A Dissertation

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A Case Study on how Teaching in a One-to-One Setting with the iPad is Aligned with the

TPACK Framework

by

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Submitted to the Graduate Faculty as partial fulfillment of the requirements for the

Doctor of Philosophy Degree in Curriculum and Instruction

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An Abstract of

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This mixed-method multiple-case study explores the ways successful teaching with the iPad in a one-to-one classroom setting is aligned with the TPACK framework. The research was conducted at a college-preparatory high school with a two-year history of teaching and learning with the iPad. A teacher was selected from each of the following content areas: English, mathematics, history and biology. Data collection included semi-structured interviews, lesson plan documents, direct classroom observations, and a survey. The qualitative data was analyzed using the Atlas.ti software and the quantitative data using the methods of descriptive statistics. In the cross-case analysis both qualitative and quantitative data were compared and contrasted with the theoretical TPACK framework and the findings of other research studies measuring the TPACK construct. This dissertation is dedicated to my husband, Rick and my son, Kevin. Their unwavering support and encouragement have carried me through to the end.

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Chapter One

Introduction

1.1 Overview

The concept of one-to-one (one-to-one) computing means that every student in a school has a personal networked learning device to participate in learning activities (Liang et al., 2005). Popular examples of networked devices to facilitate one-to-one computing are laptops, such as Notebooks or Chromebooks, tablets, such as the iPad, or other handheld devices, such as the iPod Touch or personal smartphones of the students. Response pads, graphic calculators, electronic English dictionaries and pocket game machines also fall under the definition of one-to-one computing (Liang et al., 2005); however, they are not as readily associated with the concept of one-to-one computing or popularized under this banner.

In one-to-one setting students have access to their personal networked device during and after school hours. During the school day the device enhances students' ability to find and retrieve information from the Internet, to receive individualized instruction and real-time formative assessments (Liang et al., 2005). Networked devices also enable teachers to share learning materials and various assignments with students. In class students can work collaboratively using their device in group settings where they can communicate, create, design, and problem-solve together. Outside of the classroom the 24/7 access to a personal device enables the networked student to create virtual communities where they can continue to communicate and collaborate with each other.

Mobile devices have been making their way into classrooms across the nation in the last two decades. The earliest one-to-one initiatives, such as the Microsoft's Anytime, Anywhere Learning program began to appear in the mid-1990s. This initiative tracked the experiences of students who regularly used Toshiba notebook computers outfitted with Microsoft Windows and Microsoft Office software (Rockman et al, 1998). The findings of the three-year study identified benefits of one-to-one computing as significant learning and student and teacher accomplishments in skill development, applications of technology for schoolwork, and improved critical thinking (Rockman et al, 1998).

In the past five years, with Apple Computer's increased marketing efforts and the widespread popularity of its iPad, more schools are choosing one-to-one computing. Recently there have been statewide initiatives, for instance in Maine and Texas, to incorporate technology into classroom learning across the state. Many independent, parochial, and individual public schools have also started implementing large-scale projects involving student access to computers and the Internet at school and at home (Penuel, 2006).

1.2 Statement of the Problem

Educational change is dependent on what teachers *do and think*: changes in the student learning experience ultimately reside with the teachers (Donnelly, McGarr & O'Reilly, 2011). Donnelly, McGarr and O'Reilly (2011) believe that if researchers want to understand teachers' use of technology it would be essential to grasp the knowledge and beliefs that underpin their practice. How do teachers respond to the rapid changes brought about by technology and one-to-one computing? There have been many research studies conducted on the use of laptops in one-to-one settings, but there are considerably fewer studies on teaching and learning with handheld mobile devices.

This mixed-method multiple case study explores the changes in classroom instruction as a result of teaching with the iPad in a one-to-one setting. The study explores one-to-one computing from the point of view of teachers who had three years of teaching experience with the iPad. While the research literature discusses the impact of one-to-one computing on student learning and the difficulties and resistance to technology integration in a classroom or schoolwide setting (Ertmer, 1999; Ertmer, Gopalakrishnan, & Ross, 2001; Hammonds et al., 2013; Kim, Kim, Lee, Spector, & DeMeester, 2013; Koh et al., 2014; Padmavathi, 2013), there is a gap in the discussion about the changes affecting everyday classroom instruction as a result of one-to-one computing. Furthermore, the literature provides more discussion on the experience of pre-service teachers with one-to-one computing (Chai, Koh, & Tsai, 2010; Donovan, Green, Hansen, 2011; Hashim, 2014; McGrath, Karabas, & Willis, 2011; Niess, 2015; Pamuk, 2012), but there is less research on practicing teachers' perspectives on this concept.

This study aims to fill these shortcomings of the literature by exploring the changes in instructional planning and delivery from the point of view of practicing teachers with several years of experience in the one-to-one classroom. The school selected for the case study is in the fourth, or appropriation stage of the five-stage ACOT scale (Apple Classrooms of Tomorrow) which ranks schools on their progress of technology integration (Johannson, n.d.). The appropriation stage means that a school goes beyond integrating the new technology into traditional classroom practice by focusing on cooperative, project-based, and interdisciplinary work – incorporating technology as needed, providing electronic feedback on work, and using web-based

assessment strategies to generate data that informs instruction (Johannson, n.d.). This study contributes to the emerging research literature on one-to-one computing by helping to identify the important instructional and pedagogical changes and challenges of one-toone computing that need to be part of pre-service teacher training and professional development for practicing teachers.

1.3 Significance of the Problem

Studies conducted on one-to-one computing have mainly focused on laptops, not on handheld devices (Donovan, Green & Hansen, 2011; Inan & Lowther, 2010). The research literature overall describes the positive contributions of laptops to student learning and teacher instruction. Some studies focus on measuring learning outcomes (Archambault & Crippen, 2009; Burgoyne, Graham & Sudweeks, 2010; Chai et al., 2011; Harris, Grandgenett, & Hofer, 2012) while others focus on teacher attributes of technology integration into the curriculum (Dexter, Anderson, & Becker, 1999; Donovan et al., 2011; Ertmer, 1999; Ertmer, Ottenbreit-Leftwich, & York, 2006-2007; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Hansen, 2013; Hora & Holden, 2013; Howard, 2011; Hutchison, & Reinking, 2011; Kim, Kim, Lee, Spector & DeMeester, 2013; Kirkscey, 2012; Kopcha, 2012; Levin, & Wadmany, 2006; Lim & Khine, 2006). The literature calls for further investigation of one-to-one computing in all aspects of teaching and learning (Banister, 2010; Carr, 2012; Donnell et al., 2011; Penuel, 2006). Some researchers urge further investigation of applications for mobile devices that advance the development of 21st-century skills (Liang et al., 2005), others encourage the examination of pre-service teacher readiness for one-to-one computing with laptops (Penuel, 2006).

The usefulness of mobile devices and their contribution to education also need to be explored in real classroom situations (Vannatta & Fordham, 2004). There is growing evidence in the literature on the relevance of incorporating one-to-one computing into the experience of preservice teachers (Banister, 2010; Donovan et al., 2011; Murray & Olcese, 2011), however, little is revealed in the research literature about how practicing teachers view and adjust to the changes brought on by one-to-one computing in the teaching process itself. Shi and Bilchermeyer's (2007) study conducted thirteen years apart, in 1991 and 2004, revealed that the most important elements of teachers' experiences with computers in 2004 appeared to be *the same* as they were in 1991: teachers continue to use computers primarily for administrative tasks and that intensive technology integration for innovative and meaningful teaching and learning is still a rarity. Since more and more schools are choosing to explore one-to-one computing, teachers are finding themselves working with technology on a daily basis. Do they still use laptops and tablets for mainly administrative purposes? Has the concept of one-toone computing affected the way teachers approach technology integration? This research study exploring the changes in the teaching practices of secondary school teachers with several years of experience teaching with the iPad provides insight into their instructional planning process for one-to-one teaching with the iPad.

1.4 Theoretical Framework

The Technological Pedagogical Content Knowledge (TPCK in earlier publications, or TPACK in later publications) framework proposed by Koehler and Mishra is based on the nuanced interactions of content, pedagogy, and technology. Koehler and Mishra (2006) argue that it is important to have a theoretical framework that guides the designing of curriculum. The TPACK framework enables educators to create "conceptually and epistemologically coherent learning environments" (Mishra & Koehler, 2006, p. 1034). A conceptually-based theoretical framework that establishes the relationship between content, pedagogy and technology can provide a basis for teachers' daily practice, professional development and teacher education (Mishra & Koehler, 2006). Mishra and Koehler (2006) quote Selfe in claiming that until "we examine the impact of computer technology ... from a theoretical perspective, we will continue myopically and unsystematically, to define the isolated pieces of the puzzle" in individual classroom settings and in research studies (Mishra & Koehler, 2006, p. 1018).

The TPCK framework is not an entirely new approach to content, pedagogy and technology integration. Shulman (1986, 1987) have argued that technological knowledge must exist within the context of teaching and good teaching is dependent on knowledge of pedagogy. Koehler and Mishra's framework expands upon Shulman's work by emphasizing that TPACK is more than the knowledge of the three components of content, pedagogy and technology. There are four additional knowledge domains that are depicted in in Figure 1 below. These are pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and at the heart of it all is technological pedagogical content knowledge (TPACK). Altogether these knowledge domains represent a 'class' or 'system' of knowledge that is central to teachers' work with technology (Mishra & Koehler, 2006) . TPACK knowledge would not typically be held by technology experts who know little about content or pedagogy; nor by teachers who know little about technology (Mishra & Koehler, 2006).



Figure 0. TPACK framework reproduced by permission of publisher, © 2013 by tpack.org

At the core of Koehler and Mishra's argument is that content, pedagogy and technology must be considered within the complex relationships in the system. Content knowledge (CK) is the subject matter that is to be taught, such as seventh grade mathematics, first grade literacy, or tenth grade history. Teachers must understand the nature of knowledge in their content area since central facts, theories, concepts and procedures differ across disciplines. Koehler and Mishra (2008) agree with Gardner's argument that disciplinary thinking is the most important and least-replaceable purpose of schooling; it is like "mental furniture" students learn to "think in" (Koehler & Mishra, 2008, p. 4). Technological knowledge (TK) refers to the more widely used and betterknown technologies, such as whiteboards or overhead projectors, as well as the more modern technologies, such as the Internet, Smartboards, computers, laptops, and iPads. Pedagogical knowledge (PK) refers to the methods of teaching and learning, such as practices, procedures and processes of teaching, as well as knowledge about assessment and student learning (Koehler & Mishra, 2005). This is a generic form of knowledge, not content specific, and it refers to all issues of teaching, from lesson plan development to classroom management, and to all forms of student learning, from understanding how students construct knowledge to developing habits of mind (Koehler & Mishra, 2008). Pedagogical knowledge also encompasses understanding of the learning theories and how they apply to students' cognitive and social development (Koehler & Mishra, 2008).

The applicability of the TPACK framework is in the interactions of its seven construct components provided by the overlap between the areas of content, pedagogy, and technology. "True technology integration ... is understanding and negotiating the relationships between these three components of knowledge" (Mishra & Koehler, 2006, p. 134). As Figure 1-1 shows, the overlap between pedagogy and content is the pedagogical content knowledge (PCK). Koehler and Mishra (2008) advocate that this is where the subject matter knowledge is transformed for the purposes of teaching: the teacher knows the best ways to represent the content and how to arrange or rearrange the instructional materials to maximize student learning. Pedagogical content knowledge differs from the knowledge of a disciplinary expert because PCK is concerned with pedagogical techniques for the mastery of student learning. Interestingly, prior to Shulman's work on PCK, pedagogical knowledge and content knowledge were considered separate domains (Koehler & Mishra, 2008). Koehler and Mishra (2006) claim that educators see technological knowledge (TK) as a domain independent from knowledge of content and pedagogy.

Technological content knowledge (TCK) is the understanding of how technology and subject matter impact one another in a reciprocal manner (Koehler & Mishra, 2005).

Technology and content can influence or constrain one another. Teachers need to understand that content can dictate the choice of technology as an instructional tool and that technology can positively or negatively impact the way content is taught (Koehler & Mishra, 2005). It is this understanding of the reciprocal relationship within the domain of TCK that enables teachers to merge specific content and technology in a way that it leads to enhanced teaching and ultimately to enhanced student learning.

The overlap of technology and pedagogy is the domain of technological pedagogical knowledge (TPK) which is the understanding of how teaching and learning are affected by the use of a particular technology (Mishra & Koehler, 2006). TPK contains the knowledge of how a piece of technology can enhance pedagogical designs and developmentally appropriate teaching strategies.

At the core of the TPACK framework, at the intersection of content, pedagogy and technology is technological pedagogical content knowledge (TPACK). This domain encompasses all three elements of the framework, but it goes beyond understanding them in isolation. Within this domain lies the interaction of content, pedagogy and technology, and the emerging form of understanding how these components affect one another.

Koehler and Mishra (2008) argue that effective teaching requires the understanding of the TPACK framework. Knowledge of TPACK enables teachers to possess the following competencies:

- 1. Knowledge of how to represent concepts with technologies
- 2. Knowledge of pedagogical techniques that use technology in constructive ways to teach content
- 3. Knowledge of what makes concepts difficult or easy to learn

- 4. Knowledge of how technology can help student learning
- 5. Knowledge of students' prior knowledge
- Knowledge of how technology can be used to build on existing knowledge (Mishra & Koehler, 2006).

It is important to keep in mind that technology on its own does not cause educational change. Koehler and Mishra (2005) believe that it is the way teachers use technology that has the potential to change education. To fully integrate technology and allow it to advance the processes of teaching and learning, teachers will have to learn to go beyond using technology for administrative tasks as Shi and Bichelmeyer's (2007) study indicate, and align their curriculum and instructional design with pedagogical, technological and content knowledge.

The TPACK framework empowers the individual teacher to design appropriate lessons utilizing their expertise, experience, teaching style and philosophy. The framework suggests a new kind of literacy for educators: new kinds of knowledge teachers need to develop based on their expertise (Koehler & Mishra, 2008). This new literacy empowers teacher to *design and redesign* curriculum constructs by the "conscious manipulation" and flexible understanding of the core and overlapping elements within the TPACK framework (Koehler & Mishra, 2005, p. 11).

1.5 Limitations of the Study

This multiple-case study was conducted in an all-girl college-preparatory high school. The lessons prepared and the classes observed for three out of the four teachers were for honor students and students in the high-level International Baccalaureate program. Conducting this research with teachers teaching students in the mainstream could provide different results based on teacher experience and belief.

Researcher bias is acknowledged in Chapter 3; however, it must be added here that these participants have been colleagues of the researcher. The participants in this study might have volunteered for the study possibly to showcase their utilization of the iPad or were motivated by altruism to help the researcher colleague with this study, nevertheless, their selection from a small pool of volunteer teachers was randomized. In order to overcome researcher bias during the analysis phase, each participant was referred to by their pseudonym from the start of the data analysis process. I have applied the process of continuous self-reflection during the write-up of the data in order to avoid evaluating and assessing the instructional methods of the participants.

