SD = 0.43; M= 4.11, SD = 0.52, p < 0.001$ respectively). Even with the decrease from time two to time three, the mean scores between time one and time three were still considered to be increased significantly ($p < 0.001$).

Finally, a main effect was found for TPACK ($F(1.863,316.674) = 71.94, p < 0.001, \text{MSe} = 16.25, h_p^2 = 0.297$). Post-hoc analyses revealed that the mean score for Technological
Pedagogical Content Knowledge at time two (M= 4.14, SD = 0.45) was significantly higher than the mean score for time one (M= 3.57, SD = 0.55) with the p-value less than 0.001. Again, there was a slight decrease in mean scores between times two and three (M= 4.14, SD = 0.45; M= 3.99, SD = 0.53 respectively, p = 0.003). Even with the decrease from time two to time three, the mean scores between time one and time three were still considered to be increased significantly (p < 0.001) (see Figure 5).

From the student focus interviews, it became evident that preservice teachers seldom saw their practicum teachers using technology in classrooms. The preservice teachers were surprised to find different technology tools at the schools where they were doing their practica, but the K-6 teachers were not using them. Therefore, a theme called “lack of meaningful technology modeling” was created based on the qualitative analysis. During the focus group interview, one preservice teacher commented, “My supervising teachers only use ELMO for teaching. I felt really bad when I found an interactive whiteboard abandoned in the building. It would be great to use it for teaching.” A methods course instructor also commented that she did not really know what preservice teachers were doing in the four-week practicum since practicums are supervised by a university supervisor. One instructor stated, “I asked students (preservice teachers) to write a reflection about the practicum experience, but I don’t really have control of what they have to do in these four weeks” [Course instructor interview]. Another interesting theme (The difference of technology integration into different subject matters) emerged from the focus group interview on the differences of how technology was integrated into each content area methodology course. Several students shared that they were introduced to different technologies and saw how the instructor modeled the lesson by using the
### Table 4

**TPACK One Way Repeated Measure ANOVAs with Post Hoc Test**

<table>
<thead>
<tr>
<th>Domains</th>
<th>Time 1 (T1) $M$</th>
<th>$SD$</th>
<th>Time 2 (T2) $M$</th>
<th>$SD$</th>
<th>Time 3 (T3) $M$</th>
<th>$SD$</th>
<th>$F$</th>
<th>$p$</th>
<th>$\eta^2$</th>
<th>Bonferroni Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>TK</td>
<td>3.43</td>
<td>0.66</td>
<td>3.86</td>
<td>0.53</td>
<td>3.68</td>
<td>0.63</td>
<td>38.690</td>
<td>$&lt;0.001**$</td>
<td>0.185</td>
<td>T1-T2: $p&lt;0.001**$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T2-T3: $p&lt;0.001**$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T1-T3: $p&lt;0.001**$</td>
</tr>
<tr>
<td>PK</td>
<td>3.68</td>
<td>0.51</td>
<td>4.03</td>
<td>0.50</td>
<td>4.30</td>
<td>0.43</td>
<td>100.018</td>
<td>$&lt;0.001**$</td>
<td>0.370</td>
<td>T1-T2: $p&lt;0.001**$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T2-T3: $p&lt;0.001**$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T1-T3: $p&lt;0.001**$</td>
</tr>
<tr>
<td>CKL</td>
<td>3.87</td>
<td>0.53</td>
<td>4.10</td>
<td>0.46</td>
<td>4.27</td>
<td>0.47</td>
<td>48.756</td>
<td>$&lt;0.001**$</td>
<td>0.223</td>
<td>T1-T2: $p&lt;0.001**$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T2-T3: $p&lt;0.001**$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T1-T3: $p&lt;0.001**$</td>
</tr>
<tr>
<td>CKM</td>
<td>3.61</td>
<td>0.75</td>
<td>3.94</td>
<td>0.66</td>
<td>3.95</td>
<td>0.70</td>
<td>27.081</td>
<td>$&lt;0.001**$</td>
<td>0.137</td>
<td>T1-T2: $p&lt;0.001**$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T2-T3: $p=1$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T1-T3: $p&lt;0.001**$</td>
</tr>
<tr>
<td>CKS</td>
<td>3.41</td>
<td>0.73</td>
<td>3.75</td>
<td>0.61</td>
<td>3.77</td>
<td>0.66</td>
<td>25.463</td>
<td>$&lt;0.001**$</td>
<td>0.130</td>
<td>T1-T2: $p&lt;0.001**$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T2-T3: $p=1$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T1-T3: $p&lt;0.001**$</td>
</tr>
<tr>
<td>CKSS</td>
<td>3.57</td>
<td>0.64</td>
<td>3.87</td>
<td>0.66</td>
<td>3.71</td>
<td>0.66</td>
<td>16.188</td>
<td>$&lt;0.001**$</td>
<td>0.087</td>
<td>T1-T2: $p&lt;0.001**$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T2-T3: $p=0.03*$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T1-T3: $P=0.025*$</td>
</tr>
<tr>
<td>TCK</td>
<td>3.18</td>
<td>0.74</td>
<td>4.06</td>
<td>0.57</td>
<td>3.77</td>
<td>0.66</td>
<td>92.792</td>
<td>$&lt;0.001**$</td>
<td>0.353</td>
<td>T1-T2: $p&lt;0.001**$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T2-T3: $p&lt;0.001**$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T1-T3: $p&lt;0.001**$</td>
</tr>
<tr>
<td>PCK</td>
<td>3.52</td>
<td>0.55</td>
<td>3.87</td>
<td>0.55</td>
<td>4.05</td>
<td>0.46</td>
<td>71.230</td>
<td>$&lt;0.001**$</td>
<td>0.295</td>
<td>T1-T2: $p&lt;0.001**$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T2-T3: $p&lt;0.001**$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T1-T3: $p&lt;0.001**$</td>
</tr>
<tr>
<td>TPK</td>
<td>3.88</td>
<td>0.50</td>
<td>4.35</td>
<td>0.43</td>
<td>4.11</td>
<td>0.52</td>
<td>47.308</td>
<td>$&lt;0.001**$</td>
<td>0.218</td>
<td>T1-T2: $p&lt;0.001**$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T2-T3: $p&lt;0.001**$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T1-T3: $p&lt;0.001**$</td>
</tr>
<tr>
<td>TPACK</td>
<td>3.57</td>
<td>0.55</td>
<td>4.14</td>
<td>0.45</td>
<td>3.99</td>
<td>0.53</td>
<td>71.944</td>
<td>$&lt;0.001**$</td>
<td>0.297</td>
<td>T1-T2: $p&lt;0.001**$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T2-T3: $p=0.003**$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T1-T3: $p&lt;0.001**$</td>
</tr>
</tbody>
</table>

*Note. The shaded areas represent negative significant $p$ value.*

- $p < .05$
- **$p < .01$**
different technologies in literacy methodology courses, but not as many opportunities like this happened in the other content methodology courses. One student noted, “We have to teach lessons using the interactive whiteboard in our literacy method course, but for other classes, instructors shared the technology resources but didn’t model how to use them.” One instructor also confirmed this during the interview by stating, “I need to use more technology” [Course instructor interview].

**Discussion**

While a $P$ value can inform the reader whether an effect exists, the $P$ value will not reveal the size of the effect. In order to determine the size of the effect, Cohen (1988, pp. 280–287) had suggested values of .01, .06, and .14 to indicate small, medium, or large effects for any measure of the proportion of variance explained. From the results reported above, it is worth noting that most of the domains have large effect sizes (ex. TK, CKL, PK, TCK, PCK, TPK, TPACK) and the remaining domains have medium effect sizes (ex. CKM, CKS, CKSS).

From comparing the mean differences in different knowledge domains, all the PK associated domains (PK and PCK) all show positive significance ($< 0.001$) in the Repeated Measure ANOVA comparison. This result confirms what Zechner (2010) reported in the study that method courses with practicum experience often help preservice teachers develop their teaching strategies. According to the results from the preservice teacher focus group interview, one preservice teacher specified, “I learned different teaching approaches in all my method courses”. However, several preservice teachers also pointed out there were potential issues with the practicum arrangement as well.
“Because there aren’t enough teachers to take practicum students, some get assigned to social studies classroom for science practicum. Some students (preservice teachers) have limited chance to observe teachers to teach certain subject area.” [Student response - Focus group interview]

When preservice teachers have limited access to observe and learn in a real classroom, it will be difficult for them to develop PCK properly (Niess et al., 2009). When this type of situation happens, it may impact how preservice teachers react to specific subject matter in an actual classroom.

Another interesting finding is related to content knowledge development. The results varied based on different subject areas. While literacy (CKL) increased with positive significance ($p < 0.001$), mathematics and science (CKM and CKS) mirrored each other with a very slight increase between time two to time three. On the other hand, social studies dropped significantly ($p = 0.03$) in a negative direction. Several students who participated in the focus group interview commented on the result:

“We didn’t have practicum in social studies” [Student response - Focus group interview]

“I felt I was not confident to teach social studies” [Student response - Focus group interview]

“For literacy, we have to take two courses. But only one for other subject areas” [Student response - Focus group interview]

While literacy requires preservice teachers to take two methodology courses at this institution, mathematics, science and social studies only have one methodology course. Furthermore, social studies did not include the practicum component. Preservice teachers were very uncertain about their knowledge growth in this subject matter as well as their pedagogical development.

It is also worth noting that all the means of the TK associated domains (TCK, TPK, and TPACK) decreased between time two and time three after completing methodology courses.
This could be a result of lack of technology use and integration in the methodology courses. Several preservice teachers indicated literacy was the only method course that included opportunities to learn about technologies, such as interactive whiteboard and iPad apps that could be used while teaching literacy. Preservice teachers also shared other method courses incorporated technology elements in a certain way to share resources, but modeling examples of teaching with technology was seldom provided in other methods courses, especially during practica as well. One preservice teacher commented:

“A lot of method course instructors asked preservice teachers to write technology integrated lesson plan, but didn’t explain how technology can be incorporated (lack of modeling)” [Student response – Focus group interview]

According to Koh and Divaharan (2011), subject-focused pedagogical modeling is one of the key components for preservice teachers to develop their TCK and TPACK. Without proper partnership and collaboration between students, methodology courses instructors and supervising teachers (mentor teachers), preservice teachers may not have confidence in integrating technology into their teaching (Kay, 2006).

One other interesting finding from this study was that some preservice teachers commented in the open-ended questions that method course instructors did demonstrate a variety ways to integrate technology into content area instruction. The preservice teachers reported they gained experiences of using technologies (e.g. iPad, Wiki, Comic Life and Interactive Whiteboard) while completing some of the method courses. Yet, few opportunities arose in their practicum experiences to incorporate technology. Preservice teachers were surprised that the most common technology being used in classrooms was a visual presenter. One preservice teacher commented in the focus interview, “I was really surprised the only technology the teacher was using is ELMO. They (supervising teachers) seldom use technology at all. I felt
there was a huge gap between our method courses and the real classroom.” Thompson, Schmidt and Davis (2003) explained in their study about the importance placing both preservice and in-service teachers together in classrooms to collaboratively find ways to integrate technology into the curriculum as a way to increase the comfort level of using technology. However, if part of the community is resistant or not using the technology, the effectiveness of the desired outcome can be weakened (Carroll et al., 2003).

**Future Implications and Conclusion**

The results suggest that there is work to be done related to developing preservice teachers’ TPACK during methodology courses. In this study, preservice teachers showed a slight increase in their self-assessed CK and PK, while TK, TCK, TPK, and TPACK actually decreased between taking the instructional technology course and after their methodology courses. Feedbacks from preservice teachers indicate minimal support for integrating technology from their practicum teachers or schools as well. This may provide a base for later work in monitoring specific content area courses. In order for this to happen, we must provide direction and support for methods instructors and practicum teachers to design TPACK experiences for preservice teachers that are specific to their content area. More professional development or mentoring opportunities need to be provided in order to support instructors and teachers with incorporating technology during instruction. As a teacher preparation program, relying on one technology course may not be enough. More systematic planning of incorporating technology into all teacher education courses is greatly needed.

Although the qualitative data from course instructor interviews and preservice teacher focus group interview provides some insights about the results shown in the quantitative analysis, actual observations of the instructors and K-6 teachers were not completed. Therefore,
additional data that observes classroom behaviors would be an important next step for this body of research. The plan is to observe and evaluate preservice teachers’ behaviors in practicum settings and compare these data with codes on the TPACK instrument. These data will contribute to the further validation of the TPACK questionnaire and provide information beyond the self-reported data.

Overall, longitudinal assessments such as this will provide a means to help both preservice teachers and teacher education faculty focus specifically on experiences and behaviors that encourage the development of TPACK throughout the teacher education preparation program. Studies such as this can provide teacher education programs with useful information to improve how preservice teachers are prepared with respect to using technology in alignment with strong content and pedagogical knowledge.

References


educational technology and teacher education faculty. Paper presented at the Society for Information Technology & Teacher Education, Nashville, TN.


CHAPTER 4. A PREK-6 PRESERVICE TEACHER’S JOURNEY TO DEVELOP TPACK: A CASE STUDY

A paper to be submitted to Contemporary Issues in Technology and Teacher Education: English and Language Arts Section

Wei Wang

ABSTRACT

This case study investigated how prepared a preservice teacher was to use technology for teaching during a literacy practicum experience. Both qualitative (classroom observation and follow-up interview) and quantitative (survey response) data were collected in the Spring semester 2015 to confirm the actual TPACK development of a preservice teacher as she completed a practicum experience as required for the teacher education preparation program. Findings revealed the preservice teacher was able to successfully integrate technology into her teaching. In addition, all seven TPACK domains were observed during the preservice teacher’s two teaching episodes. Three themes (emphasis on pedagogical knowledge development, modeling for preservice teachers and trajectory of TPACK) were further examined to offer possible suggestions for the teacher preparation program to consider.
Introduction

Recognizing the importance of technology integration in preservice teacher training, the International Society for Technology in Education (ISTE) established the ISTE standards for administrators, teachers, and students as a national initiative. These standards provide a framework in which technology integration has become an essential part of teaching and learning in consistent and systematic ways (ISTE, 2014). Beck and Wynn (1998) also stated that the integration of technology in teacher preparation programs should be a continuous process. Despite the recognition of the need, teacher education programs still struggle to teach and model meaningful technology integration practices in the preparation of their preservice teachers (Bakir, 2015).

In order to address this issue, teacher education programs have allocated extensive efforts and funds to develop different approaches and strategies to better prepare preservice teachers to integrate technology. Traditionally, most teacher education programs offer a stand-alone instructional technology course as part of the required core courses in the teacher preparation program (Buss, Wetzel, Foulger, & Lindsey, 2015). Based on Buss et al.’s (2015) research, it was revealed that the required technology course is usually a course offered for 1-4 credits with a focus that ranges from helping preservice teachers develop necessary computer skills to design technology-rich lesson plans. Nevertheless, such a course may help preservice teachers develop confidence and skills in using technology (Bai & Ertmer, 2008; Foulger, Buss, Wetzel, & Lindsey, 2012), but preservice teachers still typically lack the skills to facilitate meaningful technology integration into their teaching upon graduation (Brown & Warschauer, 2006; Wachira & Keengwe, 2011). In essence, the actual use of technology in the instruction was found to be influenced by teachers’ perceptions of the usefulness of the technology for content
and pedagogy purposes (Hughes, 2005). Aiming to resolve this problem, some teacher education programs have actually taken steps to integrate technology into the overall teacher education program by infusing technology throughout the program in each course (Wetzel, Buss, Foulger, & Lindsey, 2014). In particular, Niess (2005) documented efforts taken to include technology in math methodology courses. This approach of preparing teachers by integrating technology in all courses in the teacher preparation program appears promising, which might help better prepare teachers’ knowledge development in technology, pedagogy and content areas (Duhaney, 2001).

More needs to be done to help us understand how preservice teachers develop their TPACK knowledge throughout their time in a teacher preparation program. The research question of this study investigated “how prepared is a preservice teacher to use technology for literacy instruction during a practicum experience?”

A review of the literature follows, which highlights current trends in three areas that inform the design and results of the study: What is TPACK?; qualitative methods used to measure TPACK; and preservice teachers’ development of TPACK in methodology courses.

**Literature Review**

**What is TPACK?**

Technological Pedagogical Content Knowledge (TPACK) was introduced to the educational research field as a conceptual framework for understanding teacher knowledge required for technology integration (Mishra & Koehler, 2006). Although TPACK evolved from Shulman’s (1986) theory of pedagogical content knowledge (PCK), it focuses on the interplay between technology, pedagogy, and content knowledge that teachers require for successfully integrating technology.
The TPACK framework provides researchers with a useful perspective to view technology integration in a classroom setting. Moreover, the emphasis of the blended knowledge domains (TCK, TPK, PCK and TPACK) also provide a starting point for defining this framework. The TPACK framework includes seven knowledge domains which include technology knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK) and technological pedagogical content knowledge (TPACK). TK, CK and PK can be categorized as the core knowledge domains. TK represents the knowledge of technology tools ranging from low-tech tools to digital technologies. CK represents the knowledge of subject matters. PK refers to the knowledge of teaching approaches. On the other hand, PCK, TCK, TPK and TPACK can be categorized as the blended knowledge domains that require teachers to think about multiple knowledge bases while preparing instruction and teaching in classrooms. First promoted by Shulman (1986), PCK means the knowledge of teaching approaches used for specific subject matter. TCK stands for the knowledge of subject matter representation with technology. As for TPK, it refers to the knowledge of the pedagogical methods used when teaching with technology. Finally, for TPACK, it represents the knowledge of using technology that incorporate teaching approaches for specific subject matter.
Qualitative Research Methods Used to Measure TPACK

Ever since the establishment of TPACK, numerous scholars have developed related curriculum, texts, professional development modules, and advancements to help define and understand the framework (Archambault, 2016). As subsequent research progressed, instead of focusing on how to interpret TPACK, the trend shifted to different measurement methods to see how teachers develop TPACK. While most studies provide results on teachers’ self-report data related to their development of TPACK (Kereluik, Casperson, & Akcaoglu, 2010), such data are limited in measuring these individuals actual use and integration of technology in classrooms.

In addition to survey instruments, researchers have investigated TPACK using other research methods. Based on the method categories proposed by Gall, Gall, and Borg (2007), there are four other types of measurements identified. Researchers have used performance assessment rubrics (e.g., Angeli & Valanides, 2009; Harris, Grandgenett, & Hofer, 2010) with the focus on analyzing teachers’ lesson plans; open-ended questionnaires (e.g., Robertshaw & Gillam, 2010; So & Kim, 2009), which typically gather teachers’ written responses to pre-developed questions included in a questionnaire or survey; interviews (e.g., Harris et al., 2012; Mishra, Peruski, & Koehler, 2007; Ozgun-Koca, 2009) with the focus on collecting information from a series of interview questions to assess teachers’ TPACK; and observation (e.g., Hofer, Grandgenett, Harris, & Swan, 2011; Koehler, Mishra, & Yahya, 2007), which investigate teachers’ teaching performances during classroom settings.

Although different research approaches have been used to investigate preservice teachers’ TPACK development, the majority of the data over the years were collected using self-reporting
techniques like a survey or questionnaire. While self-reported data still lead to important findings that inform teachers’ TPACK development, self-reported data may not provide enough evidence or capture the manner or extent of technology integration in the actual classroom (Marquez Chisholm & Padgett, 2004). Therefore, it is relatively important that research also utilize other systematic methods, such as observations and interviews, to truly reflect on how preservice (and inservice teachers) develop TPACK.

**Preservice Teachers’ Development of TPACK in Methodology Courses**

Field experience is a fundamental component of teacher preparation, and preservice teachers have traditionally identified the field experience component as one of the most important elements in their teacher preparation experience (Blue Ribbon Panel, 2010). Since technology is considered a critical element or skill to be learned throughout a preparation program, it is important to allow preservice teachers the opportunity to witness how technology can be effectively integrated into classroom contexts during the field experience/practicum (Polly et al., 2010). As a result, several studies have sought to explain how methodology courses or practicum experiences may impact preservice teachers’ knowledge of content, pedagogy, and technology. For instance, Pamuk (2011) identified that preservice teachers’ limited pedagogical knowledge inhibits technology integration (Pamuk, 2011). Therefore, some scholars suggest that PCK can be developed through an integrative process embedded in classroom practice (Niess et al., 2009). Thus, PCK serves as a guide for teachers dealing with a specific subject matter in the classroom. Kastberg and Leatham (2005) mention that without having essential knowledge of related curriculum materials, teachers at any level of preparation may be discouraged to integrate technology into their classroom instruction.
While results are limited, Ozgun-Koca, Meagher, and Edwards (2010) reported promising findings that indicate preservice teachers’ understanding of technology shifted from viewing technology as a tool for reinforcement into viewing technology as a tool for developing student understanding. In fact, evidence from existing research indicates that technology-rich field experiences can positively influence preservice teachers’ future integration of technology (Mouza et al., 2014; Polly et al., 2010). However, in some teacher preparation programs, preservice teachers still have limited opportunity to fully develop lesson plans paying careful consideration to the interplay between technology, pedagogy, and content until at least their second field experience (Mouza et al., 2014). Nonetheless, preservice teachers were still skeptical about the appropriateness of using technology to help develop subject content concepts, specifically in mathematics and science. Furthermore, Peressini, Borko, Romagnano, Knuth, and Willis-Yorker (2004) argue that none of the experiences within a teacher preparation program (i.e., courses, field experiences, practicum, student teaching) where preservice teachers are learning to teach are independent of one another. Thus, this may imply that all experiences are interrelated in preservice teachers' learning trajectory. Nevertheless, before arriving at such a conclusion, more research is needed to unpack preservice teachers’ learning experiences. Specifically, an investigation of preservice teachers' TPACK development during different periods in teacher preparation program could shed more light on this paramount and timely topic.

Methodology

This section provides information about the research methodology used for this study. Descriptions of the research design, research context, study participant, research procedures, data collection and data analysis are provided.
Research Design

This study utilized a single-case design with embedded units (Yin, 2009). A case study design is an empirical inquiry about a contemporary phenomenon (e.g., a “case”), set within its real-world context—especially when the boundaries between phenomenon and context are not clearly evident (Yin, 2009a, p. 18). For this study, one preservice teacher was the case under examination. Thus, the preservice teacher’s TPACK survey results, practicum teaching observations, and interview are considered to be the single-case, with two additional units added (i.e., course instructor interview, methodology course observation) to support the findings (see Figure 2).

Figure 2. Single-case with multiple embedded units.
Research Context

Case study data were collected from a preservice teacher majoring in elementary education from a large Midwestern university in Spring semester 2015 (January-May, 2015). Participation in this study was completely voluntary. The researcher attended one of the intermediate literacy methods course classes to recruit potential preservice teacher participants by explaining the nature of the research study and passed around a sign-up sheet. This participant (Lisa) was the only preservice teacher who agreed to participate. This participant was a student majoring in elementary education. She had completed the introductory technology course, content courses and most of her content-specific methodology courses (e.g. literacy, mathematics, science and social studies). She was also finishing up the requirements for a reading endorsement. At the time of the study, she was planning to student teach Spring semester 2016. Based on teacher education services records at the institution, there were 747 students enrolled as elementary education majors during Spring semester 2016.

Preservice teacher requirements for obtaining teacher licensure

At this large Midwestern university, all students who are interested in pursuing an elementary education major are required to complete several steps before they can receive teacher licensure and graduate from the institution (see Figure 3).
Before actual admission into the teacher preparation program, students are required to take a minimum of 9 credits of courses. For those courses, students need to receive a 2.5 cumulative grade-point-average (GPA). Once students complete those courses with minimum or higher GPA, they are formally admitted to the teacher preparation program. In the following 1 to 2 years, preservice teachers continue taking all of the required and elective courses specified by the elementary education major curriculum. Once they complete and pass all the major department/content courses with a minimum of a C grade, preservice teachers can start to take methodology courses with the associated practicum experiences (Blocks I and II). After they complete the content methodology courses with the practicum components, preservice teachers receive their student teaching placements. When student teaching is completed, the preservice teachers apply for teacher licensure and graduate from the academic institution.

**Introductory technology course**

The teacher preparation program requires a one-semester, stand-alone technology course offered for elementary education major students. The course is taught by an instructional
technology program faculty member in a lecture and lab format: two one-hour weekly lectures and a two-hour lab each week. Content and assignments are introduced and discussed in lectures while labs focus on skill building that involves educational technology commonly used with PreK-6 students.

Typically, most preservice teachers complete the required, introductory technology course prior to taking any content methodology courses and practicums. Once the instructional technology course is completed, preservice teachers enroll in their methodology courses, commonly called Block I and Block II, over a two-semester time frame (see Figure 4).

![Organization of Methodology Courses for Elementary Education Major](image)

*Figure 4. Organizational chart of methodology courses for elementary education major.*

*Content methodology courses and related practicums*

At this institution, all elementary education majors are required to take five methodology courses: 1. Teaching Reading and Language Arts for Primary Grades (PreK-3) (4 credits), 2. Teaching Reading and Language Arts for Intermediate Grades (4-6) (4 credits), 3.
Children Mathematics (3 credits), 4. Teaching of Science (3 credits), and 5. Teaching of Social
Studies (3 credits). Each methodology course has a supervised classroom-based practicum
experience – except for the social studies course. There is no classroom-based practicum
experience required during the social studies methods course. In the methodology courses,
pedagogical approaches that target a specific content area are introduced and taught. Preservice
teachers typically are required to design lessons and related assignments in those methods
courses that involve content-specific topics and pedagogical approaches applied in typical K-6
classrooms.

Preservice teachers attending this university typically start taking the methodology
courses in the second semester of their junior year (Block I) and first semester of their senior
year (Block II). Preservice teachers in Block I take the literacy for primary grades and math
methods classes on Monday and Wednesday for the first 9 weeks of the 15-week semester.
Then, the on-campus classes stop after 9 weeks, and a 4-week school-based practicum
experience begins. So, preservice teachers are placed with a cooperating K-3 teacher in school all
day on Monday and Wednesday for 4 weeks to start applying what they have learned in their two
methodology classes (i.e., primary literacy & math). During the practicum experience, students
are supervised by a university supervisor who provides feedback and evaluation. When the 4-
week practicum ends, the Monday/Wednesday on-campus classes resume for 2 weeks until the
end of the semester.