1.6 Overview of Future Chapters

Chapter 2 gives a review of the literature starting with an overview of technology integration in education. The rapid advances in wireless technology, especially in the twenty-first century have led to the emergence of the one-to-one classroom. The chapter highlights the recent statewide and international one-to-one computing initiatives with laptops and mobile devices. These initiatives had three major goals: to prepare students for the future workforce, to improve students' skills and achievement, and to increase the quality of instruction.

Chapter 2 also discusses what it means to be a "technologically literate" teacher and why it is difficult to define this concept. The varying definitions of "technological literacy" in the literature ranging from the use of technology for increased productivity to increased student learning has led to the realities of different interpretations of this concept by practicing teachers. When teachers believe that technology can support learning and *add value* to the curriculum, they are more likely to use it; however, there are a myriad of other factors teachers consider when deciding to integrate technology into the curriculum. The Barriers to Technology Integration subsection discusses these factors known as internal and external barriers. This chapter concludes with a discussion on aligning instructional planning with Koehler and Mishra's (2006) theoretical TPACK framework and with Jaipal and Figg's (2013) practical version called TPACK-inpractice.

Chapter 3 is devoted to the discussion on the methodology of this research study. It will detail the design of this multiple-case mixed-method study including the research question and subquestions, the case selection, population, and the data collection procedures for each type of data to be collected. The latter part of the chapter is in the format of a case study protocol with details for data collection tools and procedures for each of the research subquestions. The chapter concludes with a discussion on the tools and methods to be used for data analysis.

Chapter 4 of this dissertation research focuses on the analysis of the data compiled from the cases.

Chapter 5 provides a discussion on the research findings and the implications of this study.

Chapter Two

Review of the Literature

2.1 Overview of Technology Integration in Education

In 1985 researchers Bramble and Mason predicted four phases of technology integration in schools across the United States (Shi & Bichelmeyer, 2007). Between 1960 and 1976, schools would be at the 'experimentation' stage when methods and new technologies are developed. Bramble and Mason envisioned the popularization of technology between 1977 and 1985 when "public education enthusiastically adopts computers" (Shi & Bichelmeyer, 2007). The 'transition' years from 1985 to 2000 were to bring about changes in instructional strategies and the curriculum. They predicted that during the 'integration' stage starting in the year 2001, computers would be fully infused into all aspects of education (Shi & Bichelmeyer, 2007). Bramble and Mason's timeline for technology integration greatly overestimated the pace of change in American schools and the possibility of a paradigm shift brought about by technology-rich educational environments. While one-to-one computing has becoming increasingly popular with more than two-thirds of school districts in the United States having deployed mobile technologies in a significant number of their classrooms (Nagel, 2014, June 14), it is still a relatively new concept needing research in all aspects of teaching and learning (Banister, 2010; Carr, 2012; Donnelly, McGarr, & O'Reilly, 2011; Liang et al., 2005; Penuel, 2006; Vannatta & Fordham, 2004).

What has laid the foundation and made one-to-one computing a popular concept today is the addition of computer labs during the 1980s and early 1990s. This has been one of the most important breakthroughs in technology use in education across the United States (Shi & Bichelmeyer, 2007). As the price of computers had become more affordable towards the end of the twentieth century, schools have started to purchase them in larger quantities for lab and classroom use. The computer lab, regardless of it being seen and used as a setting separate from classroom instruction, has proved to be effective in technology integration during these decades (Penuel, 2006). Initially it were the English and language arts classes that were equipped with them as composition and the development of writing skills could be aided by word processors. Teachers of other content areas found that scheduling computer lab time and arranging the logistics of the students being transferred there were cumbersome. This limited access to the computer lab has been cited by teachers as one of main reasons for not utilizing computers in education (Penuel, 2006).

The arrival of digital technology at the end of the twentieth century has greatly changed the way we disseminate knowledge and communicate with each other (McGrath, Karabas, & Willis, 2011). Prensky (2001, October) states:

Today's students have not just changed incrementally from those of the past, nor simply changed their slang, clothes, body adornments, or styles, as has happened between generations previously. A really big discontinuity has taken place. One might even call it a "singularity" – an event which changes things so fundamentally that there is absolutely no going back. This so-called "singularity"

is the arrival and rapid dissemination of digital technology in the last decades of the 20th century (Prensky, 2001, October).

The differences between traditional and digital educational technologies are based on their function, usage and transparency (Koehler & Mishra, 2009). Traditional technologies, such as the chalkboard, have been designed to have specific and clear functions that have not changed much over time. Their functions and operations can be easily understood. By contrast, digital technologies, such as computers or mobile devices are 'protean', meaning they can be used in many different ways and they are constantly changing (Koehler & Mishra, 2009). The operations and functions of digital technologies are not transparent and obvious, but rather difficult to learn (McGrath et al., 2011). This protean nature of digital technologies can be understood when we think of the three different functions of the computer: tutor, tool and tutee (Cowan, 2008). When the computer is the tutor, its function is to provide drill-and-practice exercises and it requires little teacher knowledge of technology. As a tool, there is more user control as the computer offers a variety of possibilities for student collaboration on creating an authentic product (Cowan, 2008). Using the computer as a tutee, such as for the creation of websites, requires a great deal of teacher and student technology knowledge. McGrath et al. (2011) add another characteristic to digital technologies, - 'unreliability'- as they argue that few of these devices work all the time. Support, backup, and alternate teacher plans must be the inherent components of technology integration in a one-to-one classroom.

Rapid advances in wireless technology in the twenty-first century enabled improvements to school infrastructure, such as a high-speed Internet connectivity

supported by wireless access, and led to the emergence of the one-to-one classroom. These improvements and the affordability of laptops or tablets have resulted in the physical transformation of classrooms, including preparations for the set-up of a one-toone classroom. Liang et al. (2005) describe the common components of a typical one-toone classroom environment. Figure 2 below illustrates that a most basic one-to-one classroom can be assembled from the students' personal mobile devices and a wireless local area network or Internet connection. Liang et al. (2005) expect that in the future more systems will be equipped with the other three components, namely a classroomshared display, such as a projector or a Smartboard, a teacher's device, such as the teacher's personal computer or a desktop available in the classroom, and classroom servers consisting of learning management systems.



Figure 0. The one-to-one classroom: equipped with the essential components of a projector, the teacher's computer or tablet and classroom servers consisting of learning management systems. (Liang et al., 2005)

The twenty-first century ushered in other changes as well: a change in the students who populate our schools and a change in curricular emphasis put forth by national curricular organizations and our federal government (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012). Today student-computer ratios are at an

all-time low at two students to every computer. Almost all teachers in the United States have access to the Internet in their classroom and there is a more widespread familiarity and use of available Web. 2.0 tools – these two factors can circumvent the earlier issues of limited resources cited by teachers and school districts (Ertmer et al., 2012). Students in today's classrooms are the digital natives and they are different from students just a few years ago. This digital generation is the group born during the period of the early 1980s to the late 1990s and they have been users of technology since their childhood (Donovan et al., 2011).

The new millennium did not usher in the 'infusion' stage described by Shi and Bichelmeyer (2007). In 2001 the federal government stepped in to mandate in the No Child Left Behind Act the incorporation of information and communication technologies into the curriculum in order for states to receive aid to improve school technology (Kirkscey, 2012). The No Child Left Behind Act of 2001 mandates that emphasis must be placed on technology integration in all areas of K-12 education (U.S. Department of Education, 2002). This government directive to integrate technology is based on the belief of policymakers that learning is enhanced with the aid of technology and that students must develop technology skills to be productive members of 21st-century society (U.S. Department of Education, 2001).

The increase in quality and availability of informational and educational technology has led to the significant increase of technological literacy of teachers and students. However, there is still a somewhat misguided perception that adopting technology in the classroom means that one is technologically *literate* (Davies, 2011), or that technology is, in fact, *integrated* (Padmavathi, 2013) into the curriculum and

instructional process. This misconception is perhaps perpetuated by the lack of consensus in the literature on the definition of the term 'technology integration'.

Hennessy, Ruthven, and Brindley (2005) consider technology integrated when it helps teachers productively carry out regular teaching activities. Lim and Khine (2006) believe that technology integration refers to the way teachers use technology to improve students' critical thinking abilities. There is a great difference and a fundamental discrepancy in these two above-mentioned definitions. The latter refers to the end result of technology integration as identified by the increase in student learning. The former almost exclusively refers to teachers' use of technology as productivity tool which is underscored by researchers Palak and Walls (2009) when they identify parent communication, recording and posting grades, and creating instructional materials as the areas where teachers tend to utilize technology the most.

Davies (2011) and Belland (2009) offer perhaps a better-developed definition of technology integration that reflects the complex nature of the pedagogical and instructional decision-making process of teachers. Davies (2011) argues that the goal of technology integration must be "the wise and competent use of technology to facilitate learning" (p. 50). Technology requires the understanding of the learning goals as well as the function and the usefulness of the technology which helps accomplish these goals (Davies, 2011). Belland (2009) defines technology integration as "the sustainable and persistent change in the social system of K-12 schools caused by the adoption of technology to help students construct knowledge" (p. 354). These definitions are supported by other researchers who argue that the authentic integration of technology must rely on the development and implementation of student-centered learning

experiences (Cowan, 2008; Hammonds, Matherson, Wilson, & Wright, 2013; Harris & Hofer, 2011; Jaipal & Figg, 2013).

In terms of the magnitude of technology integration perhaps one-to-one efforts have gone further than any other previous endeavors of teaching and learning with technology (Weston & Bain, 2010). The policy mandates, considerable budgets and mandatory student and teacher participation in these initiatives may provide the foothold for change and the possibility of an educational paradigm shift (Weston & Bain, 2010). Collectively these initiatives could represent "heretofore-unattained scale and disturbance in the equilibrium of classrooms and schools" (Weston & Bain, 2010, p. 9.) Once educators and researchers move past investigating what laptops and tablets can do as *technological tools*, and focus on their presence as *cognitive tools* that help teachers design and deliver instruction, the concept of one-to-one computing might be considered holistically integrated into the teaching and learning processes of schools (Weston & Bain, 2010, p. 11).

2.2 One-to-One Laptop Initiatives

Microsoft's Anytime, Anywhere Learning Program was one of the earliest one-toone initiatives that had begun to appear in the United States since the mid-1990s (Penuel, 2006). This initiative tracked the experiences of students who regularly used Toshiba notebook computers outfitted with Microsoft Windows and Microsoft Office software (Rockmanet al., 1998). The findings of the three-year study identified benefits of one-toone computing as significant student learning and teacher accomplishments in skill development, applications of technology for schoolwork, and improved critical thinking (Rockman et al., 1998).

Because of the decreasing cost of laptops and mobile devices coupled with the increased availability of wireless connectivity, one-to-one initiatives are becoming popular not only across the United States but around the globe, as well. In 2000, there were about one thousand schools using one-to-one or ubiquitous computing (Dunleavy, Dexter, & Heinecke, 2007). The first statewide initiative introduced in Maine in 2001 was one of the highest profile one-to-one efforts (Weston & Bain, 2010). In 2006 almost 25 percent of school districts were implementing some form of one-to-one computing (Bebell & Kay, 2010). In the United States, Texas, Michigan and Pennsylvania have invested in statewide initiatives to fund access to laptops for secondary school students (Murray & Olcese, 2011; Penuel, 2006). Other large-scale initiatives also exist in South Dakota, New Hampshire, Georgia, Louisiana, California, Virginia, Florida, Kansas and Massachusetts (Bebell & Kay, 2010). Furthermore, there are hundreds of smaller scale laptop and iPad programs in public, parochial and private schools across the United States (Donovan, Green, & Hansen, 2011; Penuel, 2006). one-to-one computing has also received international attention as laptop or tablet initiatives have been introduced in many countries, including Australia, Canada, France and New Zealand (Bebell & Kay, 2010; Inan & Lowther, 2010b).

These initiatives in the last decade have focused on three major goals: to prepare students for the future workforce, to improve students' skills and achievement, and to increase the quality of instruction (Inan & Lowther, 2010b). The aim of the Massachusetts pilot program called the Berkshire Wireless Initiative was to determine the efficacy of one-to-one laptop computing in a traditional middle school setting. The results indicate that one-to-one computing had a positive impact on student motivation

and academic performance (Bebell & Kay, 2010). One-to-one computing contributes to the effectiveness of the learning environment since the students have ubiquitous, 24/7 access to their device (Dunleavy et al., 2007). This access enables students to consult a wide array of resources that support their learning, to communicate with their peers and their teachers (Penuel, 2006). The Berkshire Wireless Initiative identified the most important use of personal laptops as finding information on the Internet, but other uses such as accessing teacher websites, playing games, taking notes, and editing papers were also among the frequently-mentioned uses of student laptops (Bebell & Kay, 2010). The 2003 South Dakota initiative identified similar benefits for both teachers and students such as working from anywhere, recording lectures and presentations by teachers, being more productive, and managing files by creating and saving important information (Gorder, 2007). The four-year Texas initiative called the Technology Immersion Pilot program also found that student use of laptops within and outside of school had a positive impact on academic achievement (Shapley, Sheehan, Maloney, & Caranikas-Walker, 2010).

2.3 One-to-One Computing with Mobile Devices

More recent efforts at ubiquitous computing have been focusing on handheld networked devices, such as tablets, iPod Touches, or iPads (Alexander, 2004; Garthwait & Weller, 2005; Rose, 2001; Van 'T' Hooft & Swan, 2004; Zucker, 2004). The iPad and other similar tablets have been changing the concept of mobile learning for both teachers and students. These mobile devices encourage ubiquitous learning to a greater extent than laptops because of their portability, long battery life, instant usability, multitouch screen, multisensory capabilities to engage students and an almost endless variety of

applications that can contribute to previously unseen possibilities of mobile learning (Hashim, 2014; Hutchison & Reinking, 2011; Ifenthaler & Schweinbenz, 2013; Suhr, Hernandez, Grimes, & Warschauer, 2010; Hashim, 2014). The university teachers participating in Hashim (2014) and Galligan, Loch, McDonald, and Taylor (2010) studies preferred using iPads over laptop computers because they deemed the device to be more user-friendly and liked that it encouraged collaboration and the sharing of information among users. Furthermore, the teachers in Hashim's (2014) study used the iPads to access teaching and learning materials from Dropbox and the university's learning management system. Faculty members also interacted and collaborated with colleagues through online forums and used the iPad for email communication. In distance education tablet PCs such as the iPad can foster communication and remote online collaboration among students and teachers (Galligan et al., 2010). Galligan et al. (2010) discussed the benefits of using a tablet PC for mathematics teaching at the university level. Their findings indicate that students prefer teacher use of tablet PCs during university lectures, online and face-to-face tutorials, as well as in one-to-one situations. Tablet PCs have visual and audio benefits for real time teaching as well as for student review. University faculty also found that using tablet PCs in mathematics teaching saved time in class as they were much less cumbersome than using a whiteboard or an overhead projector (Galligan et al., 2010).

In K-12 education the schoolwide and the classroom-level benefits of using an iPad have been documented in the literature (Banister, 2010; Carr, 2012; Foote, 2012; Galligan et al., 2010; Hashim, 2014; Hutchison, Beschoner, & Schmidt-Crawford, 2012; Ifenthaler & Schweinbenz, 2013; Lim, 2011; Murray & Olcese, 2011; Peluso, 2012; Suhr

et al., 2010). At the school and district level, doing things paperlessly via the iPads can improve productivity and lead to significant cost savings. In addition, teachers can save time by scanning handouts and reading materials as PDFs and posting them on class websites for students to have access (Foote, 2012). Students can also open PDFs shared via cloud storage such as Google Drive or Dropbox in a PDF reader app like Adobe Reader.

From a teaching and learning standpoint, many of the iPad's features, such as the still and video camera, microphone, storytelling apps and digital eBooks have spurred creative ways of instruction and enabled more student-centered learning (Foote, 2012; Ifenthaler & Schweinbenz, 2013). Students can practice homework or create projects using storytelling, presentation or movie making apps. The survey collected by Foote (2012) shows that 88 percent of the 854 students surveyed reported that using the iPad has enhanced their learning experience (p. 17). In the same study ninety percent reported the iPad having a positive or somewhat positive effect on their motivation to learn (Foote, 2012). Eighty-nine percent felt that because of the iPad they have the "desire to dig deeper into a subject" (Foote, 2012, p. 17). Interestingly, the students also reported that the iPad can lead to distraction both at school and at home. Since the survey was conducted in a college-bound high school, Foote (2012) concluded that these students will benefit from the opportunity to learn to manage the iPad as a learning tool during their high-school years in a smaller and more guided environment which may help ensure that they become more responsible users in college.

Since ubiquitous computing with a mobile device, such as the iPad is a relatively new phenomenon, researchers call for further investigation of its impact in all aspects of

teaching and learning with emphasis of studying its impact on teachers in the classroom setting (Banister, 2010; Carr, 2012; Ifenthaler & Schweinbenz, 2013; Lim, 2011). Furthermore, educational change is dependent on what teachers do in the classroom and Donnelly, McGarr and O'Reilly (2011) believe that if researchers want to understand teachers' use of technology, including ubiquitous computing with the iPad, it would be essential to grasp the knowledge and beliefs that underpin their practice.

2.4 Technology Literacy of Teachers

While educational or instructional technologists – who consider themselves *technologically literate* – are interested in integrating technology into classroom instruction because they are convinced of the added value technology brings to education, teachers are less convinced about the value of such integration.

The term *technology literacy* has been defined in various ways. It often refers to computer literacy (the terms are frequently used interchangeably) or one's knowledge and ability to use a computer. The term *information and communication technology literacy* refers to how an individual can utilize technology for data gathering, analysis, and reporting (Davies, 2011). A definition similar to Mishra and Koehler's (2006) definition of TPACK is offered by Hansen (2003). He defines technology literacy as "an individual's ability to adopt, adapt, invent, and evaluate technology to positively affect his or her life, community, and the environment" (Hansen, 2003). Technologically literate teachers see themselves as capable of learning about technology with a willingness to invest time and effort into the process (Hansen, 2003). They also possess the skill to make decisions and explore divergent options and reflect on how and why they use technology to attain their objectives (Hansen, 2003).

Davies (2011) defines the concept of technology literacy as "the ability to effectively use technology (i.e., any tool, piece of equipment or device, electronic or mechanical) to accomplish required learning tasks" (p. 47). This definition implies that teachers and other users of technology know what the technology is capable of and when and how to use it. Davies (2011) emphasizes with a tongue-in-cheek that "exposure to technology does not make someone a technology expert any more than living in a library makes a person a literary expert" (p. 47).

Davies (2011) developed a three-tiered framework for evaluating teachers' educational technology integration. This framework parallels teachers' technology literacy. The most basic level is the awareness level, where teachers are cognizant of the purpose and the most basic functions of a piece of technology, however, they lack practical wisdom and confidence in how to use it (Davies, 2011). The praxis level is a form of procedural knowledge where teachers experience using the technology firsthand, gaining practical wisdom for its use. They become familiar with the functionality of the technology. Only at the third level, the phronesis level, do teachers become adept at using technology. At this level they possess the sufficient level of technology literacy to reflect on why they choose to use – or not use – technology (Davies, 2011). Reaching this level is only possible through the application of technology in authentic situations. The user – teacher or student – must clearly understand the learning task, purposefully select the technology because he or she recognizes the way the technology will facilitate the attainment of the learning goal (Davies, 2011). Davies (2011) concludes that attaining technology literacy is not a one-time achievement as it requires maintenance, or
the continual education and *re*education in the use of new and familiar pieces of technology.

As technology is constantly and rapidly changing, it is impossible to claim complete knowledge about all the technology tools available. This can result in teachers being "perpetual novices in the process of technology integration" (Ertmer & Ottenbreit-Leftwich, 2010, p. 260) and resisting to embrace teaching with technology even in mandatory cases such as district- or statewide one-to-one initiatives.

2.5 Realities of Technology Integration

First and foremost, teachers are interested in meeting the needs of their students – from performing well on standardized tests to possessing 21st-century skills such as collaboration, communication, and problem solving. Teachers will judge the worth of any piece of educational technology based on whether or not it will directly help students with the learning process or help teachers meet the needs of their students (Shi & Bichelmeyer, 2007). When teachers believe that technology can support learning and *add value* to the curriculum, they are more likely to use it; however, when the technology use is perceived as not closely aligned with the curriculum, teachers are less likely to use it (Penuel, 2006; Teo, 2011). Adcock (2008) also claims that technology-assisted pedagogy depends on the teacher's understanding of the value of technology, teachers are able to develop curricular materials that lead to more complex learning tasks in a cooperative, student-centered learning environment (Adcock, 2008).

However, the mere presence of one-to-one laptops does not *add value* to the teaching and learning process. One-to-one computing is not about the laptops or the

handheld devices, rather it is about what these devices enable teachers and students to do. Dunleavy et al. (2007) stress that teachers must have opportunities to learn what curricular and instructional practices work best in a one-to-one classroom. In Ifenthaler and Schweinbenz's (2013) study the majority of the participants did not believe that tablet PCs contribute to improving learning and instruction. Most participants were not clear on how tablet PCs can be used as innovative tools and even in some cases where participants agreed that tablet PCs could have a positive impact, their agreement was based on *assumption* as opposed to their knowledge and experience. Respondents with a generally positive attitude towards using tablet PCs still exhibited considerable reservations about the technology (Ifenthaler & Schweinbenz, 2013).

Howard (2011) conducted an interesting study exploring teachers' technologyrelated risk perceptions. Similarly to Palak and Walls (2009), Howard (2011) argues that understanding why teachers make the choice to integrate technology is a very complex phenomenon. This study brought together the fields of risk theory and educational technology with the primary focus on teachers' affective response to technology-related risks. By definition an affective response is an intuitive positive or negative response to a risk. Howard (2011) discovered that there are three areas of concern relating to technology integration: the ability to problem-solve, the value of technology integration, and the loss of time associated with technology integration. Based on how teachers in the study judged these risks in relation to the overall cost or benefit to student achievement, Howard (2011) categorized participants into two groups: teachers who showed more acceptability of technology-related risks and teachers who showed less acceptability of such risks. An important finding of this study is that teachers perceived the same risks; however they varied in acceptability of those risks (Howard, 2011). The group showing more acceptability of technology-related risks had higher computer-efficacy and a more positive affect towards technology, but valuing technology integration was not a fixed belief among them (Howard, 2011). Conversely, the group showing less acceptability of technology-related risks had lower computer-efficacy and a negative affect towards technology integration. They felt it was not worth their time and frustration to change their teaching practice to incorporate technology. Most significantly, Howard (2011) concludes that there is a difference between teachers' *analytical versus experiential process* of risk perception. The analytic evaluation of risks associated with technology integration are based on teachers' *reflection* of their knowledge of technology and pedagogy, while the experiential risk perception is focused on teachers' *personal feelings* of anxiety and discomfort about the use of technology (Howard, 2011).

Penuel (2006) emphasized that teacher attitudes and beliefs about technology can influence how and when teachers integrate technology into their instruction. Their pedagogical approach, level of confidence and expertise in their content area are further predictors of technology integration (Penuel, 2006). Teo's (2011) study reveal that variables such as perceived usefulness of the technology, one's attitude towards its use, and the technology facilitating conditions have direct influences on teachers' intentions to utilize technology. The perceived ease of use of a piece of technology can indirectly influence teachers' intentions to use it. When teachers have positive attitudes towards the use of computers or any other forms of digital technology, these feelings reinforce their intentions to integrate technology. Furthermore, teachers are most likely to use technology when it is *perceived* to be an *enhancement of teacher productivity* and

relatively *free of effort*, meaning there is sufficient technical support available (Galligan et al., 2010; Harris & Hofer, 2011; Hutchison & Reinking, 2011; Teo, 2011).

Many studies also suggest that teachers' value beliefs play a significant role in their instructional decision-making (Koh, Chai, & Tay, 2014; Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010; Palak & Walls, 2009). Palak and Walls (2009) emphasize that integrating technology goes beyond merely understanding teachers' beliefs. They conducted a mixed-method study on the relationship between teachers' beliefs and their educational technology practices in technology-rich school environments. Palak and Walls (2009) set out to investigate whether teachers who work at technology-rich schools and frequently integrate technology into their lessons exhibit signs of change towards a more constructivist and student-centered paradigm. The teachers participating in the study already valued technology; however Palak and Walls (2009) discovered that the shift towards a more constructivist teaching approach did not necessarily occur among these teachers. Participants in the study used technology most frequently for recording grades, communicating with parents, and preparing instructional materials. Using technology for student-centered activities was rare even among teachers who held constructivist beliefs. There was only one teacher out of the 113 study participants who demonstrated a successful integration of technology to support a student-centered teaching practice (Palak & Walls, 2009). This particular teacher's reform-oriented teaching practice was a result of her teaching philosophy, her knowledge of pedagogy, her technical abilities, and her contextual conditions of teaching a small group of gifted students in a high-achieving school (Palak & Walls, 2009).

Palak and Walls (2009) caution that teaching is a complex practice with multiple variables, and internal and external factors that affect teachers' perceptions and value systems. Teachers may be unable to integrate technology because they simply do not know how to facilitate student-centered learning or they are bound by the contextual factors of their subject matter or by class size and student ability (Palak & Walls, 2009).

Levin and Wadmany (2006) conducted a three-year case study on teachers' beliefs and practices in technology-rich classrooms. Their findings show that while at the beginning of their study teachers exhibited more behaviorist views on teaching and learning, by the end they had more varied views with a focus on student learning rather than content coverage (Levin & Wadmany, 2006). At the end of the three years there were substantive changes in teachers' educational beliefs and classroom practices as they utilized the processes of collaborative learning with a greater focus on coaching, modeling, reflection and exploration. When Harris and Hofer (2011) conducted a study on experienced history teachers' digital technology integration into the instructional planning process, they also found that teachers were student-centered in their thinking. Harris and Hofer (2011) and Levin and Wadmany (2006) indicate that not all teachers significantly changed their views, and caution that technology must not be viewed as a 'unitary' concept, rather an individual process or journey that is unique to each teacher.

Interestingly, Levin and Wadmany (2006) found that there is a change in classroom practice *before* a teacher can consciously identify his or her change in educational or pedagogical beliefs. The change in belief is the result of the change in practice. This assumption is also supported by Ifenthaler and Schweinbenz (2013) as they found that initially teachers utilized tablet PCs to back up rather than transform their existing practice. However, with persistent use and the accumulation of relevant expertise, the integration of technology could lead to a change in teacher practice and to the transformation of teachers' philosophical beliefs (Ifenthaler & Schweinbenz, 2013). Figure 3 below, adopted from Ifenthaler and Schweinbenz (2013) depicts the change in teaching practices and beliefs based on technology use.



Figure 3. Connection between learning philosophies and technology use: technology integrations could lead to a change in teaching practice towards a more constructivist approach (Ifenthaler & Schweinbenz, 2013)

Mueller, Wood, Willoughby, Ross, and Specht (2008) found that there may be little correlation between teachers' beliefs and actual classroom practice. While the computer could have the potential to support a constructivist, student-centered teaching and learning style, the authors argue that teachers may be using the computer to enhance their practice and philosophy. It is also possible that one's teaching practice gradually changes as a result of technology use. Similarly to Harris and Hofer (2011) and Levin and Wadmany (2006), Mueller et al. (2008) also state that a change in philosophical beliefs could very well be precipitated by a change in teaching practice. While the research is inconclusive, there is one agreement: the choice to integrate technology into the teaching and learning process is very complex and multifaceted.

Liang et al. (2005) argue that if one-to-one computing can have an impact on classroom learning then it must enhance classroom activities, specifically teacherdirected instruction, small group learning and individual learning. Research conducted by Dunleavy et al. (2007) in two middle schools with one-to-one computing with laptop computers underscore this notion as they report a change in teacher lesson design towards a more constructivist and less teacher-directed approach. Dunleavy et al. (2007) identify the following 'added values' to the teaching and learning process brought on by one-to-one computing:

- 1. Teachers' increased ability to formatively assess student learning
- 2. Teachers' increased ability to individualize instruction
- 3. Students' increased capacity for self-guided pacing
- 4. Teachers' and students' increased ability to access online resources
- 5. Increased student interaction and collaboration
- Capacity for networked communication and materials management (p. 449).

Dunleavy et al. (2007) found that teachers and students most often used the laptops for online research and for drill-and-practice exercises. Teachers appreciated the value of drill-and-practice exercises in terms of individualized instruction, remediation, reinforcement and assessment. Another change to the teaching and learning process brought on by one-to-one computing as observed by Dunleavy et al. (2007) was the creation of online environments such as class websites and video for the dissemination of information and the enrichment of instruction. Interestingly, the researchers observed that some of the participating teachers have interacted less with their students or even taught less in a one-to-one classroom because they viewed the laptops as substitute instructors relieving teachers of their duty (Dunleavy et al., 2007).

Inan and Lowther (2010b) also found that teachers who feel ready to integrate technology had used computers more frequently in the classroom. Mueller et al. (2008) also argued that the actual classroom use of technology is a *prerequisite* or a *catalyst* for the integration of technology. Aldunate and Nussbaum's (2013) study explored the way technology was adopted or not adopted by teachers. Their results indicate that the technology adoption process is dominated by teachers who consider themselves innovators and early adopters. Early adopters, possibly teachers who are already using computers in the classroom, have a higher likelihood of integrating regardless of the level of complexity of the technology. Aldunate and Nussbaum (2013) also found that the absence of these early adopter and innovator teachers can decrease the likelihood of other teachers' adopting technology and can have a negative schoolwide impact.

2.6 Barriers to Technology Integration

There have been numerous studies done on identifying the barriers to technology integration (Ertmer, 1999; Ertmer, Gopalakrishnan, & Ross, 2001; Hammonds et al., 2013; Kim, Kim, Lee, Spector, & DeMeester, 2013; Koh et al., 2014; Padmavathi, 2013).

Ertmer (1999) defines external and internal barriers affecting teachers' ICT integration. External barriers or first-order barriers include time, access, support, resources and training. Another external barrier is teacher knowledge of technology which is a strong enabler for effective technology integration (Kim et al., 2013). One of the biggest obstacles to technology integration is the lack of time, specifically teachers' willingness to commit time to learn how to integrate technology (McGrath et al., 2011; Vannatta & Fordham, 2004). Teachers also believe that there is insufficient time to teach their students the technology skills in conjunction with the subject matter (Kirkscey, 2012).