Block II includes methodology courses for literacy for the intermediate grades and
science. The scheduling of the classes changes slightly during Block II. Students attend the
courses on campus for the first 5 weeks of the semester on Tuesdays and Thursdays, and then
they complete their practicum experience all day on Tuesdays and Thursdays for 4 weeks in
elementary schools. After completing the practicum, the preservice teachers return to campus and resume the methodology courses for 6 weeks until the end of the semester. The social studies methods course has a prerequisite of Block I so it varies when students complete this course (e.g. in summer, during Block II…etc.), but many take that methods course during Block II.

**Literacy methodology course and related practicum**

In the previous section, a general introduction of content methodology courses with related practicum was provided. Because the focus of this study was investigating a single-case preservice teacher’s TPACK development during her literacy methodology course and practicum, a detailed explanation of what content was covered and what technology activities were required during methods course will now be provided.

This intermediate literacy methodology course addresses the theories and processes of literacy in elementary grades four through six. The focus is on application through reading and writing across the curriculum, integration of language arts, literature-based instruction, and metacognitive strategies.

The content topics covered include factors affecting children’s continued literacy development, reading/writing strategies for diverse learners, how literacy components interacts during classroom setting, knowledge of different types of assessments, classroom management skills and technology integration in literacy classroom environment. The preservice teachers enrolled in this class have to complete: 1) a semester-long reader response assignment (response to the class readings), 2) a literature circle activity (small groups of preservice teachers gather together to discuss a piece of literature in depth), 3) a lesson plan that involves specific literacy strategies, 4) four quizzes to evaluate students’ understanding of content, and 5) a technology
integration lesson plan that involves using an iPad to teach a reading or a writing lesson. At the end of the semester, the methods course instructor conducts an exit interview with each preservice teacher. The purpose of the exit interview is to evaluate the depth of understanding and reflection that each preservice teacher has on his/her experiences in the course and practicum.

During the practicum experience, preservice teachers are placed with an elementary teacher who typically teaches in grades 4-6. The practicum is a scheduled classroom experience when preservice teachers spend all day on Tuesdays and Thursdays for the 4 weeks (total of 8 days) in the assigned elementary classroom. During this 8-day practicum experience, preservice teachers are required to teach both a writing and a reading lesson typically in an upper elementary classroom. After the preservice teachers complete the practicum experience, they return to campus to continue the methods course (for 6 weeks) until the end of the semester.

**Study Participant**

Preservice teachers who were about to complete their Block II methodology courses were asked to participate in the study during Spring semester 2015. One preservice teacher (Lisa) agreed to participate in this study and to be observed during her intermediate literacy practicum experience. At the time, Lisa was in her early 20s and a junior majoring in elementary education. She was also finishing a reading endorsement. She had completed the introductory technology course and Block I methodology courses. She was enrolled in Block II (intermediate literacy and science) during in Spring semester 2015 (January to May). Her plan was to student teach during Spring semester 2016. For this study, Lisa was observed twice during her 4-week literacy methods course practicum. A follow-up interview was conducted after the completion of the 4-week intermediate literacy practicum experience to understand more about her overall thoughts
about her development to teach literacy (with technology) and the overall teacher education
program experience. She was also asked to complete the *Survey of Preservice Teachers’
Knowledge of Teaching and Technology* (Schmidt et al., 2009). Lisa completed the survey during
the last week of Spring semester 2015. From the previous record based on an email identifier,
Lisa had completed the same survey at the beginning (pre-test) and the end of the introductory
instructional technology course (post-test) two years prior - Spring semester 2013.

**Research Procedures and Data Sources**

Data were collected in Spring semester 2015 from one preservice teacher. The data
included both quantitative and qualitative measures. For this study, the *Survey of Preservice
Teachers’ Knowledge of Teaching and Technology* (Schmidt et al., 2009) was administered
online to the preservice teacher after she completed the Block II methodology courses. The
survey was administered the first time during the first week of the semester when the
participating preservice teacher was taking the introductory technology course (Spring semester 2013). Then, the survey was administered a second time during the last week of the introductory
technology course (Spring semester 2013). Thus, this preservice teacher completed this survey 3
times (before taking the introductory instructional technology course, after completing the
introductory instructional technology course and after completing Block II) for the purposes of
this study.

The internal consistency reliability (coefficient alpha) of the survey was tested in a
previous study (Schmidt et al., 2009). Therefore, the coefficient alpha reported ranged from .75
to .92 for the seven TPACK subscales also applied to this study. This range is considered to be
acceptable to excellent (George & Mallory, 2001). This survey was specifically developed to
capture elementary education preservice teachers’ knowledge development in the areas of
technology, pedagogy, and content. The survey includes 9 demographic questions, 47 5-scale Likert items, 3 multiple-choice items and 3 open-ended questions designed to measure preservice teachers’ self-perception of knowledge development in all seven TPACK constructs. These data were collected to measure the preservice teacher’s perceptions about how her knowledge about TPACK had developed between taking the required instructional technology course and completing all methodology courses (approximately 2 years).

Qualitative data were also collected during the data collection period. Two practicum classroom observations were conducted while the participant was out for her 4-week intermediate literacy method course practicum in Spring semester 2015. One interview was conducted with the participant after the two practicum classroom observations. In addition to the participant interview, an additional interview was conducted with the literacy methods course instructor to understand more about the course content and the assignments given. Two additional literacy methods course observations were conducted to observe a typical class and activities that were completed by the preservice teachers and the discussion that occurred as a result. All the interviews were recorded and then later transcribed.

Data Analysis

Both quantitative and qualitative methodologies were used to analyze the data. For quantitative analysis, the descriptive statistical analysis was performed to see if the participant’s self-perceived rating changed over the three time periods (Time 1 - pre-test before introductory instructional technology course; Time 2 - post-test after introductory instructional technology course; Time 3 - post-test after intermediate literacy methods course (i.e., Block II)).

For qualitative analysis, the participant’s practicum observations and interview were separated into units of meaning (UoMs) for coding and analysis. Tai (2014) stated that a helpful
way to determine the UoM for the initial stage of data analysis in a study is to utilize the concept of a social practice, also known as an “activity” (Mohan, 2007). According to Mohan (2007), a social practice is a combination of knowledge and action, meaning that teachers participating in a social practice are required to know (knowledge/reflection) something and to do (action) something. For example, “verb (specifically past tense)” could mark discourse of specific reflections while “if/then” could mark discourse of general reflections.

For the supportive data collected in the additional units of the defined case, such as the method course observations and the methods course instructor interview, summative content analysis (Hsieh & Shannon, 2005) was performed which involved counting and comparisons of content, followed by the interpretation of the underlying context to match with the codes that were identified. To ensure the reliability of the coding process, another researcher with research experiences in qualitative research and TPACK was invited to participate in the process of collecting and coding the observation and interview data. A simple percentage agreement was employed to calculate the intercoder reliability. Based on the study conducted by Mackey and Gass (2005), using simple percentages to calculate intercoder agreement is “appropriate for continuous data (i.e., data for which the units can theoretically have any value in their possible range, limited in precision only by our ability to measure them)” (p. 243). Moreover, Mackey and Gass also suggest that coding should be scheduled in rounds and trials to increase the intercoder reliability. In order to follow the stated suggestions, the researchers met first for about one hour to go over the Schmidt-Crawford et al. (2016) codebook, to become familiar with the codes. Please see Appendix H for sample TPACK codes, including full codes, definitions, and examples.
After the initial meeting, a follow-up meeting was conducted for trial coding of one set of data, containing the first observation field notes in a spreadsheet. The coding process involved each coder selecting one code from the codebook that fit the defined UoM best. In other words, for every UoM, the coders assigned one code for each unit of meaning for a total of 60 UoMs defined in the data collected. In comparing the coding results from the first observation, it was revealed that the agreement between the two coders was at 84.6% (33/39 UoMs). This result is considered to be “good.” Mackey and Gass (2005) recommended that “For simple percentages, anything above 75% may be considered “good,” although percentages over 90% are ideal” (p. 244). The coding results were recorded with remarks and reminders from the discussion. The file was emailed to the other researcher for references before the researcher of this study proceeded to the next step, which was for the two coders to code another set of data separately and then meet for comparison and discussion. Then, the two coders continued to code the second observation and the follow-up interview conducted with the preservice teacher. The results of the two data sources slightly decreased to 79% (23/29 UoMs - second observation) and 77.5% (38/49 UoMs - follow-up interview), but this agreement was still considered “good.”

Through discussion, an agreement was reached on all 3 data sources (2 classroom observations and 1 interview) except for 17 UoMs. For those 17 UoMs, the two coders decided none of the existing codes in the codebook fit. Therefore, there was a need to add additional codes to the codebook. To solve this discrepancy, a third coder, an instructional technology faculty member who conducts TPACK research, was consulted and the coding issue for these 17 UoMs was resolved. The third coder coded the UoMs and compared the codes with those from the two coders. Agreement was reached after discussions and new codes were generated and added to the Schmidt-Crawford et al. (2016) codebook. During the coding process, six new
codes were created and added to the codebook: one TK code (TK_Efficacy: Teacher’s belief in his/her ability to successfully perform a technologically sophisticated task), one PK code (PK_Learn: Teacher makes general reference to how he/she learns about the pedagogical approaches or using the approaches.), one TCK code (TCK_Learn: Teacher makes general reference to how he/she learns about content specific technologies or using the content specific technological tools), one PCK code (PCK_Learn: Teacher makes general reference to how he/she learns about the pedagogical approaches for specific subject matter or using the approaches with content specific topics), and two TPACK codes (TPACK_Learn: Teacher makes general reference to how he/she learns about utilizing technological tools with pedagogical approaches in content specific classroom; TPACK_Interdiciplinary_Connection: Teacher makes interdisciplinary connections between and/or across subject areas while teaching with technology).

Results

The data for this study were collected from three major data sources; 1) the TPACK survey results from three data collection points, 2) two observations with a follow-up interview, and 3) two additional data that include literacy methods course observations and an interview with the methods course instructor. Based on the data analysis for the two classroom observations and follow-up interview, it was revealed that the highest percentage of codes based on the number of code occurrences identified in the participant’s teaching were TPACK (24%; n=27), PK (21%; n=24) and PCK (16%; n=18) (see Figure 5 for the occurrences of the TPACK related codes). The participant was observed demonstrating TK (10%; n=12), TPK (7%; n=7), and TCK (5%; n=7) in her teaching as well. However, CK was only noted for 1% of the codes.
From the data sources, there are some UoMs that described the school environment (context codes) or Lisa’s own personal opinion about education (no codes category). Thus, context codes (10%; n=12) were observed along with some of Lisa’s personal opinion codes (No codes: 5%; n=6) that were not specifically related to teaching and these make up the remaining codes included in the data analysis.

The format of the data analysis is organized based on the core knowledge domains from the TPACK framework. In the next section, a discussion around the data analysis is organized around the four foundational domains of TPACK (CK, PK, TK, and TPACK) to help discuss how these core knowledge domains were present in this study and how they interact with each other. Because literacy is this study’s focus, only results specific to literacy will be shared.

Figure 5. Participant’s profile of occurrences of TPACK related codes.

Content Knowledge (CK) Related Domains

From Lisa’s TPACK survey results, it was revealed that the mean of her literacy content knowledge (CKL) increased slightly from time one (M=4.00) to time two (M=4.33) and dropped slightly from time two to time three (M=4.00) (see Figure 6). These mean responses are based
upon a 5-point Likert scale (1 = strongly disagree; 2 = disagree; 3 = neither agree or disagree; 4 = agree; 5 = strongly agree) and the participant’s average mean response to 3 questions; I have sufficient knowledge about literacy, I can use a literary way of thinking and I have various ways and strategies of developing my understanding of literacy.

![Chart](image)

**Figure 6.** Participant survey results of the content knowledge domain - literacy.

From the classroom observations and the interview with Lisa, there was only one content knowledge code observed or noted. The code is **CK_Accurate-Response** (n=1). Thus, content knowledge (CK) represents only 1% of the total TPACK codes observed in this study. This code, **CK_Accurate-Response**, means the preservice teacher provides correct answers to questions that students ask specifically related to the content being taught. The UoM was retrieved from one of the participant’s practicum classroom observations. In the observation, the researcher documented that “Lisa is able to answer students' questions with accurate information.”

In order to help readers understand what each code represents, a table (see Table 1) was organized with domain, theme, and definition information provided. Using the “theme” information for each code (after the underscore; e.g., **CK_Accurate-Response**), readers can
locate the theme definition and then identify if that theme was observed and aligned with any of
the seven TPACK domains.