Interpersonal barriers (Koh et al., 2014), or intrinsic barriers and second-order barriers (Ertmer, 1999) refer to teacher attitudes, beliefs, practices, and their resistance to change. These can hinder technology integration even when the external, first-order barriers are removed (Kim et al., 2013; Starkey, 2012). When examining how contextual factors such as interpersonal and intrapersonal factors influence teachers' TPACK construction during their lesson planning, Koh et al. (2014) found that teachers seldom discuss their pedagogical beliefs during lesson design discussions unless they are expressly asked. Therefore, it may be that these contextual factors and their interplay must be carefully considered when evaluating teachers' TPACK use during instructional planning. ChanLin (2008) also emphasizes that technology integration is dependent on a large array of parameters including social impact, curriculum concerns, environmental support, teacher interest and experience, and personal need. Inan and Lowther (2010a) add school-level factors, such as administrative and technical support which influence teachers' beliefs and readiness for technology integration.

Padmavathi (2013) reviewed the literature on the issue of barriers to technology integration and attempted to classify the factors affecting the successful utilization of technology in the classroom. The review reveals three different levels of barriers that could hinder ICT integration: teacher-level, classroom-level and system-level barriers. The most commonly identified teacher-level barriers are lack of confidence and competence, lack of ICT support and sufficient training, lack of time to prepare instructional materials, and lack of valuing technology's use in the classroom (Padmavathi, 2013). Padmavathi (2013) describes school-level barriers as having an insufficient number of computers, difficulty of scheduling computer lab time in advance, lack of support from school leadership, and lack of ICT mainstreaming into schools. The system-level barriers include the examination and evaluation systems at the district and/or state level, the curricular overload in each subject area – which is closely tied to teachers' beliefs about the necessity to transmit large amounts of information during an academic year (Padmavathi, 2013). Padmavathi (2013) cautions that it is difficult to categorize the above-mentioned barriers into groups because there could be relationships within the levels and between the levels that could affect teachers' ultimate decision in whether or not to integrate technology into their daily teaching.

Hammonds et al. (2013) explain this further when they argue that a teacher-level barrier, such as lack of technology skill or knowledge may translate into the teacher's lack of self-efficacy and positive attitude which are necessary motivating factors to utilize technology. Ertmer and Ottenbreit-Leftwich (2010) also discuss that teachers' selfefficacy might be more important than their technological skills when it comes to classroom integration of educational technology. Their two small-scale studies bring

awareness to the notion that increasing teachers' knowledge and skills in technology can have the potential to change their attitudes and beliefs, thus eliminating more teacherlevel barriers. The studies by Ertmer, Ottenbreit-Leftwich, and York (2006-2007) and by Ertmer et al. (2012) found that teachers rated two internal factors, inner drive and personal beliefs as most influential when it comes to technology integration. Ertmer et al. (2012) found teachers' attitudes and beliefs *not to be barriers, rather facilitative factors* that provide the drive and the passion for teachers to spend extra time on learning new ways of technology integration that strongly aligned with their educational and pedagogical beliefs. Koehler and Mishra's (2008) TPACK framework suggests this kind of literacy for educators which empowers teacher to *design and redesign* curriculum constructs by the "conscious manipulation" and flexible understanding of the core and overlapping elements within the TPACK framework (Koehler & Mishra, 2008, p. 11).

2.7 TPACK in Instructional Planning

Teachers' instructional planning has been shown to be a routine activity based on their past experience and mainly organized and communicated by content learning goals (John, 2006; Yinger, 1979). Routine planning allows teachers more flexibility and consideration of student needs; however, little is known about how digital technologies are integrated into teachers' planning (Harris & Hofer, 2011). While the TPACK framework offers a theoretical representation of technology integration based on the complex interactions of technology, pedagogy and content knowledge constructs, in reality TPACK is a highly complex and situated educational construct that is not easily learned, taught or applied (Harris & Hofer, 2009b, 2011; Harris, Mishra, & Koehler, 2009; Jaipal & Figg, 2013; Lin, Tsai, Chai, & Lee, 2013; Polly, 2011). TPACK

knowledge, especially, pedagogical content knowledge (PCK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK) can be influenced by a variety of factors, such as school and organizational structure, specific classroom contexts, technological affordances and constraints, as well as the socioeconomic status of the students (Harris & Hofer, 2011; Harris et al., 2009). Therefore, teacher knowledge and instructional planning are highly situated and contextually sensitive (Harris & Hofer, 2009b; Polly, 2011). Mishra and Koehler (2006) explain this notion this way:

Quality teaching requires developing a nuanced understanding of the complex relationships between technology, content, and pedagogy, and using this understanding to develop appropriate, context-specific strategies and representations. Productive technology integration in teaching needs to consider all three issues not in isolation, but rather within the complex relationships in the system defined by the three key elements. (p. 1029)

Harris and Hofer (2009a; 2009b, 2011) have contributed to the research literature with their writings on technology integration using Koehler and Mishra's TPACK framework. Harris and Hofer's (2011) interpretivist study aimed to investigate the nature of seven history teachers' PCK, TPK, TCK, and TPACK knowledge as it was applied to instructional planning (Harris & Hofer, 2011). During professional development sessions the participating teachers had learned about content-specific learning activity types utilizing digital technologies that can be incorporated into lesson planning. Harris and Hofer (2011) found that both before and after professional development teachers' main consideration was matching the learning activity to the content. The learning needs of

their students were secondary along with considerations of other factors, such as class time allotted and the depth of the content coverage.

Investigating the participants' pedagogical content knowledge revealed that PCK decisions were strategic and conscious based on time considerations, depth of content coverage, and past experience (Harris & Hofer, 2011). Teachers' pedagogical decisions about the utility of a particular technological tool (TPK construct) were based on whether the tool affected deeper, more self-directed and more engaging learning: in other words, teachers used the tool if they saw that it would enable them to do a better job (Harris & Hofer, 2011).

In Harris and Hofer's (2011) study little is reported about teachers' technological content knowledge (TCK): teachers only acknowledged that content drove the selection of digital technologies to be integrated. When examining the changes of biology teachers' TPACK after their participation in professional development on technology integration, Graham et al. (2009) also found that participants' TCK knowledge scores were significantly lower than the other constructs surveyed – namely TP, TPK, and TPACK. The authors proposed that biology teachers might have more knowledge of technologies designed for *teaching* biology (instructor demonstration) as opposed to *doing* biology (student engagement) (Graham et al., 2009). Another underlying fact for this finding could be that instructor presentation and demonstration utilizing technology might be the only viable option due to the physical space limitations of the classroom or technology constraints.

Interestingly, the fact that teachers attribute TCK the least amount of importance in these studies by Harris and Hofer (2011) and Graham et al. (2009) is in direct contrast

with Koehler and Mishra's (2008) theoretical assertion about the importance of technological content knowledge:

Teachers need to master more than the subject matter they teach. They must also have a deep understanding of the manner in which the subject matter (or the kinds of representations that can be constructed) can be changed by the application of technology. (p. 16)

Teachers' decision making on technology use based on their overall TPACK knowledge reveal that PCK, TPK, TCK are considered concurrently, consciously, judiciously and strategically (Harris & Hofer, 2011). If a technological tool *fits* the content, teachers would use the tool instructionally. This notion develops with experience in instructional planning and teaching with digital technologies and *fit* "seemed to be how they [participants] consciously both conceptualized and operationalized TPACK" (Harris & Hofer, 2011). These studies reveal that Koehler and Mishra's TPACK in theory might serve as an explanation for understanding how technology integration happens, but to understand the reality of integrating technology into the instructional process the TPACK framework might need some adjustment.

Jaipal and Figg (2013) claim that their TPACK-in-practice framework which they developed after conducting longitudinal studies of technology integration of pre-service and in-service teachers can bridge the gap between the theoretically defined knowledge components of the TPACK framework and the actions that demonstrate these components in practice. Jaipal and Figg's (2013) definition of TPACK-in-practice is that it "refers to the knowledge about how teachers think about representing content using technology in instruction" (p. 216). TPACK-in-practice identifies teacher actions that characterize teacher knowledge – especially TCK, TPK and TPCK – important for successful technology-enhanced teaching. Figure 4 depicts Jaipal and Figg's (2013) framework with the three components of TCPK-in practice, TCK-in practice, and TPK-in practice.

Jaipal and Figg (2013) argue that the knowledge construct TPCK-in-practice is made up of a repertoire of technology-enhanced learning activity types and the knowledge of content-based models of teaching which are appropriate for the activity types. Jaipal and Figg (2013) used the learning activity types developed by Harris and Hofer (2009b) which identify specific content-based, technology-enhanced learning activities that should be the building blocks for planning effective instruction.



Figure 4. TPACK-in-practice framework with its three components of TCPK-in-practice, TCK-in-practice, and TPK-in-practice (Jaipal & Figg, 2013)

Harris and Hofer (2009b) suggest that these learning activity types should be the conceptual planning tools for teachers and should be selected *after* the curriculum-based learning goals are chosen. "By focusing first and primarily upon the content and nature of students' curriculum based learning activities, teachers' TPACK is developed authentically, rather than technocentrically" (Harris & Hofer, 2009b, p. 101). Figure 5 shows a sample of the learning activity types developed specifically for teaching social studies content.

Activity Type	Brief Description	Possible Technologies
Produce an Artifact	Students create a 3-D or virtual artifact	Imaging tools, drawing software
Build a Model	Students develop a written or digital mental model of a course concept/process	Concept mapping software, presentation software, spreadsheets
Design an Exhibit	Students synthesize key elements of a topic in a physical or virtual exhibit	Wikis, presentation software, video creation software (e.g., Movie Maker, iMovie)
Create a Newspaper/News Magazine	Students synthesize course information in the form of a periodical; print-based or electronic	Word processor, wiki, Web authoring software
Create a Game	Students develop a game, in paper or digital form, to help other students learn content	Puzzlemaker, interactive presentation software, imaging tools, Web authoring software
Create a Film	Using some combination of still images, motion video, music and narration students produce their own movies	Video creation software (e.g., Movie Maker, iMovie), digital video camera

Figure 5. Social studies learning activity types (Hofer & Harris, 2011)

The second knowledge construct, TCK-in-practice is defined by Jaipal and Figg (2013) as "the knowledge teachers use to select and think about how to use contentappropriate technologies" (p. 218) and teachers' personal competence (personal technical skills) at utilizing these technologies in the classroom. The third construct is TPK-in-practice which refers to practical teaching competences, such as classroom management, differentiated instruction, and assessment. TPK-in-practice is divided into three categories: planning, preparation and implementation. Figure 6 illustrates the characteristics and actions relating to teacher planning.



Figure 6. Planning characteristics of TPK-in-practice including assessment, activity choices, sequencing, differentiating for technical competence and backup instruction (Jaipal & Figg, 2013)

During the instructional planning phase teachers select technology-enhanced activities based on their subject matter learning outcomes, and then sequence these activities in order to build technology skills as well as content skills. The implementation phase of TPK-in-practice involves teacher modeling of technology tool use and utilizing classroom management techniques that best support student technical skill development and content learning. Figure 7 illustrates the implementation phase of Jaipal and Figg's (2013) framework.



Figure 7. Implementation characteristics of TPK-in-practice including modeling technology use to and for students and classroom management (Jaipal & Figg, 2013)

Similarly to Jaipal and Figg, Harris and Hofer (2009b) and Cowan (2008) developed steps to consider when planning technology-rich lessons. Harris and Hofer (2009b) suggest that after determining the learning goals, depth of content coverage and learning configuration, teachers must select and combine specific learning activity types, determine the assessment strategies, then choose the technology tools and/or resources. The following detailed list is Cowan's (2008) suggestion for planning an effective and successful technology-enhanced learning experience:

- 1. What is the topic of the lesson? What content will be covered?
- 2. What are the content-knowledge and skill objectives?
- 3. What standards are covered in the lesson?
- 4. How many days or periods are required? How can time be scheduled in a way that ensures success?
- 5. What will be the grouping strategy (e.g., individual work, partners, or teams)?
- 6. What technology hardware and software will be used to accomplish the task?
- 7. What access and passwords are required for the lesson?
- 8. What system will be put in place to save and protect data?
- 9. What are the technology-knowledge and skill objectives?
- 10. What will constitute the sequence of events?
- 11. What supporting materials such as textbooks, Web sites, and handouts will be used?
- 12. What is the plan for students who finish early and students who need more time?
- 13. What can be done if the technology fails?
- 14. How will the lesson-technology and content objectives be assessed? (p. 58)

Jaipal and Figg (2013) developed the TPACK-in-practice framework based on their studies of elementary teachers and they caution that it is still a work in progress.

Furthermore, TPCK-in-practice and TCK-in practice illustrate teacher thinking processes not their concrete actions. The authors also want to emphasize that their research contribute to the paradigm shift from "teaching the tool to thinking how to teach *with* the tool" (Jaipal & Figg, 2013). This call to move away from the 'technocentric' planning of instruction where the technological affordances are considered *before* the content learning goals and the needs of the students has also been emphasized by other researchers (ChanLin, 2008; Forssell, 2012; Harris & Hofer, 2009b; Lin et al., 2013).

Chapter Three

Methodology

3.1 Introduction

This dissertation research design was developed based on Yin (2014) case study protocol. The protocol contains the research instruments as well as the procedures for data collection. Developing a protocol is essential in case study research, especially in a multiple-case study, as it is a way to increase the reliability of the case study research (Yin, 2014). Protocol development helps keep the focus on the topic of the case study as it forces the researcher to think about and anticipate possible problems that might arise during the completion of the study (Yin, 2014). Based on Yin's (2014) recommendation this case study protocol has the following four sections:

- 3.2 Overview of the case study
- 3.3 Data collection procedures
- 3.4 Data collection questions
- 3.5 Data analysis

3.2 Overview of the Case Study

This multiple-case, mixed method study investigated how teaching with the iPad in a one-to-one classroom is aligned with the TPACK framework. The study aimed to answer these questions:

"In what ways is teaching with the iPad in a one-to-one classroom setting aligned with the TPACK framework?"

- 1.A. How are teachers' lesson plans aligned with the TPACK framework when they plan instruction for a specific lesson with the iPad in the one-to-one classroom?
- 1.B. How are teachers' actual one-to-one classroom instruction aligned with the TPACK framework?
- 1.C. What changes have these teachers experienced in their teaching when integrating the iPad?
- 1. D. How do teachers rate their TPACK skills associated with teaching with the iPad?

3.2.1 Case Study Design This case study research followed Yin's (2014) multiple case study design with each case considered holistically as a single-unit of analysis. The Figure 8 below gives a visual illustration of Yin's design and Figure 9 is the design pertaining to this study:



Figure 8. Holistic multiple-case study design (Yin, 2014)



Figure 9. Multiple-case design specific to this study

The advantage of a multiple-case study design for this research topic is that it allows for a more robust study of the issue with stronger effects and stronger external validity (Yin, 2014). The four cases in this study were carefully selected so that they may predict contrasting results but for anticipatable reasons, such as differences in teaching specific content areas or the participating teachers' teaching style and beliefs; therefore providing explanations as to how successful teaching with the iPad in a one-to-one classroom setting is aligned with the theoretical TPACK framework. Yin (2014) suggests that a four-case study has the ability to provide theoretical replication, while investigating two or three cases would only provide literal replications, where the cases are designed to corroborate each other (p. 57). The participants in this study have been teaching in the one-to-one classroom since the fall of 2013. Therefore, this study aimed to discover the TPACK skills of each participant and how they aligned their instruction with the theoretical TPACK framework.