Table 1.  
TPACK Codes and Themes Observed

<table>
<thead>
<tr>
<th>Themes</th>
<th>Definition</th>
<th>TK</th>
<th>PK</th>
<th>CK</th>
<th>TCK</th>
<th>PCK</th>
<th>TPK</th>
<th>TPACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use</td>
<td>Teacher demonstrates the ability to use technology and/or pedagogy for content teaching</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Match Affordance</td>
<td>Teacher selects technology and/or pedagogy to match the teaching/learning objectives.</td>
<td></td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Troubleshoot</td>
<td>Teacher demonstrates the ability to troubleshoot.</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prepare</td>
<td>Teacher demonstrates the ability to use technology and/or pedagogy to prepare for content teaching.</td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaborate</td>
<td>Teacher collaborates with others to use technology and/or pedagogy for content teaching.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Assess</td>
<td>Teacher uses technology and/or pedagogy to assess student learning.</td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connect</td>
<td>Teacher uses technology and/or pedagogy to connect students’ learning to others.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Learner Centered</td>
<td>Teacher uses technology and/or pedagogy to create student-centered environment for content learning.</td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reflect</td>
<td>Teacher reflects on his/her use of technology and/or pedagogy for content teaching.</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learn</td>
<td>Teacher learns from other to use technology, to use specific approach, or to use technology to teach content</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Others</td>
<td>Teacher demonstrates the ability to integrate technology and/or pedagogy into content teaching, e.g., teacher shows efficacy toward TK, teacher elicits students’ knowledge in a content area by using specific teaching strategy, coordinate technology, identified what teacher need in order to use technology to teach content and scaffold content learning.</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
On the other hand, there was one interesting finding occurring in all data sources. That is, the difficulty of identifying a teacher’s isolated content knowledge (CK) during classroom observations. While only one CK code was identified during Lisa’s practicum observations and follow-up interview, no other content-specific theme can be found in the literacy method course instructor interview and method course observations as well. Even when there was content information involved, content knowledge was not seen as a separate entity but was usually blended with other TPACK domains. For example, this can be illustrated with this researcher’s field note excerpt during a methods course observation, “After preservice teachers completed the lit circle activity, methods course instructor also shared how this can be used in teaching.” The content of the lit circle is all about reading, but the ways it was introduced to the preservice teachers are combined with pedagogical approaches, such as modeling, synthesizing and group activity. Next, findings for the PK related domains will be shared.

**Pedagogical Knowledge (PK) Related Domains**

Based on the survey results obtained from Lisa at the three designated data collection points, both her pedagogical knowledge related domains (PK and PCK) mean responses decreased from time one (M=3.71; M=3.50) to time two (M=3.00; M=3.00) respectively, and then increasing from time two to time three (M=4.43; M=4.00). During these data collection points Lisa responded that her PK and her PCK has some change from neither agree or disagree to agree during this time period (see Figure 7).
From Lisa’s practicum observations and interview data, eight different codes were acknowledged for the pedagogical knowledge related domains (PK and PCK). Three codes (PK_Use (n=21); PK_Learner-Centered (n=2) and PK_Learn (n=1)) were observed from the PK domain and represented 21% (n=24) of the total TPACK codes observed while Lisa was teaching in the classroom. One example of PK_Use coded during an observation was “Lisa regrouped students [after the activity] and asked if they changed their mind after talking to other peers.”

During the actual methods course observations, the researcher noted that the literacy methods course instructor always devoted time in each class period to talk about different classroom management skills, like grouping of students, by providing tips or answering related questions posed by preservice teachers.

On the other hand, five codes PCK_Use (n=6), PCK_Assess_Learning (n=1), PCK_Learn (n=1), PCK_Provide_Examples (n=1), and PCK_Reflect (n=9) were documented from the PCK domain and represented 16% (n=18) of the total TPACK codes observed. During

Figure 7. Participant survey result of the pedagogy-related domains.
her interview Lisa illustrated her development of PCK when she commented about using specific instructional strategies to teach literacy:

I think specific strategies from classrooms, from methods classes like Words Their Way or The Daily Five or Big Programs. I'll definitely use things like that and then implement ideas into that. [Preservice teacher interview]

Although it appears that observing a teacher’s content-specific knowledge while teaching can be challenging, a lot of pedagogical content knowledge related codes emerged and were able to be identified. Another example was observed during a methods course observation, when the methods course instructor introduced the topic of text complexity. The instructor shared and demonstrated different scenarios on how preservice teachers might pick out books that were the right text reading level for their students. Obviously, the literacy methods course was specifically designed to share pedagogical methods that preservice teachers could use in their practicum experiences and beyond while teaching literacy. For example, the preservice teachers were required to keep a reference sheet that included a list of reading/writing strategies taught during the literacy methods course to be used at a later date [course syllabus & methodology course observation]. The results from the TK related domains are presented next.

**Technology Knowledge (TK) Related Domains**

Based on the survey results gathered from Lisa at the three distinct data collection points, results from the technological knowledge related domains (TK, TCK and TPK) were mixed. Lisa’s TK-related mean responses for TK, TCK and TPK all increased from time one (TK=3.50; TCK=3.25; TPK=3.80) to time two (TK=3.83; TCK=4.00; TPK=4.20). However, results from time two to time three were mixed. While Lisa’s TK mean response decreased slightly from time two (M=3.83) to time three (M=3.67), her TCK mean response (T2 M= 4.00; T3 M= 4.00)
remained unchanged, while her TPK mean response (T2 M= 4.00; T3 M= 4.20) showed a slight increase from time two to time three (see Figure 8).

Figure 8. Participant survey result of the technology-related domains.

A total of twelve codes were identified from the TK related domains (i.e. TK, TCK and TPK) while observing and talking with Lisa. Five codes (TK_Use (n=4); TK_Troubleshoot (n=1); TK_Prepare (n=1); TK_Efficacy (n=1); and TK_Reflect (n=5)) were categorized from the TK domain and represented 10% (n=12) of the total TPACK codes observed. Lisa specifically commented during her interview about how she gained additional technology knowledge from her Block II literacy practicum because of her cooperating teacher:

A lot of it [technology integration ideas] actually came from my cooperating teacher. She was a great teacher and she used it [technology tools] to enhance what she was doing, so it was really cool to see it used well. I learned a lot from her. [Preservice teacher interview]

On the other hand, Lisa commented that her experience during Block I was the complete opposite in terms of developing her technology-related knowledge with regards to literacy and
teaching. Due to the lack of modeling provided by her Block I cooperating teacher, she did not feel that her technology knowledge was enhanced:

It didn't feel like it really enhanced it all that much other than just projecting occasionally something on the board for the students to see. My block one practicum, I don't remember really using technology at all. We used a big white paper board and then we would use markers and then rip it off and do that again. Not a lot of technology in that room. [Preservice teacher interview]

Three TCK codes (TCK_Use \(n=3\); TCK_Match-Affordance \(n=3\) and TCK_Learn \(n=1\)) were observed. These TCK codes represent 6\% \((n=7)\) of the total TPACK codes observed. A typical example of TCK_Use code (e.g., use blogging instead of pencil paper writing) was retrieved from Lisa’s practicum classroom observation notes and illustrate how Lisa used technology to teach specific content in a literacy classroom.

For TPK codes, four codes (TPK_Match-Affordance \(n=4\); TPK_Connect \(n=2\); TPK_Refelct \(n=1\); TPK_Coodinating Technology \(n=1\)) were identified and represented 7\% \((n=8)\) of the total TPACK codes that were either observed in the classroom or mentioned during the interview (see Table 1). Below is an example of a TPK_Match-Affordance code retrieved from one of the practicum classroom observations. During the observation, students in class were having difficulty logging into the website to access the literacy materials, Lisa noticed the issue and decided to show the website on the screen and modeled the steps how students can access the website [Preservice teacher practicum classroom observation]. This example demonstrates how Lisa matched the affordances of the technology with the pedagogy she used while teaching a literacy lesson.

It might also be worth noting in this section a specific context code that was documented could be linked to Lisa’s TK development. The (Context_Technology-Skill-Differences) code
was identified as of a result of conducting Lisa’s interview. Lisa actually pointed out that there were great differences in the technology integration skill level between her Block I and Block II cooperating teachers. She also elaborated on the fact that preservice teachers have little control over who they are assigned to for these classroom experiences, and shared:

I think teachers, too, some of them are more comfortable with technology and some of them are less comfortable. In my block one, she would ask me like, "Hey, can you help me figure out my email?" Just very simple things that are simple to me that she ... way over her head and she needed help with very small things. I think she would have been very overwhelmed to try to use it with the students, especially because the students seem to know more than teachers now. I think it depends on the teacher and her experience or his experience. The one in [name of city], she was young and she came from a district in [name of state] and they used technology, so she was well versed in using technology in the classroom. [Preservice teacher interview]

Lisa’s results specific to TPACK are shared in the next section.

**Technological Pedagogical Content Knowledge (TPACK) Domain**

Based on the survey results obtained from Lisa at the three data collection points, her technological pedagogical content knowledge mean response showed an increase from time one (M=3.63 - approaching agree) to time two (M=4.00 - agree). For time two and time three (M=4.00 - agree), the mean response was the same (see Figure 9).
A total of nine TPACK codes [TPACK_Match Affordance (n=3); TPACK_Collaborate (n=2); TPACK_Assess_Learning (n=4); TPACK_Reflect (n=5); TPACK_Learn (n=6); TPACK_Scaffolding-content (n=4); TPACK_Resources-content (n=1); TPACK_Teacher Need (n=1); and TPACK_Interdiciplinary (n=1)] were identified during data analysis. These codes represented 24% (n=27) of the overall TPACK codes observed and/or mentioned by Lisa during this study (see Table 1).

The code, TPACK_Learn (see Table 1), was identified the most frequently in the major data sources. Below are two typical examples retrieved from Lisa’s interview. During her interview, Lisa commented about how she was able to learn from a past instructor and her Block II practicum cooperating teacher to use technology for teaching in a classroom setting:

She [practicum cooperating teacher] used her projector a lot. She used different games. She used Kahoot. She used things like that. She was a great teacher and she used it to enhance what she was doing, so it was really cool to see it used well. [Preservice teacher interview]
I [Lisa] think methods courses and 201 do a good job in preparing us, it's just then can we actually use them [technologies] when we get out there? [Preservice teacher interview]

While Lisa appeared to have several opportunities to learn from her Block II practicum cooperating teacher about how to integrate technology in a literacy classroom, she pointed out that the modeling classroom teachers provide preservice teachers, and the resources available in the assigned school districts can be critical factors that impact a preservice teacher’s ability to integrate technology:

I think if the resources are at the school I would be confident to use them. I think the teacher where you have your practicums in teaching is a big factor in whether or not you’re going to go through with the technology. [Preservice teacher interview]

Lisa further elaborated on her literacy methods course experiences that she had related to technology during her interview. She mentioned that methods course instructors typically provide technology-related resources, but most of those resources are not specifically for teaching or using them directly with elementary students. Lisa specifically mentioned that the intermediate literacy methods course (part of Block II) was the methods course that put the most emphasis on how to integrate technology into a content area.

There's a lot of technology more so with the professional development side, so they'll give us a lot of strategies, they'll give us a lot of websites that we as teachers can use, but not necessarily resources for in the classroom with students. There's some [technology]. They [method course instructors] definitely give you some, but I think [this literacy course] 378 has been the heaviest on using technology in the classroom. [Preservice teacher interview]

The methods course instructor later confirmed Lisa’s comment and experience related to learning more about applying technology, pedagogy and content within the literacy methods.
Specifically, the instructor mentioned how she can build upon what the preservice teachers learn in the introductory technology course, “We [Method course instructor and preservice teachers] can then talk about how literacy could be infused even more into the technology things that they maybe had done in the past or that they were looking at.”

**Discussion**

From the overall results reported above, three major findings related to this preservice teacher’s development of TPACK will now be discussed. They are “Emphasis on Pedagogical Knowledge Development”, “Modeling for Preservice Teachers” and “Trajectory of TPACK Development”. In the following sections, a detailed explanation for each is provided.

**Emphasis on Pedagogical Knowledge Development**

According to Akarsu and Kaya (2012), methods courses are generally designed to help preservice teachers develop their pedagogical content knowledge (PCK). While preservice teachers have more opportunities to learn how to teach specific subject matter, they also gain confidence in applying a teaching approach to teach a content-specific topic in classroom settings (Kelly, 2000). Such findings as these are consistent with the results from this case study. It was clear from the methods course classroom observations that the focus was to teach preservice teachers how to use content-specific (i.e., literacy) teaching approaches in classroom settings. Some specific topics included in this elementary literacy methods class are classroom management, reader response along with lit review, lesson plan writing and introduction of reading/writing strategies. Based on these case study results, Lisa probably showed the most personal growth in the pedagogical-related TPACK domains. Using her survey results that were administered during three times during her preparation program, Lisa reported the most change
in her pedagogical knowledge domains from time one to time two. Furthermore, she actually demonstrated having this pedagogical knowledge and pedagogical content knowledge while teaching in her literacy practicum and then upon reflection during her follow-up interview. The literacy methods course instructor also shared a general observation about preservice teachers’ pedagogical-related growth after taking her course:

  They [preservice teachers] come in well prepared from the other classes and then we just continue to grow. I think their comfort level and their reasons ... They can articulate why they're using it [teaching approach], which is, to me, the ultimate way of knowing that they know how to use it. They can say why they're doing what they're doing, which is very good. [Literacy method course instructor interview]

**Modeling for Preservice Teachers**

It was revealed that during the two practicum classroom observations that Lisa could actually demonstrate quite consistently her knowledge from five of the seven TPACK domains (TK, PK, TCK, PCK and TPACK). During her Block II practicum, Lisa was able to learn how she could better integrate technology into content specific instruction from the modeling that was provided from both her cooperating teacher and her literacy methods instructor. Thus, Lisa was able to observe and learn what was considered to be good examples of using technology with appropriate pedagogical approaches and literacy content. A good example of the importance of teacher modeling was mentioned by Lisa during her interview:

  She shared with me what [technology tool and teaching idea] was really common in her classroom. She was sharing with me that earlier this year they had done blogging in their classroom. They had blogged with a school from [city in Iowa] where the teacher actually grew up. [Preservice teacher interview]
While Lisa gained positive experience working with her cooperating teacher from her practicum experience, she also commented how the courses she took throughout her preparation program prepared her well for meaningful technology integration.

Yeah. I think the courses prepared us well for technology integration. After 201 you're exposed to a lot of different things. Then as you go into content courses, I know a lot of my classmates and I will be doing something and think, “Oh, that technology resource would be really fitting for this.”

[Preservice teacher interview]

This idea of providing appropriate technology integration models for teachers is consistent with other existing research. That is, technology-rich field experiences where cooperating teachers model and scaffold appropriate technology while effectively teaching the content can positively influence preservice teachers’ integration of technology (Mouza et al., 2014; Polly et al., 2010). The literacy methods course instructor also commented on the power of modeling for preservice teachers:

We do exit interviews at the end, and one of the questions that I don't grade ... I just ask them, "What are the things that helped you this semester?" I'd say a large percentage, maybe 60 to 70%, mention the technology lessons and those kinds of things they felt were really helpful because they knew about it. They knew how to do it, but now they felt they knew how to really use it to meet learning goals for literacy. That's what they've mentioned that the practice doing it and modeling have helped them feel confident in it and then the more confident they feel, I think the more they will probably use it then when they get to the classroom. [Literacy methods course instructor interview]

Thus, even with proactive modeling from cooperating classroom teachers or methods course instructors, preservice teachers’ TPACK development may still be impacted by the differences associated with cooperating teachers’ TPACK during practicum and student teaching.
experiences. Lisa is part of a large teacher preparation program with nearly 800 elementary teacher education majors enrolled. Several hundred placements are made each semester for early field experiences, Block I and II practicums and student teaching. The challenge remains on how to best place preservice teachers with TPACK teachers for continued professional development in this area. Quite frankly, it is almost impossible to have the required number of cooperating teachers who model TPACK for the number of preservice teachers entering the profession. Not to mention requiring cooperating teachers to also have some TPACK expertise. For instance, Lisa had very different experiences between her Block I and Block II placements. While Lisa’s Block I literacy cooperating teacher was very uncomfortable with using technology, her Block II literacy cooperating teacher was able to effectively use technology while teaching literacy. Lisa stated, “It was really cool to see it (technology) used well.” Again, having technology-rich field experience can better prepare preservice teachers to teach with technology (Mouza et al., 2014; Polly et al., 2010).

It was revealed during this study’s data collection process that the school where Lisa completed her Block II literacy practicum supports a one-to-one device program. All of the students who attend this school have 24/7 access to individual Chromebooks. Kastberg and Leatham (2005) noted that having access to technology is key but without essential knowledge of related curriculum materials teachers may actually be discouraged to integrate technology in their classroom instruction.

**Trajectory of TPACK Development**

In teacher preparation programs, teacher candidates can potentially develop TPACK by taking a dedicated educational technology course, content-specific teaching methods courses, or
practicum courses; or by exposure to TPACK concepts throughout the duration of coursework in a teacher preparation program (Hofer & Grandgenett, 2012). Peressini, Borko, Romagnano, Knuth, and Willis-Yorker (2004) also emphasize that none of the experiences (e.g., content courses, teacher preparation courses, preservice field experiences) in learning how to teach are independent of one another. They all influence a prospective teacher’s learning trajectory.

While research exists that reports preservice teachers’ knowledge increases in the area of pedagogical content knowledge (PCK) during their methods course experiences, their development of technology related knowledge (that is TK, TCK, TPK and TPACK) shows varying results (Mouza et al., 2014; Ozgun-Koca et al., 2009; Polly et al., 2010). In this study, Lisa reported a slight increase in two pedagogy-related domains (PK and PCK) from time two to time three in completing the TPACK survey (see Figure 7). Even though Lisa’s self-perceived development of her knowledge in the technology-related domains of TPACK decreased (see Figure 8), the researchers still observed her demonstrating and applying all TPACK domains during her practicum experience (see Table 1). Clearly, Lisa is aware of her growing knowledge in TPACK and realizes she still needs continuous personal development with TPACK-related knowledge. In fact, Lisa agreed that the introductory technology course, the literacy methods courses and her practicum experiences collectively prepared her at this point in her preparation program to be a successful teacher.

Conclusion

Strudler and Wetzel (2005) specified effective technology integration should be a multi-layer process and require adjustments at different educational levels (i.e. student, teacher, colleges of education). Some important findings (Brzycki & Dudt, 2005; Chuang et al., 2003;
Wetzel, Wilhelm & Williams, 2004) suggest steps such as moving from a stand-alone technology course to technology-integrated curricula and context-specific approaches, providing more exemplary models of technology use by teacher preparation educators, increasing faculty development opportunities, and increasing expectations that prospective teachers use technology while in classrooms. There is broad agreement among educators that technology can be effective and support learning only if it is meaningfully integrated into teaching (Pamuk, 2012). For teacher preparation programs, it is especially important to provide consistent content and curriculum coverage for all preservice teachers regarding professional core and content methods courses. While it might be challenging to pair preservice teachers with cooperating teachers who have TPACK tendencies related to skills and integration, it seems essential and critical that teacher preparation programs attempt to work closely with K-12 school districts to ensure that every effort is made to provide classroom placements where preservice teachers work closely with skilled cooperating teachers who work to integrate technology successfully into the instructional routine.

Figg and Jaipal (2009) state that teachers need TPK to integrate technology successfully in instruction, “TPK characteristics played the most significant role in successful planning and implementation, and the lack of these foundational understandings had a negative impact on lesson implementation in practice” (p. 4). They concluded with a recommendation of needing a strong focus on instructional planning and implementation strategies as a way to provide key assistance for preservice teachers. Based on this recommendation, this might be another useful suggestion for teacher preparation program curriculum committees and course instructors to consider when planning the goals and learning outcomes of the program courses.
While this study may shed some light to show how prepared one preservice teacher developed TPACK before actually student teaching, more cases will need to be established to examine how other preservice teachers are prepared to do the same. Those summarized outcomes can then serve as evidence to suggest further program revisions and possible systemic changes. On the other hand, this study only investigated preservice teachers’ TPACK development until the end of methods course experience, so it seems plausible to continue efforts that develop longitudinal studies that investigate preservice teachers’ TPACK development from the beginning until the end of the teacher preparation program experience.

References


Archambault, L. (2016). Exploring the Use of Qualitative Methods to Examine TPACK. *Handbook of Technological Pedagogical Content Knowledge (TPACK) for Educators*, 65.


Robertshaw, M.B. & Gillam, R.B. (2010). Examining the validity of the TPACK framework from the ground up: Viewing technology integration through teachers’ eyes. In D. Gibson & B. Dodge (Eds.), Proceedings of Society for Information Technology & Teacher Education International Conference 2010 (pp. 3926-3931). Chesapeake, VA: AACE.


CHAPTER 5. GENERAL SUMMARY

The establishment of pedagogical content knowledge (Shulman, 1986) set an important foundation for teacher education to identify what knowledge is needed for preservice teachers to successfully teach in a classroom setting. Knowledge of technology later emerged as another knowledge domain that requires further attention in the field (Koehler & Mishra, 2009). Recognizing the need of developing technology knowledge in preservice teachers, teacher preparation programs started to incorporate curriculum with a focus on teaching preservice teachers to integrate technology in their classrooms. While stand-alone educational technology courses can help increase preservice teachers’ confidence in using technology, they sometimes fall short in promoting the meaningful use and integration of technology integration into preservice teachers’ teaching practices (Wachira & Keengwe, 2011). Therefore, it is recommended by researchers that technology training need to be integrated throughout the entire teacher education program to better promote meaningful technology integration (Angeli & Valanides, 2009; Hughes, 2013; Tondeur et al., 2012).

To assist the implementation, a conceptual framework called Technological Pedagogical Content Knowledge (TPACK) developed by Mishra and Koehler (2006) was widely used to guide the technology integration process. The framework was also utilized to develop curriculum, professional development modules and other advancements (Archambault, 2016). Recently, research in this area has shifted its focus to using various measurement methodologies to determine teachers develop TPACK. Currently, all the research methodology categories can be identified into the following five types (Gall, Gall, and Borg, 2007): 1) self-report measure (e.g., Archambault & Crippen, 2009; Lee & Tsai, 2010; Schmidt et al., 2009), 2) performance assessment rubrics (e.g., Angeli & Valanides, 2009; Harris, Grandgenett, & Hofer, 2010); 3)
open-ended questionnaires (e.g. Robertshaw & Gillam, 2010; So & Kim, 2009); 4) interviews (e.g., Harris et al., 2012; Mishra, Peruski, & Koehler, 2007; Ozgun-Koca, 2009); and observations (Hofer, Grandgenett, Harris, & Swan, 2011; Koehler, Mishra, & Yahya, 2007). While various instruments were created to measure teachers’ TPACK development, most studies were designed to investigate a single scenario or course. Only limited studies (Bate, Day, & Macnish, 2013; Hofer & Grandgenett, 2012; Schmidt et al., 2009) addressed the intention of extending the research conducted into a longitudinal investigation in which teachers’ TPACK development could be examined while completing their preparation program. In order to better understand how preservice teachers develop TPACK knowledge during teacher preparation program, it seems worthwhile to explore the potential of collecting data over a longer period of time (Chai, Koh & Tsai, 2010).

The three journal articles tapped into the essential components surrounding the dissertation’s focus of preK-6 preservice teachers’ TPACK development during their teacher preparation program. The first article, “Preservice Teachers’ TPACK Development: A Review of TPACK Literature” provided an extensive literature review. Based on the analysis of the literatures, this article examines the development of TPACK framework with a specific focus on assessing preservice teachers’ TPACK development via five different research methods (self-report, open-ended questionnaire, performance assessment, interview, and observation). Two themes were found from analysis result revealed the importance of technology integration modeling and challenge of observing integrated knowledge domains (TCK, TPK).

The second article, “Examination of Preservice Teachers’ Development of Technological Pedagogical Content Knowledge (TPACK) After Completing Content Methodology Courses” actively explored preK-6 preservice teachers’ development of technological pedagogical content
knowledge (TPACK) through triangulated assessments (i.e., survey, interviews and open-ended questions) after completing a series of required content methodology courses (required in literacy, math, social studies and science). Findings revealed that the methodology courses play a critical role in developing preservice teachers’ knowledge in content and pedagogy. Lack of support for technology integration in field classrooms and various degree of TPACK incorporated in different method courses may result in preservice teachers’ decrease of technology knowledge (TK), technology content knowledge (TCK), technology pedagogy knowledge (TPK) and TPACK domains.

In the third article, “A PreK-6 Preservice Teacher’s Journey to TPACK: A Case Study” utilized case study approach to investigate how prepared a preservice teacher is to use technology within literacy content instruction during a practicum experience. Findings affirmed the participating preservice teacher was able to meaningfully integrate technology in her practicum teachings with characteristics from all seven TPACK domains identified. It was also realized that positive technology integration scaffolding from course instructors or supervising teachers and course content consistency might play an important role in preservice teachers’ TPACK development.

The three articles provided an analysis of the relevant literature and thoroughly explored the research questions that were posed. A thorough data analysis provided evidence regarding the impact of teacher preparation program experience on preservice teachers’ TPACK development. In general, main conclusions can be drawn from this study. These include the following: technology integration modeling or scaffolding from teacher preparation program instructors and field instructors can enhance preservice teachers’ overall TPACK development, the need of continuing longitudinal study to keep track of preservice teachers’ TPACK development during
teacher preparation program, and close relationship of pedagogical-related knowledge
development and methodology courses. Method courses provide the opportunity for preservice
teachers to learn more about content-specific pedagogical approaches and teach in real
classrooms. This study was able to shed some lights to reflect preservice teachers’ growth in
various areas.

**Recommendations for Future Research**

This dissertation provided a starting point for future educational research that explore
TPACK measurement, teacher preparation program, and how they relate to preK-6 preservice
teachers’ development of TPACK. Some possible future studies could continue to track
 preservice teachers’ TPACK development during their teacher preparation journey. This
dissertation made the attempt to track preservice teachers from introductory technology course to
practicum experience. It will be worthwhile to extend this effort to monitor preservice teachers’
complete TPACK development until the end of student teaching. This type of longitudinal
research effort will provide an opportunity for teacher preparation programs to evaluate how well
they incorporate TPACK framework to prepare preservice teachers to teach with technology.
Also, further research could continue to investigate preservice teachers’ TPACK characteristics
by classroom observations. An attempt was made in this dissertation to further analyze one
 preservice teacher’s case, but more cases will need to be done to help researchers to triangulate
observed characteristics with self-report data. Another topic that could be explored is the
comparison between preservice teachers with learning technologies minor and preservice
teachers without learning technologies minor. Because of the focus on course requirement in
 technology, it may be interesting to see if the extra course requirement may generate impact on
 preservice teachers’ TPACK development.
Through the analysis of the literature and an in-depth exploration, the components essential and necessary in promoting preservice teachers’ TPACK development were discovered. Future educational professionals, and other researchers can incorporate the findings and methods into their own research designs. This dissertation is only the beginning of my investigation into the TPACK incorporation into preK-6 teacher preparation program.