The research question and its subquestions could be best answered by a mixed methods design. Mixed methods design refers to the procedure of collecting both qualitative and quantitative data in a single study, and analyzing and reporting this data based on priority and sequence of information determined by the researcher (Creswell, 2002). While the initial mixing of qualitative and quantitative data can be traced back to the late 1950s, the rise and advocacy of mixed methods designs has become prevalent since the late 1980s (Creswell, 2002). Since Campbell and Fiske's original interest in converging quantitative and qualitative data to better explain a phenomenon, the method of triangulation – a term taken from naval military biology – developed by Jick in the late 1970s, has greatly contributed to the greater generalizability of the two types of data

collected (Creswell, 2002). Triangulation in social biology research refers to the collection and integration of various kinds of data in order to explain the same phenomenon (Creswell, 2002). Researchers could employ a mixed methods design for a variety of reasons, such as gaining a broader understanding of an issue or to build a more encompassing theoretical explanation.

This study used the triangulation mixed method design as defined by Creswell (2002). This research design refers to the simultaneous data collection of both qualitative and quantitative data, followed by the analysis and the merging of the data, and the interpretation of the results. While in this study *all* data was collected in the data collection phase of the study, there was a specific order to the data collection procedure (described in detail in section 3.3 of this chapter) with the qualitative data collected *prior* to the quantitative data. The qualitative data which allows for the exploration of the research question(s) with the research participants at the research site was given more weight than the qualitative data (Creswell, 2009). Since the weight of the study was more qualitative, the actual mixing of the two methods took place in the data analysis phase (described in detail in section 3.5 of this chapter).

3.2.2 Research Subjectivity As a researcher, I have to acknowledge my own subjectivity when it comes to this dissertation research. I am a high school teacher in a college-preparatory high school with a one-to-one computing program in place since the 2013-2014 school year. This research study was conducted at this high school and the four participants in the study were my colleagues that I have known and worked with for at least five years.

After the school's leadership had decided to pursue one-to-one computing with the iPad, the first step in the implementation was for the faculty to receive the mobile device in February of 2013. The school-wide iPad rollout for the students followed shortly during the fall of 2013. Prior to the student iPad rollout, teachers received basic training on the functioning of the iPad and were introduced to a collection of non-content specific apps that could be utilized in the teaching and learning process.

Since the fall of 2013, one-to-one teaching with the iPad for me has been an experimentation relying on my teaching experience and my educational background in Curriculum and Instruction and the inspiration from my doctoral-level studies in Educational Media. I consider myself very fortunate because my workplace continues to facilitate professional growth in curriculum and technology integration. As I grow in theoretical and practical knowledge of one-to-one computing, I try new methods of curriculum and instructional design and work towards integrating the iPad into the teaching and learning process to facilitate student success.

Based on my familiarity with the participants and the context of this study I tried to minimize bias by purposefully phrasing the interview questions as 'how' questions which can seem more non-threatening than 'why' questions to the participants (Yin, 2014, p. 110). The interview protocol was designed as a semi-structured protocol to allow for the participants to express their thoughts and beliefs more freely. I have also tried to suspend my beliefs and attitudes about the context and aimed to facilitate a relaxed and non-threatening atmosphere during the interviews.

3.2.3 Case Selection This bounded case study research was carried out at a private, all-girl, college-preparatory high school in northwest Ohio. It must be noted that this school was *not* the original site selected for this study, but was chosen as an alternate site since the number of research participants could not be obtained at the original site.

This private, all-girl, college-preparatory high school has been utilizing a one-toone computing program with the iPad since 2013. Prior to the school-wide rollout teachers have received a series of two professional development workshops from a local non-profit organization providing professional development in the field of educational technology. There were two trainers present at each of the professional development sessions and each session lasted for two hours. The faculty was divided into two groups for both sessions to facilitate small-group instruction.

The goal of professional development was twofold: to have the faculty become familiar with the general features of the iPad and to provide training on how various applications can be utilized to enhance teaching and learning. The first training session which was conducted shortly after the faculty has received the iPads offered basic training on how to use the iPad. The faculty was divided into a 'beginner' and 'intermediate' group which allowed for better accommodation and pacing of the workshop. The second session took place towards the end of the 2012/13 school year. The trainers during this session introduced the faculty to apps that promote student collaboration and cooperative learning, such as BaiBoard, Groupboard and Collaborate. Presentation apps, such as Nearpod, Educreation, and Electric Slide were also introduced, along with some content-specific apps for the various disciplines. The session was

hands-on where teachers could try Groupboard for collaboration or explore Nearpod while creating a brief presentation.

During the school year there have been 30-minute optional training sessions for faculty on various topics from cloud computing with Google Drive to using specific content-area apps and teacher tools, such as GradeCam. The sessions have been developed and led by one of the biology teachers who also serves in the capacity of educational technology consultant. However, this person does not have a formal training in the field of educational technology. The school does not have an educational technologist: the school's dean of academics is responsible for curriculum and technology integration related decisions.

3.2.4 Participants Four high school teachers, one from each of the content areas of literature, mathematics, history, and biology, make up the individual cases in this study. The teachers have at least five years of teaching experience prior to the school's implementation of one-to-one computing. The participant selection was somewhat randomized since there were two volunteers from each of the content areas. The final selection of participants was determined by a random drawing; however, it must be acknowledged that the participants wanted to be part of this study either because they have personal or professional interest in technology and teaching with the iPad or simply to offer help to the researcher with this study.

3.2.4.1 Case 1 Mathematics: Jeff Jeff has twenty years of experience teaching mathematics and he holds a master's degree in mathematics education. At this college-preparatory high school Jeff teaches sophomore honors math classes, as well as Advanced Placement Calculus and an International Baccalaureate (IB) Mathematics

course. The students taking these rigorous higher-level courses receive college credit. Jeff uses technology in his personal life such as a PC, a tablet and a smartphone, but he only uses technology for what he deems necessary.

The two-part interview took place during Jeff's planning period prior to his teaching of the lesson. Since Jeff indicated that he had time, both parts of the interview were conducted at the same time. The field notes from the direct observation have generated additional, mainly clarification questions and Jeff graciously agreed to answering them via email. This correspondence, although initially not part of the data collection procedure, had become an additional data item for the triangulation process.

3.4.2.2 Case 2 Literature: Laurie Laurie has been the member of the English department for the past eight years and has a total of ten years of teaching experience. She holds a master's degree in literature. Laurie teaches higher-level courses, such as Honors English and IB Literature, along with an elective called Culture and Literature. She owns a laptop and a smartphone and similarly to Jeff, she only uses technology when she needs it.

The two-part interview took place during Laurie's planning period a couple of days prior to her teaching the lesson. Since Laurie had time, she preferred to do both parts of the interview in one sitting.

3.4.2.3 Case 3 Biology: Seth Seth has ten years of teaching experience and he has been teaching biology at this school for eight years. Besides his bachelor's degree in education, he holds a master's degree in zoology. Seth teaches honors-level Biology courses for freshmen, Environmental Biology for juniors and seniors, and Advanced Placement Environmental Biology, also for juniors and seniors. The two-part interview took place during Seth's planning period prior to his teaching of the lesson. Since Seth indicated that he had time, both parts of the interview were conducted at the same time. The field notes from the direct observation have generated additional, mainly clarification questions and Seth graciously agreed to answering them via email. This correspondence, although initially not part of the data collection procedure, had become an additional data item for the triangulation process.

Seth is a technology-enthusiast who enjoys using technology in his personal life and he keeps up with technology news on the latest gadgets he can use in his personal life. He owns a PC, a laptop, a tablet, a smartphone, an iPod Touch, and a Kindle.

3.4.2.4 Case 4 History: Ashley Ashley is a member of the history department with seven years of teaching experience. She teaches American History to sophomores, along with Economics, US Government, and Advanced Placement US Government. She holds a master's degree in adolescent education. In her personal life, Ashley enjoys using technology and similarly to Seth, she keeps up with the news on the latest gadgets. Ashley owns a laptop, a smartphone, a tablet and an iPod Touch.

The first part of the interview took place during Ashley's lunchtime prior to her teaching the lesson. Ashley did not provide lesson plan documentation at this time. Relying on her past experience, she admitted that her lesson plans are rather brief write-ups about what she wants to teach. She provided an electronic copy of the lesson plan at a much later time, approximately a month after the observation. The second part of the interview took place about a week after the observation, once again, during Ashley's lunchtime.

3.2.5 Types of Data Collected

- 1. Participant survey
- 2. Participant interview
- 3. Documentation in the form of lesson plans
- 4. Direct observation of classroom instruction

3.3 Data Collection Procedures

With the necessity of securing the alternate research site the principal graciously offered to help facilitate this study. She gave permission to inform the faculty about the study and the need for volunteers from the English, mathematics, history and biology departments. The volunteer teachers needed to meet these criteria:

- 1. They have been teaching with the iPad since the implementation of the program.
- 2. They have teaching experience in a traditional teaching setting, not just in a oneto-one classroom with the iPad.

Prior to the start of fieldwork the volunteer participants were contacted in order to discuss the extent of the study and the possible time commitment. The participants were informed that this research study aims to examine the changes in the instructional process as a result of teaching in a one-to-one setting with the iPad. The participants did not know the research questions or the subquestions. Yin (2014) emphasizes that a good case study protocol should distinguish among the different levels of questions. The researcher's line of inquiry, meaning the research question and its subquestions which

Yin (2014) calls Level 2 questions are different than the Level 1 questions posed to each participant during the interviews. The questions posed to each participant facilitated a "verbal line of inquiry" while the research question and subquestions make up the "mental line of inquiry" (Yin, 2014, p. 91). Furthermore, there were no references made to the TPACK framework or any of its constructs so as not to influence the participants' responses in any way.

Since case study research involved spending time at the site in an authentic setting, the participants' schedules were accommodated and the fieldwork did not interfere with the day-to-day teaching or the school day. Planning a visit to the site prior to data collection and securing the availability of a quiet place for conducting interviews with the participants facilitated the unobtrusive gathering of research data.

Each of the four participants were asked to select a brief teaching unit (consisting of two to three lessons) that best showcases their teaching with the iPad. Research data collected (interview, written lesson plans and direct observation) were about this chosen unit. A schedule of the data collection procedures based on the availability of the participants during the school day and/or after school hours helped plan the data collection procedure. The projected time of data collection was two weeks.

3.4 Data Collection Questions

This section of the case study protocol is for the data collection from each of the four single cases that make up this multiple-case study. The following questions were answered in this study:

"In what ways is teaching with the iPad in a one-to-one classroom setting aligned with the TPACK framework?"

- 1.A. How are teachers' lesson plans aligned with the TPACK framework when they plan instruction for a specific lesson with the iPad in the one-to-one classroom?
- 1.B. How are teachers' actual one-to-one classroom instruction aligned with the TPACK framework?
- 1.C. What changes have these teachers experienced in their teaching when integrating the iPad?
- 1. D. How do teachers rate their TPACK skills associated with teaching with the iPad?

After the participants have selected the teaching unit and the corresponding lesson plans, the order of the various types of data collected for each of the four cases was as follows:

- 1. Collection of lesson plans
- 2. Conducting participant interview
- 3. Direct observation of classroom instruction
- 4. Participant survey

One of the most important sources of evidence in a case study is the interview because it facilitates a targeted focus on the line of inquiry and provides insightful explanations and personal views on the research topic (Yin, 2014). The weakness of the interview lies in poorly worded or articulated questions. Therefore, some of the interview questions were purposefully phrased as 'how' questions instead of 'why' questions based on Becker's (1998) recommendation that questions starting with the word 'why' may create defensiveness in the part of the participant whereas 'how' questions can seem more non-threatening (Yin, 2014, p. 110). The interview protocol developed for this research facilitates the research inquiry; however, the questions are semi-structured to allow for a more fluid, but guided conversation as recommended by Yin (2014). Another weakness inherent in participant interviews is reflexivity, or the bias of the researcher in the selection of research topic and the type of investigation used. Beliefs and attitudes based on personal experience must be suspended and the researcher should "appear genuinely naïve about the topic" (Yin, 2014, p. 111) in order to allow the interviewers to fully participate, feel non-threatened and provide fresh insights into their experience with one-to-one computing with the iPad. With the permission of the interviewes all interviews were recorded.

Documents in case study research are mainly used to corroborate and augment evidence from other sources (Yin, 2014). The strength of documentations, such as written lesson plans collected from the participants is that they were not created as a result of this case study, therefore lessening the probability of reflexive bias. However, there was participant bias in selecting the small teaching unit to showcase the 'best' teaching with the iPad.

Direct observation was another type of evidence used to help answer the research questions. The goal of the direct classroom observation was to provide additional evidence of how teacher lesson planning and the constructs of the TPACK framework were carried out in the classroom setting. The direct observation provided insight into how the TPACK theoretical framework proposed by Koehler and Mishra (2009) was applied in the instructional planning process and whether or not the framework was modified as suggested by Jaipal and Figg's (2013) TPACK-in-practice model. The evidence from the direct observation provided an additional base for triangulating data from lesson plans, interviews and the participant survey.

The purpose of the participant survey was to make inferences about participants' TPACK skills associated with teaching with the iPad. Neither the word "TPACK" nor the names of any of its constructs appeared on the actual survey so as not to sway the participants towards rating themselves more favorably, contributing to reflexive bias. To further counter reflexivity, this cross-sectional survey about the technical competencies of each participant was collected *after* all other forms of data had been gathered. The reason for the collection of this survey data at the very end of the data collection phase was to avoid the participants 'guessing' what the study was about and/or possibly being influenced by it during the interviews or the direct observation.

The self-administered survey was advantageous because participants could complete them at their convenience. The web-based design utilizing a Google survey form allowed for some cost and time savings.

Data triangulation using multiple sources of data enhanced the construct validity of this multiple-case study (Yin, 2014). The section below details the connection – or the "crosswalk" (Yin, 2014, p. 90) – between the research inquiry and the sources of evidence that provided the answer.

3.4.1 Question 1.A *How are teachers' lesson plans aligned with the TPACK framework when they plan instruction for a specific lesson with the iPad in the one-to-one classroom?*

Participants: the four individual participants

<u>Tools</u>: Part A of the interview protocol consists of semi-structured questions and written lesson plan for the corresponding lesson. The participants were asked to provide a copy of their written lesson plan for this specific lesson and this document was used in the data triangulation process along with the survey and interview data. The interview protocol developed for questions 1.B and 1.D was adapted from Harris, Grandgenett, and Hofer (2012) and Pamuk (2012). The open-ended questions in Part A of the interview inquired about instructional planning for a specific lesson where iPad is utilized as a teaching and learning tool. Part A of the protocol is as follows:

- 1. TK: What feature of the iPad will you use in this unit (i.e. apps, Internet browser, reading platform, cloud computing, etc.)?
- 2. CK: Describe the content and/or the process for the unit.
- 3. CK: Describe student learning goals/objectives addressed in this unit.
- 4. PK: Describe your students. (i.e. grade level, learning needs)
- 5. PK: Describe the issues of classroom management with this group of students.
- 6. PCK: What teaching approach and/or strategies are effective when teaching this content?
- 7. PCK: What difficulties and/or misunderstandings do students encounter while learning this content?
- 8. PCK: What plans do you have to assist students overcoming the difficulties in understanding this content?
- 9. TCK: How and why do the particular iPad features (i.e. apps, Internet browser, reading platform, cloud computing, etc.) used in this unit "fit" the content and/or process goals?
- 10. TCK: How will these particular iPad features (i.e. apps, Internet browser, reading platform, cloud computing, etc.) used in these lessons aid and/or enhance content delivery?
- 11. TPK: How will these particular iPad features (i.e. apps, Internet browser, reading platform, cloud computing, etc.) used in these lessons "fit" the instructional strategies you will use?
- 12. TPK: How will this particular iPad features (i.e. apps, Internet browser, reading platform, cloud computing, etc.) contribute to student learning?
- 13. TPK: How will you assist your students using this particular iPad features (i.e. apps, Internet browser, reading platform, cloud computing, etc.)?
- 14. TPACK: How and why do the learning goals, instructional strategies, and the particular iPad feature you will use "fit" together in this unit?

<u>Data storage</u>: The interview data was recorded, transcribed and stored electronically. An electronic back-up copy was made of each of the hard copies of the lesson plan documents. The hard copies were stored in a folder; the back-up copies were stored electronically.

3.4.2 Question 1.B How are teachers' actual one-to-one classroom instruction aligned with the TPACK framework?

Participants: the four individual participants

<u>Tool:</u> Direct observation of participants' teaching of one of the lessons in their chosen unit. The observation instrument developed was based on Jaipal and Figg's (2013) TPKin-practice model for planning, preparing and implementing technology-rich lessons. The observation protocol focused on the following:

- 1. Teacher modeling of technology use:
 - a. Model best practice for use of iPad or specific application(s)
 - b. Model generic functions/features of the iPad
 - c. Use of teacher-created exemplars
 - d. Have students model iPad skills
- 2. Classroom management:
 - a. Use of student grouping techniques to support technical skill and content learning

3.4.3 Question 1.C *What changes have these teachers experienced in their teaching when integrating the iPad?*

Participants: the four individual participants

<u>Tool:</u> Part B of the interview protocol which asked semi-structured and open-ended questions about the changes in instructional planning as a result of iPad integration. The interview protocol developed for this subquestion was also adapted from Harris et al. (2012) and Pamuk (2012). Part B of the protocol is as follows:

- 1. TK: What features of the iPad (i.e. apps, Internet browser, reading platform, cloud computing, etc.) do you most often use in your one-to-one classroom?
- 2. PCK: What teaching approach is effective with your content area?
- 3. TCK: How do the iPad features you use most "fit" with your content area?
- 4. TCK: How do the iPad features you use most contribute to student learning?
- 5. TPK: How do the iPad features you use most "fit" with your instructional strategy?
- 6. TPACK: What teaching approach and/or strategy are effective when teaching your content area with the use of the iPads?

Open-ended questions:

- 7. What are the challenges of integrating the iPad into teaching?
- 8. What are some of the problems you encountered while teaching with the iPad?
- 9. What aspects of the iPad integration still need improvement?

10. Would you have preferred teaching in a one-to-one classroom with laptops instead of the iPad?

Data storage: The interview data was recorded, transcribed and stored electronically.

3.4.4 Question 1.D How do teachers rate their TPACK skills associated with teaching with the iPad?

Participants: the four individual participants

<u>Tool:</u> TPACK survey measuring participants' TPACK knowledge (Appendix A). The survey items were adapted from the studies of Archambault and Crippen (2009), Chai, Koh, and Tsai (2011), and Schmidt et al. (2010). The survey question asked of the participants was "*How would you rate your confidence level associated with technology and teaching*?" and the survey had no reference to any of the TPACK constructs. Data storage: The survey data was received and stored electronically.

3.5 Data Analysis

Each of the four cases was treated as an individual unit but the method of analysis applied to them was the same. The survey data for question 1.D was analyzed using the quantitative methods of descriptive statistics. Atlas.ti software was used for the qualitative data analysis for questions 1.A, 1.B and 1.C. Some data analysis took place simultaneously with the data collection. The interviews were transcribed shortly after they had taken place and the lesson plan documentation was reviewed during the data collection phase in order to make any necessary changes to the case study protocol. Similarly, the notes from the direct observations were reviewed shortly after the observation had taken place. Atlas.ti is a highly intuitive software package that has been designed from the earlier "paper and pencil" paradigms of qualitative research. The qualitative part of the research project was be organized within a "container" file called the Hermeneutic Unit (HU). The HU not only held but also maintained pathways to the types of data sources within the project: the interview transcripts for Part A and Part B of all participant interviews, the lesson plan documents and the data from the direct observations.

The early stages of working within Atlas.ti involved assigning various codes to the different types of data collected. The software allowed for easy searching, marking and color coding of the data. The data was then explored by grouping the codes into sets and subsets based on identifying patterns and relationships and emerging themes. Once the data was explored; it was retrieved and displayed in a variety of network views to facilitate the making of connections and the emergence of code families. This iterative process of interpreting data led to the write-up of the analysis and facilitated the exploration of connections about the various aspects of the data.

After all the qualitative data had been collected for each individual case, the analysis in Atlas.ti began with the process of pattern matching which is one of the most highly recommended technique for case study analysis (Yin, 2014). Since the research line of inquiry centered on exploring how successful teachers in a one-to-one setting with the iPad have aligned their teaching with the TPACK framework, descriptive coding helped match the empirical findings of the study to the constructs of the TPACK framework. After the data had been combed through, the emerging codes could be grouped and organized into code families in order to facilitate the process of explanation building and the matching of the code families to Koehler and Mishra's (2006)

theoretical and/or Jaipal and Figg's (2013) practical TPACK frameworks. This was an iterative process with the evidence being examined and reexamined to discover new perspectives and to revise and reorganize emerging code families.

Descriptive statistics was used to analyze the data collected for question 1.D (How do teachers rate their TPACK skills associated with teaching with the iPad?). For each case the mean score for each construct of the TPACK framework (CK, PK, TK, CPK, PCK, TPK, and TPACK) was calculated. For each case, the most frequent answer within each construct was also recorded. In the final cross-case analysis the mean for each construct was calculated along with the mean for each survey item within the construct (i.e. there are seven individual survey items measuring the construct TK). Lastly, the grand mean for all four cases was calculated.

In the cross-case analysis both qualitative and quantitative data were compared and contrasted with the theoretical TPACK framework and the findings of other research studies measuring the TPACK constructs, such as the works of Archambault and Crippen (2009), Chai et al. (2011), Jaipal and Figg (2013), Hashim (2014), Schmidt et al. (2010).

Chapter Four

Data Analysis

This chapter discusses the results of the data analysis for each of the four individual cases. In this multiple-case study each case was analyzed individually utilizing the same procedures in each case.

4.1 Data Analysis Process

For the qualitative data:

- Creating a new hermeneutic unit for each case and uploading PDF copies of all the documents in Atlas.ti 7 software.
- 2. Descriptive coding of all the documents for each case. Descriptive coding refers to summarizing the primary topic of an excerpt.
- 3. Organizing the codes into code families, or codes that relate to certain topics, in this case, to the research questions. This process served three purposes: to discover related codes that could be organized into a code family, to align the coding process with the research questions and the TPACK constructs, and to discover patterns and overarching themes in the data.
- Defining the code families and matching them to the constructs of the TPACK framework

For the quantitative data:

The quantitative TPACK survey provided data for question 1.D "*How do teachers rate their TPACK skills associated with teaching with the iPad*?" The process of this data analysis was as follows:

- Individual-case calculation of the means for each of the seven TPACK constructs using Microsoft Excel. A grand mean of all the seven constructs was calculated for each case.
- Cross-case calculation of the means for the participants combined for each of the seven TPACK constructs and for each survey item within the constructs.

4.2 Code Family Alignment with TPACK Framework

The code families aligned with the constructs of the TPACK framework connect the data to the overarching research question of "*In what ways is teaching with the iPad in a one-to-one classroom setting aligned with the TPACK framework?*" Table 1 below shows how the qualitative research questions were aligned with the code families and the TPACK framework. There are code families associated with all the cases, however, due to the open-ended interview questions and the use of content-specific apps or activity for teaching and learning some of the code families are only associated with a certain case or cases. (These are specifically indicated in the table below.) The code family "*IPad use in the one-to-one classroom*" can be aligned with two of the qualitative research questions because it is a larger code family containing descriptions about teaching *and* learning with the iPad. Table 1

Qualitative research questions aligned with code families and TPACK framework

1.A. How are teachers' lesson plans aligned with the TPACK framework when they plan instruction for a specific lesson with the iPad in the one-to-one classroom?

Lesson planning	CK, PK, TK, CPK, TPK, TCK,		
	TPACK		
GeoGebra app – Case 1	TK, TCK, TPACK		
Hungry Birds app – Case 3	TK, TCK, TPACK		
Cold war web quest – Case 4	TK, TCK, TPACK		

1.B. How are teachers' actual one-to-one classroom instruction aligned with the TPACK framework?

Classroom instruction	СК, РК, ТК, СРК, ТРК, ТСК, ТРАСК
Effective teaching techniques	CK, PK, TK, CPK, TPK, TCK,
IPad use in the one-to-one classroom	TPACK CK, PK, TK, CPK, TPK, TCK,
	ТРАСК

1.C. What changes have these teachers experienced in their teaching when integrating the iPad?

Teacher technology knowledge (Case 1, 2, 3)	ТК
Challenges of the one-to-one classroom (Case	TPK, TCK, TPACK
2, 3, 4)	
IPad use in the one-to-one classroom	CK, PK, TK, CPK, TPK, TCK,
	ТРАСК

4.2.1 Code Family Definitions

1. Lesson planning: This code family refers to all the descriptive codes

relating to the participants' planning for the lesson of the direct observation. The code family also includes the description on how each teacher ranked the importance of learning goals, content, pedagogy and technology during their lesson preparation process. This family is aligned with research question 1.A.

- 2. Effective teaching techniques: This code family refers to the descriptive codes associated with each participant's beliefs about best practice in their content area. It contains descriptions about their teaching philosophy, instructional methods, student difficulties in each of the content areas and classroom management techniques. This family is aligned with research question 1.B.
- 3. Classroom instruction: This code family is associated with the direct observation of each of the participants' teaching of their chosen lesson. The descriptive codes that make up this family are mainly from the field notes of the observation and they describe class atmosphere, teaching and instructing, cooperative learning, critical thinking, grouping students, modeling and guiding instruction. This family is aligned with research question 1.B.
- 4. IPad use in the one-to-one classroom: This code family contains all the descriptive codes associated with teacher- and student-use of the iPad in the one-to-one classroom for the content areas of mathematics, literature, biology and history. Some of the descriptive codes in this family are file sharing, using online resources, and choosing *not* to use the iPad for instruction. This is the only code family that can be aligned with all three of the qualitative research questions.
- 5. **Teacher technology knowledge:** This code family is associated with only Cases 1, 2 and 3. The descriptive codes associated with the technology

knowledge of the participants and the teaching of technical skills make up the code family. There are also descriptive codes pertaining to the personal professional growth of the participants in their technology knowledge. This family is aligned with research question 1.C.

- 6. Challenges of the one-to-one classroom: This code family is associated with only Cases 2, 3 and 4. This code family holds the descriptive codes associated with technical issues during instruction and classroom management issues brought about by the presence of the mobile device. This family is aligned with research question 1.C.
- 7. **GeoGebra app:** This code family is associated with Case 1 only. This app was integrated into geometry teaching and learning during the observed lesson. The descriptive codes are about learning to use the app, teaching it to the students and evaluating the app in terms of aiding and enhancing content delivery and student learning. This family is aligned with research question 1.C.
- 8. **Hungry Birds app:** This code family is associated with Case 3 only. This app was integrated into biology teaching and learning during the observed lesson. The descriptive codes are about learning to use the app, teaching it to the students and evaluating the app in terms of aiding and enhancing content delivery and student learning. This family is aligned with research question 1.C.

9. Cold War web quest: This code family is associated with Case 4 only. An individual student activity using a browser app of the iPad was the instructional method during the observed lesson. The descriptive codes are about the web quest itself and also about the benefits of learning content via this activity. This family is aligned with research question 1.C.

4.3 Case 1 Mathematics: Jeff

"Math is still kind of an open-ended pursuit.... My goal is to get them to appreciate geometry as a living subject...."

The lesson observed for this case was a sophomore Honors Math class of twentyfive students; two of which were freshmen. This lesson was one of the last lessons in the geometry unit and served as a 'wrap-up' and review of content learning. Prior to the direct observation Jeff provided a copy of the lesson plan and a handout of the math problems the students were to complete during the 85-minute class period of the school's regular block scheduling. The students were to use a geometry app on their iPad called GeoGebra to complete these math problems. The students were to use GeoGebra to make drawings based on the directions on their handout. Most problems required them to come up with hypotheses and test them. The iPad was also going to be used for a brief Internet search of vocabulary words related to geometry and mathematics.

4.3.1 Lesson Planning Jeff describes this class as a "typical" sophomore honorslevel class with "pretty strong" students who earn mainly As and Bs. He admits that he has had stronger students in the past and he believes that for this particular group math may not be their strongest interest of this particular class. Jeff's learning goal for this lesson is to reinforce that mathematics and geometry have components based on the process of experimentation and to empower students to make discoveries on their own. Jeff's goal then is the reinforcement of his teaching philosophy and his love and appreciation of the biology of mathematics. He wants his students to "get them to kind of appreciate geometry as a living subject, as something they can discover on their own."

Jeff describes his lesson planning process as somewhat informal since he can rely on his twenty years of experience and allow planning to become somewhat of a routine. When asked to rank content, goals, pedagogy and technology in order of importance when it comes to planning lessons, after some careful consideration and thinking out loud, Jeff ranked them as follows:

1. content

2. goals

3. pedagogy

4. technology

Upon further thinking, followed by his admittance that this is an interesting thing to ponder, Jeff added that pedagogy is very closely followed by technology as he believes technology influences pedagogy.

Jeff explains that he considers time to be a factor in terms of what material he needs to cover in a particular amount of time. To be in sync with his constructivist teaching philosophy, he would very much like to have a student-centered classroom with discovery learning all the time. However, he knows that this is not always feasible due to time and curricular constraints. There's always a balance of do I have to kind of talk more than I want to or can I slow down and let them [students] just try to discover this, even though I know it's gonna take twice as long.

When Jeff discussed his choice of using the app called GeoGebra, he said that the app allows him to teach new content and/or concepts. Since it is very easy to use, Jeff could incorporate these problems into this review lesson. He indicated that some of the problems were brand new to him; he had not used them in previous years. He knew "the kids like using the app, and so I searched for interesting geometry problems to allow us to justify such play." He also adds that while he has always tried to convey that experimentation and discovery are what mathematics is about, "it's difficult to convey the need and enjoyment and satisfaction of experimentation and self-discovery without the use of the app (or technology), so reinforcing that aspect of mathematics was not something I could do that much without technology."