References


Archambault, L. (2016). Exploring the Use of Qualitative Methods to Examine TPACK. *Handbook of Technological Pedagogical Content Knowledge (TPACK) for Educators*, 65.


Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary issues in technology and teacher education, 9*(1), 60-70.


APPENDIX A. IRB MODIFICATION APPROVAL LETTERS AND ORIGINAL APPROVAL LETTER

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Date: 2/17/2016
To: Wei Wang
N062 Lagomarcino Hall
CC: Dr. Denise (Schmidt) Crawford
N031 Lagomarcino Hall

From: Office for Responsible Research
Title: Preservice Teachers' Development in Technology, Pedagogy and Content Knowledge (TPACK) After Content Methodology Courses
IRB ID: 11-494
Study Review Date: 2/16/2016

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

1. Research conducted in established or commonly accepted education settings involving normal education practices, such as:
- Research on regular and special education instructional strategies; or
- Research on the effectiveness of, or the comparison among, instructional techniques, curricula, or classroom management methods.

2. Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
- Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
- Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:
- You do not need to submit an application for annual continuing review.
- You must carry out the research as described in the IRB application. Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. Only the IRB or designees may make the determination of exemption, even if you conduct a study in the future that is exactly like this study.

Please be aware that approval from other entities may also be needed. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires
Date: 1/29/2015
To: Wei Wang
N062 Lagomarcino Hall
CC: Dr. Denise (Schmidt) Crawford
N031 Lagomarcino Hall

From: Office for Responsible Research

Title: Preservice Teachers’ Development in Technology, Pedagogy and Content Knowledge (TPACK) After Content Methodology Courses
IRB ID: 11-494

Study Review Date: 1/29/2015

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

• (1) Research conducted in established or commonly accepted education settings involving normal education practices, such as:
  • Research on regular and special education instructional strategies; or
  • Research on the effectiveness of, or the comparison among, instructional techniques, curricula, or classroom management methods.

• (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  • Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  • Any disclosure of the human subjects’ responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:
• You do not need to submit an application for annual continuing review.

• You must carry out the research as described in the IRB application. Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. Only the IRB or designees may make the determination of exemption, even if you conduct a study in the future that is exactly like this study.
The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

1. Research conducted in established or commonly accepted education settings involving normal education practices, such as:
   - Research on regular and special education instructional strategies; or
   - Research on the effectiveness of, or the comparison among, instructional techniques, curricula, or classroom management methods.

2. Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
   - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
   - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:

- You do not need to submit an application for annual continuing review.
- You must carry out the research as described in the IRB application. Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only
Survey of Preservice Teachers' Knowledge of Teaching and Technology

Project Title: Preservice Teachers' Knowledge of Technology and Teaching

Project Investigators: Dr. Denise Crawford, Wei Wang and Lindsay Woodward

The purpose of this study is to understand how preservice teachers develop and apply their knowledge of technology and teaching. You are being invited to participate in this study because you are currently enrolled as a student in content methodology courses at Iowa State University.

Your participation involves completing an online questionnaire (15-20 minutes). The online questionnaire contains 64 multiple-choice questions and three open-ended questions. Records identifying participants will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available. Your individual name or email address will not at any time be associated with your individual responses. Participating in the study is voluntary and you may withdraw at any point. There are no foreseeable risks from participating in the study.

Thank you in advance for taking time to complete this questionnaire. Please answer each question to the best of your knowledge. Please answer all of the questions and if you are uncertain of your response you may always select "Neither agree or disagree". Your thoughtful and candid responses will be greatly appreciated. Again, your responses will be kept completely confidential and will not influence your course grade.

If you have any questions about this research, please contact Wei Wang at weiyui72@iastate.edu or 515-294-9997. Thank you!

If you agree to participate in the study, please click the NEXT button.
Survey of Preservice Teachers' Knowledge of Teaching and Technology

1. Your ISU e-mail address (e.g. jess@iastate.edu)

2. Gender
   - Female
   - Male

3. Age range
   - 18-22
   - 23-26
   - 27-32
   - 32+

4. Major
   - Early Childhood Education (ECE)
   - Elementary Education (ELIED)
   - Other

5. Area of Specialization
   - Art
   - Early Childhood Education Unified with Special Education
   - English and Language Arts
   - Foreign Language
   - Health
   - History
   - Instructional Strategist: Mild/Moderate (K-12) Endorsement
   - Mathematics
   - Music
   - Science-Basic
   - Social Studies
   - Speech/Theater
   - Other

6. Year in College
   - Freshman
   - Sophomore
   - Junior
   - Senior

7. Are you completing a digital learning minor (formerly educational educational computing minor)?
   - Yes
   - No
Survey of Preservice Teachers' Knowledge of Teaching and Technology

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

8. I know about a lot of different technologies.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Disagree</th>
<th>Neither Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

9. I have the technical skills I need to use technology.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Disagree</th>
<th>Neither Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

10. I keep up with important new technologies.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Disagree</th>
<th>Neither Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

11. I know how to solve my own technical problems.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Disagree</th>
<th>Neither Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

12. I can learn technology easily.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Disagree</th>
<th>Neither Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

13. I frequently play around the technology.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Disagree</th>
<th>Neither Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

14. I have had sufficient opportunities to work with different technologies.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Disagree</th>
<th>Neither Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>
### Survey of Preservice Teachers' Knowledge of Teaching and Technology

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

15. I can use a mathematical way of thinking.
   - [ ] Strongly Agree
   - [ ] Agree
   - [ ] Neither Agree nor Disagree
   - [ ] Disagree
   - [ ] Strongly Disagree

16. I can use a literary way of thinking.
   - [ ] Strongly Agree
   - [ ] Agree
   - [ ] Neither Agree nor Disagree
   - [ ] Disagree
   - [ ] Strongly Disagree

17. I can use a scientific way of thinking.
   - [ ] Strongly Agree
   - [ ] Agree
   - [ ] Neither Agree nor Disagree
   - [ ] Disagree
   - [ ] Strongly Disagree

18. I can use a historical way of thinking.
   - [ ] Strongly Agree
   - [ ] Agree
   - [ ] Neither Agree nor Disagree
   - [ ] Disagree
   - [ ] Strongly Disagree

19. I have various ways and strategies of developing my understanding of mathematics.
   - [ ] Strongly Agree
   - [ ] Agree
   - [ ] Neither Agree nor Disagree
   - [ ] Disagree
   - [ ] Strongly Disagree

20. I have various ways and strategies of developing my understanding of literacy.
   - [ ] Strongly Agree
   - [ ] Agree
   - [ ] Neither Agree nor Disagree
   - [ ] Disagree
   - [ ] Strongly Disagree

21. I have various ways and strategies of developing my understanding of science.
   - [ ] Strongly Agree
   - [ ] Agree
   - [ ] Neither Agree nor Disagree
   - [ ] Disagree
   - [ ] Strongly Disagree

22. I have various ways and strategies of developing my understanding of social studies.
   - [ ] Strongly Agree
   - [ ] Agree
   - [ ] Neither Agree nor Disagree
   - [ ] Disagree
   - [ ] Strongly Disagree

23. I have sufficient knowledge about mathematics.
   - [ ] Strongly Agree
   - [ ] Agree
   - [ ] Neither Agree nor Disagree
   - [ ] Disagree
   - [ ] Strongly Disagree
### Survey of Preservice Teachers' Knowledge of Teaching and Technology

**24. I have sufficient knowledge about literacy.**
- [ ] Strongly Agree
- [ ] Disagree
- [ ] Neither Agree nor Disagree
- [ ] Agree
- [ ] Strongly Agree

**25. I have sufficient knowledge about science.**
- [ ] Strongly Agree
- [ ] Disagree
- [ ] Neither Agree nor Disagree
- [ ] Agree
- [ ] Strongly Agree

**26. I have sufficient knowledge about social studies.**
- [ ] Strongly Agree
- [ ] Disagree
- [ ] Neither Agree nor Disagree
- [ ] Agree
- [ ] Strongly Agree
Survey of Preservice Teachers' Knowledge of Teaching and Technology

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

27. I can use a wide range of teaching approaches in a classroom setting.

☐ Strongly Disagree  ☐ Disagree  ☐ Neither Agree or Disagree  ☐ Agree  ☐ Strongly Agree

28. I can adopt my teaching style to different learners.

☐ Strongly Disagree  ☐ Disagree  ☐ Neither Agree or Disagree  ☐ Agree  ☐ Strongly Agree

29. I know how to assess student performance in a classroom.

☐ Strongly Disagree  ☐ Disagree  ☐ Neither Agree or Disagree  ☐ Agree  ☐ Strongly Agree

30. I am familiar with common student understandings and misconceptions.

☐ Strongly Disagree  ☐ Disagree  ☐ Neither Agree or Disagree  ☐ Agree  ☐ Strongly Agree

31. I can assess student learning in multiple ways.

☐ Strongly Disagree  ☐ Disagree  ☐ Neither Agree or Disagree  ☐ Agree  ☐ Strongly Agree

32. I can adapt my teaching based-upon what students currently understand or do not understand.

☐ Strongly Disagree  ☐ Disagree  ☐ Neither Agree or Disagree  ☐ Agree  ☐ Strongly Agree

33. I know how to organize and maintain classroom management.

☐ Strongly Disagree  ☐ Disagree  ☐ Neither Agree or Disagree  ☐ Agree  ☐ Strongly Agree
Survey of Preservice Teachers' Knowledge of Teaching and Technology

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

34. I know that different mathematical concepts require different teaching approaches.
   - Strongly Disagree
   - Disagree
   - Neither Agree or Disagree
   - Agree
   - Strongly Agree

35. I know that different literacy concepts require different teaching approaches.
   - Strongly Disagree
   - Disagree
   - Neither Agree or Disagree
   - Agree
   - Strongly Agree

36. I know that different science concepts require different teaching approaches.
   - Strongly Disagree
   - Disagree
   - Neither Agree or Disagree
   - Agree
   - Strongly Agree

37. I know that different social studies concepts require different teaching approaches.
   - Strongly Disagree
   - Disagree
   - Neither Agree or Disagree
   - Agree
   - Strongly Agree

38. I can select effective teaching approaches to guide student thinking and learning in mathematics.
   - Strongly Disagree
   - Disagree
   - Neither Agree or Disagree
   - Agree
   - Strongly Agree

39. I can select effective teaching approaches to guide student thinking and learning in literacy.
   - Strongly Disagree
   - Disagree
   - Neither Agree or Disagree
   - Agree
   - Strongly Agree

40. I can select effective teaching approaches to guide student thinking and learning in science.
   - Strongly Disagree
   - Disagree
   - Neither Agree or Disagree
   - Agree
   - Strongly Agree

41. I can select effective teaching approaches to guide student thinking and learning in social studies.
   - Strongly Disagree
   - Disagree
   - Neither Agree or Disagree
   - Agree
   - Strongly Agree
Survey of Preservice Teachers' Knowledge of Teaching and Technology

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

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>42. I know about technologies that I can use for understanding and doing mathematics.</td>
<td>Strongly Disagree, Neither Agree or Disagree, Agree, Strongly Agree</td>
</tr>
<tr>
<td>43. I know about technologies that I can use for understanding and doing literacy.</td>
<td>Strongly Disagree, Neither Agree or Disagree, Agree, Strongly Agree</td>
</tr>
<tr>
<td>44. I know about technologies that I can use for understanding and doing science.</td>
<td>Strongly Disagree, Neither Agree or Disagree, Agree, Strongly Agree</td>
</tr>
<tr>
<td>45. I know about technologies that I can use for understanding and doing social studies.</td>
<td>Strongly Disagree, Neither Agree or Disagree, Agree, Strongly Agree</td>
</tr>
</tbody>
</table>
Survey of Preservice Teachers' Knowledge of Teaching and Technology

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, iPads, handhelds, interactive whiteboards, software programs, etc. Please answer all of the questions and if you are uncertain of or neutral about your response you may always select "Neither Agree or Disagree".

46. I have the technical skills I need to use technology appropriately in teaching.
   □ Strongly Agree □ Disagree □ Neither Agree □ Agree □ Strongly Agree

47. I can adapt the use of the technologies that I am learning about to different teaching activities.
   □ Strongly Agree □ Disagree □ Neither Agree □ Agree □ Strongly Agree

48. I am thinking critically about how to use technology in my classroom.
   □ Strongly Agree □ Disagree □ Neither Agree □ Agree □ Strongly Agree

49. I have the classroom management skills I need to use technology appropriately in teaching.
   □ Strongly Agree □ Disagree □ Neither Agree □ Agree □ Strongly Agree

50. My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom.
   □ Strongly Agree □ Disagree □ Neither Agree □ Agree □ Strongly Agree

51. I can choose technologies that enhance the teaching approaches for a lesson.
   □ Strongly Agree □ Disagree □ Neither Agree □ Agree □ Strongly Agree

52. I can choose technologies that enhance students' learning for a lesson.
   □ Strongly Agree □ Disagree □ Neither Agree □ Agree □ Strongly Agree
Survey of Preservice Teachers' Knowledge of Teaching and Technology

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, handelds, interactive whiteboards, software programs, etc. Please answer all of the questions and if you are uncertain of or neutral about your response you may always select "Neither Agree or Disagree".