4.3.2 GeoGebra App Jeff uses this app for the geometry unit in this honors mathematics class, but his higher-level IB Mathematics students also find it useful. This is Jeff's second year of teaching the geometry unit using GeoGebra. Teaching with the iPad in the one-to-one classroom has prompted Jeff to search for an alternative to the PC geometry program called Sketchpad. He found the GeoGebra app via a simple Google search. Jeff made the decision to use GeoGebra after he tried it and realized that the app was very user-friendly and easy to learn. His approach to learning how to use apps is similar to his approach to learning about GeoGebra:

I try to open up an app and play around with it like a kid would and if it works easily then it seems appropriate. If it's really cumbersome then I start to realize that there is this time-balance here and it may not work out in our favor.

Jeff believes that with the GeoGebra app it is worth taking the time to slow down and choose student-centered discovery because "it's fairly easy with the app and it's fairly enjoyable and... they just pay attention more than they would pay attention to me talking."

Jeff believes that the app helps reinforce his teaching philosophy when he explains that GeoGebra "helps me achieve the goal of getting students to realize that mathematics is about discovery and making hypotheses and getting them to think critically." Furthermore, Jeff shares that "I think when one gets to realize that … you don't just read about mathematics you do it. So this [GeoGebra] really reinforces that because … they're actively making these drawings." Jeff admits that it would have been possible to complete these math problems without the use of technology, but it would have been very cumbersome, time-consuming and problematic with the students making many mistakes along the way and possibly missing the discoveries the problems had led to. Jeff explains that his students are used to making drawings for experimentation into their notebooks for testing easier ideas, but when the drawings get complicated – as they do in this geometry unit – that's when the technology helps student learning and increase his teaching efficacy.

4.3.3 Effective Teaching Techniques Jeff's teaching style which is rooted in modeling and guided instruction is aligned with his constructivist teaching philosophy and his view of mathematics. He encourages student-led discovery whenever possible and when it is not, he prefers guiding class discussions. He facilitates student learning and critical thinking through modeling and asking and answering questions. This quote sums up his beliefs:

Math is still kind of an open-ended pursuit. Mathematics and in particular geometry has this component where we want the kids to experiment and discover things on their own and make conjectures and test the conjectures. My bigger goal is to get them to kind of appreciate geometry as a living subject, as something they can discover on their own.

Jeff believes that student-centered discovery is most effective when teaching mathematics: "You don't just sit back and learn it. You do it, it's a process." In his view the main student difficulty with math is the actual perception of math. Many students equate doing well in mathematics to being good at memorizing. Jeff believes that this misperception leads students to "lose sight of the fact that people do math because, you know, it's interesting and has these surprises, and it's satisfying."

Jeff views math as a journey towards discovering interesting phenomena and deriving satisfaction from these discoveries. The field notes indicate that during the observed lesson Jeff consistently modeled the discovery process in mathematics in his actions when using the GeoGebra app and in his words as well: "I might very well forget about this particular result a month from now, just like you will, and that's okay. Math is about experimentation. The GeoGebra app helps us learn it by doing it." Jeff used

GeoGebra to 'fit' everything together: goals, content, pedagogy, allotted time, teaching philosophy, and his knowledge of this particular group of students. His effective use of the GeoGebra app and other pieces of classroom technology, such as the Smartboard and an Elmo made his teaching successful.

Jeff describes his teaching style as informal and admits that other teachers might view his students as "too rambunctious" but he says it works for him. The field notes of the observation show that his students felt very comfortable asking him questions and helping each other with the GeoGebra app. Students also felt free leaving their seats in order to ask questions and/or offer help to a classmate. This informal way of running his class did not take away from student learning. The field notes indicate that the students were on task and focused on the math problems at hand. All student activity was related to student-centered learning. For Jeff student questions and comments and their moving around the classroom are preferable to his quiet class where he feels like he is "pulling teeth" sometimes.

This informal teaching style sometimes means that Jeff does not monitor student use of the iPad as much as his administration thinks he should. He is aware that sometimes his students are off-task with the iPad. However, he admits that it is worth risking students maybe being off-task as opposed to not using the iPad at all. His belief is reinforced in the literature in Howard's (2011) study of teacher's perceived risk perceptions when it comes to technology use. When they deem the risk minimal and the outcome greater, they choose to integrate technology. In Jeff's words: "... the fact that they have these iPads with them all the time is worth putting up with the risk that maybe they are not always doing what they're supposed to."

4.3.4 Classroom Instruction Jeff's teaching and interaction with his students which was observed during the 85-minute lesson were the result of his lesson planning, considering a variety of factors within the TPACK framework, such as content and his past experience teaching it, pedagogy, the issue of time, the usefulness of the GeoGebra app in this lesson and for this particular group of students. Jeff's teaching philosophy of student-centered discovery and his belief that mathematics is a process were evident in his instruction and reflected in the way his students learned during the lesson.

The field notes reveal that the class atmosphere was very relaxed. Students had the option to work alone or in groups, but the number of students in a group was left up to them. Students felt free to leave their seat and interact with each other, talking about the math problems and the useful features of GeoGebra, or simply ask and answer questions. The field notes from the direct observation reveal several examples of the students and teacher 'being in this together', meaning that all had the same focus and worked towards the same goal. At one point Jeff enlisted the help of a student who figured out a new feature of the app to show it on the Elmo so the entire class could see it. At another time Jeff asked his students "What part of this problem do you think you will need my help on?" Jeff empowered his students to be in charge of their own learning, work at their own pace, and determine when and how much help they needed from their teacher. On one occasion, while Jeff was walking around the room and helping students, he identified a student who was ahead of the class on her problems as the "expert" to whom the others could turn with their questions. On another occasion the teacher mentioned that he had fallen behind working out these problems on his iPad, and he has to catch up to the

students, indicating that his students worked at a faster pace and were better at using GeoGebra than him.

Critical thinking is facilitated via teacher guiding and modeling and with the utilization of GeoGebra. Jeff used the technique of modeling to show how to solve the problems using GeoGebra: either he himself demonstrated the process of solving the problem using the Elmo and the Smartboard or he projected a student exemplar and let the student explain how she solved the problem. The math problems to work out with GeoGebra that Jeff had carefully selected for this lesson facilitate critical thinking as this example below taken from the student handout illustrates:

Construct an illustration of the Pythagorean Theorem using GeoGebra. Start with a right triangle. Construct squares off each side of the triangle. Display the area of each square. How does this illustrate the theorem?

4.3.5 IPad Use in the One-to-One Mathematics Classroom In the one-to-one classroom for the last three years Jeff has been using the iPad mainly for document sharing via Google Drive. One benefit of the iPad for the entire math department is the reduction of paper use as the math textbook for freshmen, sophomore and junior students are online and shared via Google Drive. Jeff believes the students like having all the resources with them on the iPad so they can access it anytime and anywhere. He hardly has any technical difficulties besides the occasional slow speed of the school's network and he believes that the one-to-one classroom with the iPad facilitates technology integration into the teaching and learning process because "…with the iPad, it's just seamless and they [students] always have it with them. So I found myself using it a lot more to their benefit, really."

When reflecting on why he had seldom used the PC program called Sketchpad, Jeff mainly cites the difficult and time-consuming nature of facilitating student access to the Sketchpad program on laptops. Then he had made the deliberate decision not to integrate technology after considering the pros and cons. And the cons outweighed the pros:

I honestly used it [Sketchpad] maybe once in ten years because I had to go down to the resource center [first floor of building] or I had to get the laptop cart up here [third floor where his classroom is]; it was very cumbersome to get this to work.

When weighing the pros and cons of teaching with the iPad, Jeff has realized that the pros outweigh the cons. He believes the way the iPad can be integrated into the teaching and learning process is "seamless." The iPad adds value to his instruction and to student learning and he feels disappointed that he had not made the effort to use Sketchpad more often in the past:

Sometimes I look back on the years I didn't use something like this [Sketchpad] 'cause it was a pain in the neck ... I feel, you know, kind of chagrined I didn't make more of an effort. But it just didn't work well.

This idea of choosing not to integrate technology or choosing not to use a specific feature of the iPad is reflected in Jeff's discussion about how he views technology integration in mathematics in general. He thinks that this subject doesn't always lend itself as easily as other subject to the iPad use as he believes that "math itself is, maybe, one of the harder ones [content areas] to kind of use an iPad creatively." Besides a few concepts that involve graphics and a few videos he shows in class every now and then, he

believes that there are not that many quality apps available for teaching high school mathematics. He considers GeoGebra uniquely well-made and well above the other apps for geometry or other areas of math.

Jeff does not want to use technology for technology's sake because that does not fit with his teaching methods and philosophy and the other factors he considers when planning a lesson, such as time constraints and student needs:

I mean I know how to make iMovies, but I don't know that there is much point to that in my class. I guess I could have the student, you know, discover something and make an iMovie about their discovery but I'm the kinda teacher to look at that and think "No, they made their discovery a week ago and now they are spending a week on the technology and that is not a good use of our class time.

4.3.6 Teacher Technology Knowledge Jeff feels good about his exploration of using the iPad for instruction. He admits that over the past three years he has been using it more in his daily teaching. Sometimes he learns about apps from younger colleagues whom he considers more tech-savvy, but he also takes the initiative to search for quality apps to use in his classroom. He knows what he is looking for in an app as his evaluation of GeoGebra indicates.

Jeff admits that he does not teach technical skills to his students in a systematic way. His students have learned the features of GeoGebra by making discoveries about the content. Jeff therefore, tries to maximize instructional time by infusing content learning with technical skills learning. He believes this is a good use of classroom time since for every hour they use the app for content learning only 10-15 minutes was about

technical skill learning. Students also helped each other with technical skills learning during the observed lesson as they moved about the classroom to assist each other.

Jeff has set personal professional development goals for himself. He would like to incorporate the iPad into the other courses he teaches and would like to research apps to use in those branches of mathematics. He admits he is more likely to accomplish these goals if he tackles one branch at a time, such as finding some good apps for his calculus class first, using them in that course, and then moving onto apps for algebra, and so on. Based on this description and the daily realities of teaching and working in a high school, iPad integration is an ongoing process. With the constant new apps and technology updates, teachers can feel overwhelmed about what it is that they should know and what new piece of technology is worth pursuing.

Jeff is an experienced teacher and he could easily rely on his past experience and teaching expertise and choose *not* to teach with the iPad. Why doesn't he do just that? Jeff believes that his teaching with the iPad enables him to journey on the path of constructivist teaching, to validate his teaching philosophy and his view of mathematics, and to motivate and empower his students in the process.

4.3.7 TPACK Survey Results Calculating the average for each construct reveals that Jeff is most confident in his Content Knowledge (CK). Table 2 shows that the next highest averages for Jeff are knowledge constructs associated with pedagogy, namely Pedagogical Content Knowledge (PCK) and Pedagogical Knowledge (PK). The grand average of the survey is 3.29 which is slightly higher than the average for the items measuring his TPACK knowledge (M=3.0). An explanation for this is that Jeff's CK and PCK averages have led to the overall increase in the grand average.

Table 2

Case 1	ТРАСК	survey	results
	-		

Case 1 Mathematics: Jeff			
CK average PCK average PK average	4 3.75 3.4		
TCK average	3		
TPK average	3		
TPACK average	3		
TK average	2.86		
Grand average	3.29		

Jeff rates his knowledge and confidence weaker in the knowledge domains associated with technology: Technological Content Knowledge (M=3.0), Technological Pedagogical Knowledge (M=3.0), and Technological Pedagogical Content Knowledge (M=3.0) and Technological Knowledge (M=2.86). The fact that his TCK, TPK, and TPACK are higher could be explained by his confident ratings in his content and pedagogical knowledge domains. His weakest area is the Technological Knowledge – the construct measuring one's knowledge about utilizing the more widely-used technologies. Table 3 shows Jeff's rating for each item measuring this construct. Jeff lacks confidence when it comes to creating web sites and utilizing social media.

Table 3

TPK construct items	Rating
I can troubleshoot technical problems associated with hardware (e.g. network connections).	4
I can address various computer issues related to software (e.g. downloading appropriate plug-ins, installing programs).	3
I can assist students with troubleshooting technical problems with their iPad.	3
I frequently play around with technology.	
TPK construct items	Rating
I can learn technology easily.	3
I am able to create web pages.	2
I am able to use at least one type of social media (e.g. Blog, Wiki, Facebook).	2

4.4 Case 2 Literature: Laurie

"Things [class materials] are more efficient for me to share so I spend a lot less time at

the copier, but in terms of the actual classroom teaching I'm pretty much the same."

The class observed was an International Baccalaureate (IB) Literature class. This is Laurie's third year of teaching this course. She taught the course without the iPad during the first year, then in a one-to-one setting during the following two years. IB Literature is a two-year course starting in the 11th grade. Laurie and a colleague from the English department share teaching this course, and Laurie teaches the second year.

There were seventeen students in the class, all of them are seniors and Laurie describes them as "very high-achieving, very independent thinkers." A few days prior to the direct observation Laurie provided a copy of the lesson plan for the 85-minute class period. During the interview she described that the first part of the lessons would be spent in preparation for the upcoming IB Literature exam. Her students were to evaluate sample essays which are essays based on two of the four novels Laurie has taught during the second semester. Then the class would move onto working in groups to practice writing thesis statements using prompts from past exam. The last part of the lesson would be student-led class discussion of the novel they were reading, The Handmaid's Tale by Margaret Atwood. The iPad was to be used to access shared materials via the Google Drive app, and students had the option to use the device for practicing writing their thesis statements.

4.4.1 Lesson Planning When Laurie planned this lesson she relied on her previous two years of teaching this course and did what had worked best for her and her students in the past. Laurie's general lesson planning approach for all the courses she teaches is to divide the 85-minute class period into two or three segments that facilitate the logical 'flow' of instruction or the dissemination of content material. Laurie says "I almost never do something for a whole class, unless it's a test." She found that this approach works for her as a teacher and it is beneficial to keep her students' attention focused during the 85-minute lessons. Laurie usually divides the block into segments this way: "I start with content to back up notes or vocabulary and then we do discussion usually as a big class and then we do some sort of extension with small groups." The order of the segments might not always be as she describes it above, but she generally prefers them this way.

The instructional segments are reflected in her lesson plan document as well. Laurie's main goal for the lesson is to "push their critical thinking." The instructional objectives refer to two different components of the course curriculum: the first is the test preparation (as required by the IB Organization) and the second is teaching content (The Handmaid's Tale). Below are Laurie's learning objectives: At the completion of this class:

1. Students will be better prepared for standardized IB Assessment after looking at exemplars and brainstorming thesis statements and organizational strategies.

2. Students will engage in a close reading of the ending of The Handmaid's Tale based on their reading notes and class discussion.

The lesson procedures on Laurie's lesson plan document further reflect her approach to chunking the class period into three distinct learning activities:

- As a class (teacher led), students will engage in a critique of Paper 2 exemplars they read for homework (especially as compared to the essays they wrote last class).
- In groups of 3-4, students will brainstorm 2 possible thesis statements for past Paper 2 prompts.
- Students will engage in a class discussion (student led) of the last chapters of The Handmaid's Tale.