53. I can teach lessons that appropriately combine mathematics, technologies and teaching approaches.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

54. I can teach lessons that appropriately combine literacy, technologies and teaching approaches.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

55. I can teach lessons that appropriately combine science, technologies and teaching approaches.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

56. I can teach lessons that appropriately combine social studies, technologies and teaching approaches.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

57. I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

58. I can use strategies that combine content, technologies and teaching approaches that I learned about in my coursework in my classroom.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

59. I can provide leadership in helping others to coordinate the use of content, technologies and teaching approaches at my school and/or district.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree

60. I can choose technologies that enhance the content for a lesson.

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree
### Survey of Preservice Teachers' Knowledge of Teaching and Technology

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

**61. My mathematics education professors appropriately model combining content, technologies and teaching approaches in their teaching.**

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Disagree</th>
<th>Neither Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**62. My literacy education professors appropriately model combining content, technologies and teaching approaches in their teaching.**

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Disagree</th>
<th>Neither Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**63. My science education professors appropriately model combining content, technologies and teaching approaches in their teaching.**

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Disagree</th>
<th>Neither Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**64. My social studies education professors appropriately model combining content, technologies and teaching approaches in their teaching.**

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Disagree</th>
<th>Neither Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**65. My instructional technology professors appropriately model combining content, technologies and teaching approaches in their teaching.**

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Disagree</th>
<th>Neither Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**66. My educational foundation professors appropriately model combining content, technologies and teaching approaches in their teaching.**

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Disagree</th>
<th>Neither Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**67. My professors outside of education appropriately model combining content, technologies and teaching approaches in their teaching.**

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Disagree</th>
<th>Neither Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Survey of Preservice Teachers' Knowledge of Teaching and Technology

68. My PreK-6 practicum teachers appropriately model combining content, technologies and teaching approaches in their teaching.

- [ ] Strongly Disagree
- [ ] Disagree
- [ ] Neither Agree nor Disagree
- [ ] Agree
- [ ] Strongly Agree
### Survey of Preservice Teachers’ Knowledge of Teaching and Technology

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.

69. In general, approximately what percentage of your teacher education professors have provided an effective model of combining content, technologies and teaching approaches in their teaching?

- 25% or less
- 26% - 50%
- 51% - 75%
- 76% - 100%

70. In general, approximately what percentage of your professors outside of teacher education have provided an effective model of combining content, technologies and teaching approaches in their teaching?

- 25% or less
- 26% - 50%
- 51% - 75%
- 76% - 100%

71. In general, approximately what percentage of the PreK-6 practicum teachers have provided an effective model of combining content, technologies and teaching approaches in their teaching?

- 25% or less
- 26% - 50%
- 51% - 75%
- 76% - 100%
Survey of Preservice Teachers' Knowledge of Teaching and Technology

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.

72. Describe a specific episode where one of your methods professors or instructors (CI 377, 448, 468A, 468C, 378, 449, 468B or 468D) effectively demonstrated or modeled combining content, technologies and teaching approaches in a classroom lesson. Please include in your description what content was being taught, what technology was used, and what teaching approach(es) was/were implemented.

73. Describe a specific episode where one of your PreK-6 practicum teachers effectively demonstrated or modeled combining content, technologies and teaching approaches in a classroom lesson. Please include in your description what content was being taught, what technology was used, and what teaching approach(es) was/were implemented. If you did not observe a teacher using technology, please speculate on the reason why the technology was not used in the classroom.

74. Describe a specific episode where you effectively demonstrated or modeled combining content, technologies and teaching approaches in a classroom lesson. Please include in your description what content you taught, what technology you used, and what teaching approach(es) you implemented. If you did not have the opportunity to teach a lesson using technology, please explain why.
APPENDIX C. STUDENT FOCUS GROUP INTERVIEW PROTOCOL

STUDENT FOCUS GROUP INTERVIEW PROTOCOL

Date: ______________
Start Time: ______________
End Time: ______________
Participant: _____________

1. Warm-up

- "This is the typical IRB consent with all the elements. Do you mind reading in order to participate?" [Sign "Informed consent statement."]

- [Ask permission to tape the interview. If the interviewee does not give permission to tape the interview, just take notes.]

- "Thank you very much for making time for this interview. The goal of this study is for researchers to investigate how students develop TPACK overtime and throughout the ISU teacher preparation program. Your experiences and opinions are extremely valuable for this study. Everything you say in this interview will be kept confidential. Please feel free to ask for any clarification at any time. If any question will make you uncomfortable, just say that you prefer not to answer. Could you give me the permission for audio recording the interview?"

2. Initial Background Questions

- What's your focus area?

- What grade levels have you taught during your method courses?

3. TPACK Questions

- After taking your methodology courses, do you feel more confident to incorporate technology into your future teaching? In a particular content area more than others? Why or Why not?
• How has this course helped prepare you to become a future teacher? Please elaborate especially in terms of the pedagogical aspect and technological aspect.

• Try to remember back to taking CI 201, since that time how do you feel that your knowledge has improved/not improved in terms of integrating technology into the content areas or your classroom?

• Describe some examples of how your instructors used technology during any of your methodology classes?

• Describe some examples of how your cooperating classroom teachers used technology during your practicum experiences? How were you able to use technology for teaching your lessons?

• What are your current thoughts about using technology in your future classroom?

• What skills or knowledge related to technology, content and pedagogy do you think you are still lacking as you head into your student teaching experience?

4. Concluding statement

• Thank you for taking the time for meet with me/as today. Your feedback is greatly appreciated.
APPENDIX D. INSTRUCTOR INTERVIEW PROTOCOL

INSTRUCTOR INTERVIEW PROTOCOL

Date: ________________
Start Time: ________________
End Time: ________________
Participant: ________________

1. Warm-up

- “This is the typical IRB consent with all the elements, do you mind to read and agree to sign?” [Sign “Informed consent statement”]

- [Ask permission to tape the interview. If the interviewee does not give permission to tape the interview, take notes.]

- “Thank you very much for making time for this interview. The goal of this study is for researchers to investigate how students develop TPACK overtime and throughout the ISU teacher preparation program. Your experiences and opinions are extremely valuable for this study. Everything you say in this interview will be kept confidential. Please feel free to ask for any clarification at any time. If any question will make you uncomfortable, just say that you prefer not to answer. Could you give me the permission for audio recording the interview?”

2. Initial Background Questions

- What degree do you hold?
- What method courses are you teaching this semester? (Course introduction)
- What is the most rewarding and challenging aspect of this course? Why?

3. TPACK Questions

- Describe some examples of how you use technology in your methodology course?
- Describe ways that you have your preservice teachers use technology in your courses?
- What are your observations of the preservice teachers' ability to use technology in teaching lesson related to your content?
- What could we do better in our program to prepare preservice teachers for teaching with technology in this content area?
- What would you have do differently if you would teach this class again?
4. Concluding statement

- Those are the questions for today's interview. Once again, thank you very much for making time for this interview.
APPENDIX E. TPACK-IN-ACTION OBSERVATION INSTRUMENT

TPACK-in-Action Observation Instrument

<table>
<thead>
<tr>
<th>Teacher Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Level</td>
<td></td>
</tr>
<tr>
<td>Number of Students</td>
<td></td>
</tr>
<tr>
<td>Class/Topic</td>
<td></td>
</tr>
</tbody>
</table>

**Pre-Observation: Background Information**

**Brief Description of Classroom/Learning Context:**
Is it a traditional classroom? Or a lab? Describe the settings of the classroom. Are there computers? Projector? Others?

**Brief Lesson Plan (with teaching objectives)**

---

**During Observation**

Spell out as much detail of your observation as you can

<table>
<thead>
<tr>
<th>TK Knowledge about how certain technology works</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Use Technology (List the technology used)</td>
</tr>
<tr>
<td>□ Use technology to engage students</td>
</tr>
<tr>
<td>□ Identify Affordance of technology</td>
</tr>
</tbody>
</table>
### TPACK-in-Action Observation Instrument

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Use technology to create a student centered learning environment</td>
<td></td>
</tr>
<tr>
<td>Troubleshoot</td>
<td></td>
</tr>
<tr>
<td>Support from others</td>
<td></td>
</tr>
<tr>
<td>Collaborate with others</td>
<td></td>
</tr>
<tr>
<td>Other (Specify)</td>
<td></td>
</tr>
</tbody>
</table>

### PK

Knowledge about students' learning, instructional methods, different educational theories, and assessment to teach a subject matter without references to content

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Use strategies to teach, such as questioning, guided instruction, differentiating instruction, etc. (List the strategies used.)</td>
<td></td>
</tr>
<tr>
<td>Use strategies to manage classroom (List the strategies used)</td>
<td></td>
</tr>
<tr>
<td>Facilitate student-centered learning</td>
<td></td>
</tr>
<tr>
<td>Use assessment strategies (on-content related)</td>
<td></td>
</tr>
<tr>
<td>Have pedagogical support from others</td>
<td></td>
</tr>
<tr>
<td>Other (Specify)</td>
<td></td>
</tr>
<tr>
<td>CK</td>
<td>Knowledge of the subject matter without consideration about teaching the subject matter</td>
</tr>
<tr>
<td>----</td>
<td>-------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Exhibit content knowledge, for example, providing a definition for a specific concept, using an example to illustrate a specific concept in a content area, etc.</td>
</tr>
<tr>
<td></td>
<td>Make connections between and/or across subject areas with content being taught (i.e., interdisciplinary)</td>
</tr>
<tr>
<td></td>
<td>Respond to content specific questions with accurate information</td>
</tr>
<tr>
<td></td>
<td>Other (Specify)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TCK</th>
<th>Knowledge about how to use technology to represent and create the content in different ways regardless of teaching strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Use technology for content teaching and learning</td>
</tr>
<tr>
<td></td>
<td>Match the affordance of technology to content being taught</td>
</tr>
<tr>
<td></td>
<td>Use technology to create an alternative representation of doing a content task</td>
</tr>
<tr>
<td></td>
<td>Other (Specify)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PCK</th>
<th>Knowledge of representing content knowledge and adopting pedagogical strategies to help learners understand better about specific subject matter, content, and topics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Use strategies to teach content.</td>
</tr>
</tbody>
</table>
### TPACK-in-Action Observation Instrument

| □ Provide specific examples related to content area material to enhance students' understanding of the topic |
| □ Elicit students' knowledge in a content area by using content-specific teaching strategies, such as questioning. (List the strategies used.) |
| □ Use strategies to engage students in content learning |
| □ Use strategies to facilitate student-centered content learning |
| □ Assess students' learning of content |
| □ Collaborate with others for teaching (before, during, or after teaching) |
| □ Other (Specify) |

### TPK

Knowledge of the existence and specifications of various technologies to enable teaching approaches without reference to subject matter

| □ Prepare instructional materials with technology |
| □ Using strategies to demonstrate how to use technology, such as providing instructions, modeling the use, etc. |
| □ Use technology to engage students in learning |
### TPACK-in-Action Observation Instrument

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Use technology to connect with others not in the classroom, including teachers, students, and parents.</td>
</tr>
<tr>
<td></td>
<td>Match technology with pedagogy</td>
</tr>
<tr>
<td></td>
<td>Trouble shooting while managing classrooms</td>
</tr>
<tr>
<td></td>
<td>Involve students in the teaching role</td>
</tr>
<tr>
<td></td>
<td>Other (Specify)</td>
</tr>
</tbody>
</table>

### TPACK

**Knowledge of using various technologies to teach, represent, and facilitate knowledge creation of specific subject content**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Use teaching strategies to facilitate student learning in a content area(s) with technology</td>
</tr>
<tr>
<td></td>
<td>Assess students' learning with technology in a content area</td>
</tr>
<tr>
<td></td>
<td>Use technology to connect to others beyond the classroom for the purpose of content learning</td>
</tr>
<tr>
<td></td>
<td>Use technology for student-centered content learning</td>
</tr>
</tbody>
</table>
### TPACK-in-Action Observation Instrument

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Use resources (e.g., content &amp; technology) that are collected over time to teach</td>
<td></td>
</tr>
<tr>
<td>☐ Use technology to engage students in content learning</td>
<td></td>
</tr>
<tr>
<td>☐ Match the technology with the content being taught and the teaching strategies used</td>
<td></td>
</tr>
<tr>
<td>☐ Other (Spotify)</td>
<td></td>
</tr>
</tbody>
</table>

### Post-Observation: Questions/Issues to address in the Interview

Address questions based on the observation and issues that emerged from the observation and needs clarification and verification.
APPENDIX F. PRESERVICE TEACHER INTERVIEW PROTOCOL

PRESERVICE TEACHER INTERVIEW PROTOCOL

Date: ______________________
Start Time: ______________________
End Time: ______________________
Participant: ______________________

1. Warm-up
   • "This is the typical IRB consent with all the elements, do you mind to read and agree to sign?" [Sign "Informed consent statement."]
   • Do you mind to fill in this demographics questionnaire? [Give "Demographic questionnaire" to fill in.]
   • "Thank you very much for making time for this interview. The goal of this study is to --- I would like to learn how you teach and what you think about your teaching experiences with technology. I am particularly interested in a comprehensive picture of what it is like for you to teach with technology. Your opinions are extremely valuable for this study. Therefore, I would like you to share as much information as you can about your teaching experiences. Everything that will be said in this interview will be kept confidential. Please feel free to ask for any clarification at any time. If any question will make you uncomfortable, just say that you prefer not to answer. Could you give me the permission for taping the interview?"
   • [Ask permission to tape the interview. If the Interviewee does not give permission to tape the interview, take notes.]

2. Initial Background Questions
   • What is your major and specialization?
   • How many method courses have you taken?
   • What grade levels and subject area have you taught during your practicum experience?

3. TPACK Questions
   • Why did you see the need to use technology in this lesson?
   • What do you think went well? What didn’t? What changes would you make if you were to teach the lesson again?
   • If you have taught this lesson before without using technology, why did you decide to start using technology?
   • What are some of the challenges you face while using technology in the classroom?
   • What type of changes in your students’ learning/attitude/motivation do you see while teaching with technology?
   • After taking this method course/practicum experience, do you feel more confident to incorporate technology into your future teaching? Why or Why not?
   • How has this course helped prepare you to become a future teacher? Please elaborate especially in terms of the pedagogical aspect and technological aspect.
• Comparing to your experience after taking CI 201, do you feel more comfortable incorporating technology into literacy area or science area?

• Did your method course instructor or supervising teacher model the use of technology in his/her class? How?

4. Concluding statement and questions

• What else do I need to know to understand what you feel is important to preparing and supporting teachers to teach with technology?
APPENDIX G. CONSENT FORM FOR PARTICIPANT (PRESERVICE TEACHER AND COURSE INSTRUCTOR)

CONSENT FORM FOR: Preservice Teachers’ Development in Technology, Pedagogy and Content Knowledge (TPACK) After Content Methodology Courses

This form describes a research project. It has information to help you decide whether or not you wish to participate. Research studies include only people who choose to take part—your participation is completely voluntary. Please discuss any questions you have about the study or about this form with the project staff before deciding to participate.

Who is conducting this study?
This study is being conducted by Iowa State University faculty and graduate student.

Faculty: Dr. Denise Crawford (Denise Schmidt)
Graduate Student: Wei Wang

Why am I invited to participate in this study?
You are being asked to participate in this study because you are an ISU preservice teacher who will be completing your Block II methodology courses. The researchers would like to measure your knowledge development of the interplay between content, pedagogy, and technology. You took a similar survey after C I 201 and we would like to know where you are now with that knowledge development after completing most of your teacher education courses.

What is the purpose of this study?
The purpose of the study is to investigate how preservice teachers develop, understand and apply technology, pedagogy and content knowledge (TPACK) throughout their teacher preparation program.

What will I be asked to do?
The two principal investigators, Wei Wang and Denise Crawford, will ask the instructor for permission to attend one of their class meetings. Once permission has been granted the investigators will attend a class session to inform students of the study’s main purpose and to answer any questions.

After that, the principal investigators will attend 1-2 class sessions to observe students’ course interactions in order to understand their growth in TPACK area. An additional time will be set up with the instructor of one of the Block II courses (C I 378 or CI 449) to come to class and administer the online survey to you who volunteer to participate. Laptop computers will be provided in the classroom so if you agree to participate will have access. The survey will be administered at the end of a class period. You will use your name and an ID number for identification purposes. Those identification numbers will be used throughout the study to match your responses over time. You will be asked to complete an Informed Consent Document that will be made available online. The document will ask your willingness to answer the survey and to participate the focus group interview. It should take students between 20-30 minutes to complete the survey. According to your responses to participate in the focus group interview, an interview date will be scheduled and if you who agree to participate will gather to answer the
questions regarding to your growth in TPACK area. The focus group interview will use approximately 30 minutes of your time.

What are the possible risks and benefits of my participation?
There are no foreseeable risks from participating in this study.

Benefits – You may not receive any direct benefit from taking part in this study. We hope that this research will benefit society by contributing to teacher professional development and ultimately effective student (K-12) learning with technology.

How will the information I provide be used?
The information you provide will be used for the following purposes:

- As a result of this study, the researchers will further understand the complex relationships between technology, pedagogy, and content knowledge (TPACK) as teachers begin to develop their own understanding of how to use and integrate technology (with its relationship to pedagogy and content) in PreK-6 classrooms.
- This inquiry will potentially impact the planning of curriculum and classroom experiences for teacher education programs that are interested in designing TPACK-based experiences for their future teachers, as well as in-service teachers obtaining advanced degrees.

What measures will be taken to ensure the confidentiality of the data or to protect my privacy?
Records identifying participants will be kept confidential to the extent allowed by applicable laws and regulations. Records will not be made publicly available. However, federal government regulatory agencies, auditing departments of Iowa State University, and the ISU Institutional Review Board (a committee that reviews and approves research studies with human subjects) may inspect and/or copy your records for quality assurance and analysis. These records may contain private information.

To ensure confidentiality to the extent allowed by law, the following measures will be taken.
Each participant will be given a pseudonym and that name will be kept with the data collected from each observation, interview, and survey. The pseudonym will be removed once the coding of data is complete. Audiotapes, transcripts of the interviews and log files will be kept in a secured and place (i.e., password protected folder) when not in use for the analysis. The data will be stored on the researchers’ password protected computer and access to those data will be limited to the researchers. The data will be erased by September 06, 2016. If the results are published, your identity will remain confidential.

Will I incur any costs from participating or will I be compensated?
You will not have any costs from participating in this study.

What are my rights as a human research participant?
Participating in this study is completely voluntary. You may choose not to take part in the study or to stop participating at any time, for any reason, without penalty or negative consequences. During the follow-up interviews you can skip any questions that you do not wish to answer.
Whom can I call if I have questions or problems?
You are encouraged to ask questions at any time during this study.

- For further information about the study contact Wei Wang, 515-294-9997, N062 Lagomarcino Hall, Iowa State University, Ames, IA 50011 – weiyui72@iastate.edu

- If you have any questions about the rights of research subjects or research-related injury, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3115, Office for Responsible Research, 1138 Pearson Hall, Iowa State University, Ames, Iowa 50011.

Consent and Authorization Provisions
Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.

Participant’s Name (printed) __________________________________________

(Participant’s Signature) ___________________________ (Date)
CONSENT FORM FOR: Presenting Teachers' Development in Technology, Pedagogy and Content Knowledge (TPACK) After Content Methodology Courses

This form describes a research project. It has information to help you decide whether or not you wish to participate. Research studies include only people who choose to take part—your participation is completely voluntary. Please discuss any questions you have about the study or about this form with the project staff before deciding to participate.

Who is conducting this study?

This study is being conducted by Iowa State University faculty and graduate student:

Faculty: Dr. Denise Crawford (Denise Schmidt)
Graduate Student: Wei Wang

Why am I invited to participate in this study?

You are being asked to take part in this study because you are the instructor of content methodology course in Department of Curriculum and Instruction.

What is the purpose of this study?

The purpose of the study is to investigate how presenting teachers develop, understand and apply technology, pedagogy and content knowledge (TPACK) throughout their teacher preparation program.

What will I be asked to do?

The two principal investigators, Wei Wang and Denise Crawford, will ask you (the instructor) for permission to attend one of your class meetings. Once permission has been granted the investigators will attend a class session to inform students of the study's main purpose and to answer any questions.

After that, the principal investigators will attend 1-2 class sessions to observe students' course interactions in order to understand their growth in TPACK area. An additional time will be set up with the instructor of one of the Block II courses (CI 378 or CI 449) to conduct an interview. Questions related to TPACK and students' growth in technology integration would be asked at this time.

What are the possible risks and benefits of my participation?

There are no foreseeable risks from participating in this study.

Benefits – You may not receive any direct benefit from taking part in this study. We hope that this research will benefit society by contributing to teacher professional development and ultimately effective student (K-12) learning with technology.

How will the information I provide be used?
The information you provide will be used for the following purposes:

- As a result of this study, the researchers will further understand the complex relationships between technology, pedagogy, and content knowledge (TPACK) as teachers begin to develop their own understanding of how to use and integrate technology (with its relationship to pedagogy and content) in PreK-6 classrooms.
- This inquiry will potentially impact the planning of curriculum and classroom experiences for teachers and students in prekindergarten through grade 6 who are interested in designing TPACK-based experiences for their future teachers, as well as in-service teachers obtaining advanced degrees.

What measures will be taken to ensure the confidentiality of the data or to protect my privacy?

Records identifying participants will be kept confidential to the extent allowed by applicable laws and regulations. Records will not be made publicly available. However, federal government regulatory agencies, auditing departments of Iowa State University, and the ISU Institutional Review Board (a committee that reviews and approves research studies with human subjects) may inspect and/or copy your records for quality assurance and analysis. These records may contain private information.

To ensure confidentiality to the extent allowed by law, the following measures will be taken. Each participant will be given a pseudonym and that name will be kept with the data collected from each observation and interview. The pseudonym will be removed once the coding of data is complete. Audiotapes, transcripts of the interviews and log files will be kept in a secured place (i.e., password protected folder) when not in use for the analysis. The data will be stored on the researchers’ password protected computer and access to those data will be limited to the researchers. The data will be erased by September 06, 2016. If the results are published, your identity will remain confidential.

Will I incur any costs from participating or will I be compensated?

You will not have any costs from participating in this study.

What are my rights as a human research participant?

Participating in this study is completely voluntary. You may choose not to take part in the study or to stop participating at any time, for any reason, without penalty or negative consequences. During the follow-up interviews you can skip any questions that you do not wish to answer.

Whom can I call if I have questions or problems?

You are encouraged to ask questions at any time during this study.

- For further information about the study contact Wei Wang, 515-294-9997, N062 Lagomarcino Hall, Iowa State University, Ames, IA 50011 – weiyui72@iastate.edu
- If you have any questions about the rights of research subjects or research-related injury, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3115, Office for Responsible Research, 1138 Pearson Hall, Iowa State University, Ames, IA 50011.
Consent and Authorization Provisions

Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.

Participant’s Name (printed) __________________________________________

(Participant’s Signature) __________________________ (Date) ____________
### APPENDIX H. TPACK CODEBOOK SAMPLE

<table>
<thead>
<tr>
<th>Code</th>
<th>Full Code</th>
<th>Definition</th>
<th>Example</th>
<th>Key Word</th>
</tr>
</thead>
<tbody>
<tr>
<td>701</td>
<td>TPACK_Match Affordance (709)</td>
<td>Matching the affordances of technology to content being taught with pedagogy in mind. The teacher selects technology based on their knowledge of what the technology can do (affordances) and cannot do (limitations) in relationship to teaching strategies used in specific content.</td>
<td>The use of flipcharts allowed reteaching, which provided the opportunity and also motivations for students to want to do better. (BW_D1). Teacher were able to design her class to let students practice multiple skills and subject area skills within one class. (AF_C2)</td>
<td></td>
</tr>
<tr>
<td>703</td>
<td>TPACK_Prepare</td>
<td>Preparing content-specific instructional materials with technology with pedagogy in mind. The teacher creates content-specific instructional materials with technology to use for teaching.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>704</td>
<td>TPACK_Collaborate (711)</td>
<td>Collaborating with others to plan or teach a technology enhanced lesson. The teacher collaborates with others such as tech coordinator or tech coach to plan or teach a technology enhanced lesson.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>705</td>
<td>TPACK_Assess_Learning (702)</td>
<td>Assessing student learning. The teacher uses technology and strategies to assess students’ content learning in classroom.</td>
<td>Formative assessment during the process of recording, which allowed the teacher to provide advice as each individual needed. (BW_D1)</td>
<td></td>
</tr>
<tr>
<td>706</td>
<td>TPACK_Connect (706, 713)</td>
<td>Using technology to connect to others beyond the classroom for purpose of learning content. Using technology to connect to others outside the classroom, e.g., students in different classes, schools, districts, states or countries or content experts in different locations, for purpose of learning content.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>707</td>
<td>TPACK_Engage</td>
<td>Using technology to engage students in learning.</td>
<td>Pairs were also used to engage students in the production process, i.e., learning from each other in terms of how to better tell a digital story. (BW_D1)</td>
<td></td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

I would like to take this opportunity to express my gratitude to those who have helped to make this dissertation a reality.

First and foremost, I would like to thank my major professor, Dr. Denise Schmidt-Crawford for her great guidance, patience and continuous support throughout my Ph.D. journey and the writing of this dissertation. Her insights and words of encouragement have often inspired me and encouraged me to reach my highest potential. My thanks also go to my co-major professor, Dr. Ann Thompson for her constructive feedback that helped me enrich my dissertation.

I would also like to thank my committee members, Dr. Ana-Paula Correia, Dr. Amy Hutchison and Dr. Volker Heigelheimer for their encouragement and for providing me with insightful suggestions to strengthen my work.

Throughout my Ph.D. journey, I received a lot support from my colleagues and friends. Without their friendship and encouragement, I could never accomplish such task. My special thanks go to my colleagues in CELT (Center for Excellence in Learning and Teaching) for supporting me when I need to balance between my research and work. I would also like to extend my appreciation to my friends, Yi, Diana, Dennis, Tera, Aliye, Nadia and Kajal for giving me extraordinary support and opportunities to learn from you both personally and professionally.

Most of all, I would like to thank my parents, Cheng-Hsiung Wang and Hsiu-Yun Chen for their unconditional love and support for fulfilling my dream; my sister (Yuan-Lan Wang) who have listened all my concerns and been patient; and my husband, Hung-Yun Chen for always believing in me and cheering me up with his love and care. Without all your helps, it will not be possible to become who I am today. Thank you!