As Laurie describes the first chunk of the IB Literature lesson she says that she tries to give her students as much preparation for the IB exam as possible because on exam day the students will be presented with three questions that they have never seen before and will have to think on the spot which two books they want to compare and contrast (out of the four she had selected for the course) and which thesis writing technique they want to use. Laurie discussed how she had a choice of novel selection when she put together the curriculum for the second year of this course. Laurie used her content knowledge and past experience to make the selection:

In choosing the Handmaid's Tale particularly, the four novels that I had taught this semester that they have to compare and contrast are The Scarlet Letter, The Bluest Eye, The Great Gatsby and The Handmaid's Tale, I chose the Handmaid's Tale because it does a lot of the same things that the Scarlet Letter does in terms of women's repression, but in a completely different format, so I thought that would be a good pairing to compare and contrast.

When asked to rank content, goals, pedagogy and technology in order of importance when it comes to planning lessons, Laurie ranked them as follows:

1. goals

- 2. content
- 3. pedagogy
- 4. technology

Laurie hesitated on ranking goals or content first on her list. She eventually chose goals and offered the reason why:

My content... well, my goals, my goals are the most important because I could've chosen from hundreds of novels for critical thinking, so the critical thinking is my goal then I try to choose the content... choose a work that isn't too difficult but that lends itself to discussion and to comparison.

She ranked pedagogy third because she wants to "be able to teach in a way that is relevant to them and that gives them ownership of the material." Technology ranked last "just because of my subject matter doesn't lend itself, I don't think, as much to

technology [as some other subjects]." She also explained that "people have always been doing close reading of a novel with the novel so it's finding a way, I guess to incorporate more technology is my, sort of my last thought."

4.4.2 Effective Teaching Techniques Laurie has a "more relaxed approach" to teaching and she explains that "all of my classes are more discussion based, not really lecture." For this college-level IB Literature class Laurie mostly uses the "guide on the side" approach, which she explains as: "I let them pretty much run the class themselves and just redirect them to the appropriate topic if needed, but they're generally pretty self-driven."

This "guide on the side" approach was observed during the direct observation of the lesson. The field notes reveal that the class discussion segment of the lesson was student-directed: students sat in a circle on the large rug in the middle of the classroom. Laurie sat behind them at her desk. The discussion about the novel "The Handmaid's Tale" was relaxed and students took the initiative to comment on a classmate's perspective and/or lead the discussion towards a new direction. Laurie monitored the discussion, providing guidance when needed to ensure that the discussion stayed on the track she had chosen as the learning goal for the lesson.

Student-centered and student-directed learning were also part of Laurie's lesson plan. She describes under the instructional procedures part of her lesson plan document that two segments of the class were to be student-led:

 In groups of 3-4, students will brainstorm 2 possible thesis statements for past Paper 2 prompts as written by IBO; groups will share these theses with the class and get feedback/suggestions. Students will engage in a class discussion (student led) of the last chapters of The Handmaid's Tale.

Relying on her past three years of teaching this course Laurie describes that the students who struggle the most are the ones who "have difficulty with this level of critical thinking and discussion, especially if they are reticent by nature." She believes the biggest challenge for these students is to get "their ideas out there" orally or in writing especially if the topic at hand is "a little bit above their head or if they feel overwhelmed by talking in a group." To enroll in the two-year IB program and in the IB Literature class requires the recommendation of the content area teacher and the program coordinator, but ultimately it is a self-selected program. With regards to this Laurie believes that "the biggest difficulty is if they [students, parents, counselors] didn't choose the proper class for them."

Laurie helps the more quiet students (who she believes lack confidence) overcome their difficulty of voicing their opinion by assigning guiding questions to the class for homework. These guiding questions serve as the basis of class discussion during the following lesson and this way all students have a chance to think and prepare their answers. Laurie asks these students which question they had found interesting or thought provoking "so that they can feel comfortable giving their ides first without being overwhelmed by a bunch of different girls talking at the same time." She mentioned that while this is a positive and comfortable class environment for her students "sometimes it is difficult to hear each girl's voice individually because some tend to dominate."

A difficulty in IB Literature that affects all learners is the challenging nature of writing thesis statements for essay prompts. Laurie incorporates thesis writing practices into her lessons throughout the second semester in order to provide plenty of preparation for the IB exam at the end of the year. Thesis statements are a challenge because students need to use higher-level thinking in order to address multiple issues in each question and they have to use at least two books out of the four novels they had been taught to illustrate their answer. Here are two examples of essay prompts from the file she had shared for to provide additional information for the purposes of this research:

- Explain how the authors of at least two literary works have portrayed a social group in a particular way. How might the contexts of the authors have influenced their portrayal of these social groups?
- 2. To what extent can the meaning of a literary work change over time? How does this question apply to at least two of the works that you have read?

4.4.3 Classroom Instruction The field notes attest to Laurie's opinion of her class atmosphere being comfortable for her students. Her classroom -- being one of the corner classrooms on the third floor of the building -- is more spacious than other classrooms. It is an inviting environment with posters relating to literature and movies and quirky images of cats and cartoons. Besides the student and teacher desks, there are a couple of armchairs in a corner by the window. There is a big area rug in the center of the room. Student seating is not the traditional rows facing the Smartboard, but the two rows of student desks form a semicircle, encircling the big area rug in the middle. This space is used for class discussions or group work.

In the first segment of her teaching block Laurie asked her students to look at shared files on Google Drive and find the essay sample she had shared with them. Her students had no difficulty accessing the materials as they have been using Google Drive since the beginning of the school year. Students used their iPads as they went over the sample essay which they had to read and grade for the observed lesson. The teacher directed the discussion as they read parts of the essay together and discussed the way they graded it using the rubric provided by Laurie via Google Drive. During the lesson students were on task and focused on their learning, but they seemed to be relaxed and enjoying themselves.

One student did not bring her iPad to class but when asked how she would participate she replied that she would be listening. While her students were on task, the field notes from the direct observation reveal that the same few students participated in the discussion, while the other students were quieter.

While this first segment of the lesson was more teacher-led, during the rest of the lesson Laurie's "guide on the side approach" were observed. While her students were collaborating in assigned groups on writing thesis statements, Laurie circulated among them and asked and answered questions. When they were ready to move share their statements, students were instructed to sit in a circle on the area rug while Laurie chose to sit behind them at her desk. The groups shared their thesis and Laurie only interjected when she wanted clarification or to make sure they were meeting all the requirements of a good thesis statement. She also provided positive feedback for her students. The final segment of the lesson was a whole-class discussion about the ending of The Handmaid's Tale. Students stayed seated on the rug in the circle, and Laurie stayed behind them at her desk. Students no longer needed to be in their assigned groups as the discussion was based on individual participation. The observation notes show that students led the discussion, all waited for their turn to speak. Their behavior was very respectful.

4.4.4 IPad Use in the One-to-One Literature Classroom When asked whether the presence of the iPad has changed Laurie's teaching or teaching philosophy, she replied that "…in terms of the actual classroom teaching I'm pretty much the same." Since Laurie divides the 85-minute periods to various segments, she describes that the use of the iPad use (or when she asks her students to put it away) signals the transition from one segment into the next. She believes it helps her students focus and fully participate in that part of the class.

When they are doing the contents or notes, I let them type their notes so they know that this is like 'down to business' time and then I have them put their iPad away for class discussion so that they're present in the moment, and not maybe distracted by alerts or anything like that....

In all of Laurie's classes the iPad is mainly used as a device that facilitates file sharing with the students contributing to more efficient lesson planning and class preparation for her as a teacher. With the help of the app called Genius Scan Laurie can scan all the materials she wants to share with her students. This replaces copying pages after pages for her students. She admits that:

Things are more efficient for me to share so I spend a lot less time at the copier. I did struggle in the past without the iPad giving them enough sample work because the essays tend to be ten pages long and if I have forty students total in this course that was, ... four hundred pages of copying. So it has been a big help being able to share samples with them electronically.

4.4.4.1 File Sharing via Google Drive App Laurie and her students utilize the Google Drive app on their iPads to access class materials. She says "... with the file sharing, it's really easy to give them discussion questions and documents via Google Drive." When Laurie instructed her class to find a file in the shared Google Drive folder for their IB Literature, she modeled accessing the file on the Smartboard during the direct observation. All class materials had been shared on Google Drive since the beginning of the school year: within the class folder there were several folders organized by topics taught. It was natural for the students to use Google Drive; they accessed the file with ease and needed no help from the teacher. The only material Laurie does not like sharing with students is class notes "because I want them to reword it for themselves." Except during the winter when many school days were lost due to inclement weather she chose to share class notes directly with them. She admits "I have to be flexible sometimes, but I prefer not to."

From a pedagogical standpoint sharing materials via Google Drive allows for the purposeful and gradual dissemination of content material so her students do not feel overwhelmed by great amounts of content material. Laurie says that for the IB Literature course she did not share many samples with her students at the beginning of the year "because I didn't want them to be intimidated by what they're reading."

4.4.4.2 Apps to Increase Student Productivity Laurie and her students use two other non-content-specific apps that are beneficial for both teaching and learning in the Literature classroom. The app called Notability (or any other note taking app) has helped Laurie be more efficient during instruction because "I don't have to repeat myself as many times as I used to." Quizlet is the other app that Laurie's students use often while learning new vocabulary. Laurie says "I do the vocab orally; just say the word and definition and they... most girls put it directly into Quizlet." She finds that it is helpful as the typing increases the legibility of student writing – which is a much-appreciated added benefit for teachers of English.

Laurie finds the use of note taking apps beneficial from a teaching perspective. She wants her students to reword the class notes for themselves when they write them down. She believes her students are more efficient typing these notes using note taking apps like Notes or Notability because typing reduces the likelihood of misspelling that could occur during handwriting. Laurie knows from experience that a "lot of them have trouble keeping up when they handwrite their notes." She also sees her students use Quizlet for their vocabulary learning and Laurie thinks that app has been helpful for the same reason as the note taking apps.

4.4.4.3 Student Preference for Traditional Learning Methods Laurie shared during the interview that the class that was to be observed would have some girls using the iPad for note taking and some girls would hand write their notes. Laurie confessed that while she shares the guiding questions via Google Drive and students have it on the iPad, "a lot of girls, you'll see, prefer to have them printed out so it will be a mix if they're looking at the iPad and looking at handwritten notes." The field notes of the class observation reveal that handwriting was preferred by sixteen of the seventeen students: "Only 1 student writes the thesis on iPad using Notes app. All others write on handout from teacher."

The notion of student iPad use being a "mix" in the IB Literature class can also be seen in the students' preference for a paper copy of The Handmaid's Tale. Laurie has

allowed her students to read an electronic version of the novel and several of the students in IB Literature have the book on their iPad because they purchased the Kindle addition of the novel, but most prefer the paper copy. Laurie thinks it is a tradition to have the actual book in hand while reading when she says that "people have always been doing close reading of a novel with the novel."

Laurie has let her students use their iPads for more creative projects but she "mostly let them choose the apps themselves." She explains one such project that took place in her sophomore British Literature class:

We just did poet presentations where they had to do some sort of presentation, most of them used PowerPoint or Google Slides, and then they had to use a modern connection, they had to find videos and things like that...

The field notes show that students had no technical difficulties during the observed lesson. Student use of Google Drive seemed second-nature, they had no problem accessing drive and finding the folder. When asked if her student have any technical difficulties with the iPad she answered:

Not really. Sometimes they don't get the file [she had previously shared] for whatever reason, but then another girl will just share it. They're better at it than I am, so they haven't really needed too much help. If it's charged, that's the biggest issue, I find.

4.4.5 Challenges of the One-to-One Literature Classroom At the beginning of the interview Laurie was asked if she had any classroom management issues with the IB Literature class and she laughed and said no. When asked "What are the challenges of integrating the iPad into teaching?" Laurie replied: "I think just making sure they're

using it appropriately. I just have to trust that they're looking at what they're supposed to be looking at." She commented that she does have issues with students being off-task with the iPad. So when she answered 'no' to the initial question about classroom management, she must have understood the term 'classroom management' in the traditional sense, meaning students being disruptive, disrespectful, tardy, etc.

Laurie explains that because of the set-up of desks in the two concentric semicircles in her classroom she has trouble walking between and behind the student desks. The field notes from the direct observation show that: "One student is on iPad, does not seem to pay attention as she is doing something else on iPad. Teacher does not acknowledge. Student closes iPad after 1-2 minutes." Laurie admits she would like a method of monitoring of what the students see on their iPad when she says: "I would love some sort of program where I could guide them more directly on their iPad." Prior to working at her current job Laurie had taught in a one-to-one setting with laptops and that school used a program called DyKnow where teachers could control what was on their students' screen. Laurie found that useful because "I could actually freeze their screen, ... so I could stop at certain slides if I wanted."

What are the consequences for students being off task on their iPad? Or for students forgetting to bring their iPad to class as it was observed during the direct observation of the lesson? When Laurie asked the one student who did not bring her iPad to class how she would participate, the student said that she would try to listen and participate without using the iPad. Laurie confesses that she does not go out of her way to mete out punishment; she just tries "to let the consequences be pretty natural, so if they were on Pinterest instead of taking notes, then they don't have the notes." She admits
that she is "not hyper-vigilant" about monitoring students on their iPads. She equates being off-task on the iPad to doodling on paper instead of taking notes, so "I figure it's pretty much the same problem."

Another issue Laurie mentions to be an instructional challenge for her in the oneto-one setting is her difficulty in facilitating true student collaboration during group assignments. She discussed that she noticed that students in a group are not collaborating as a team, but completing different tasks within the assignment and at the end "pushing it all onto one file." Laurie expressed that "I wish that they would talk more about what they find as opposed to like 'I'll do slide one, you do slide two'."

4.4.6 Teacher Technology Knowledge Laurie did not specifically say during the interview that she systematically teaches technical skills to her students. The observed class was a 12th-grade course, so they have been in the one-to-one classroom setting for the past three years. It can be assumed that her students already knew about cloud computing and file sharing via Google Drive and have most likely been using Notability in other classes (since this app is one that was purchased by the school and is available to all students).

In terms of content-specific apps, Laurie admits that "I haven't really found many apps for literature that are really helpful ...yet." She adds that "my subject matter doesn't lend itself, I don't think, as much to technology use" as some other subjects. She shares her unsuccessful attempt to teach content, specifically Beowulf, with technology:

I tried to use Beowulf via Google Drive, ... because there were several different translations and I wanted the girls to be able to choose the translation they liked the best and read that version, but I couldn't get that many books. It didn't go

over that well; they didn't seem to like that as much, so I actually taught the paper copy again this year.

Laurie discussed during the interview that she does not know much about note taking and/or presentation apps on the iPad. When it comes to assigning projects, she usually lets her students choose the presentation app they want to use: "I let them choose the apps themselves, cause I'm not very good at that." When she referred to students taking notes via a note taking app during the upcoming lesson observation, she did not know which app students would use: "I'm not sure if they are going to open it in Notability or whatever, whichever app they prefer."

When asked if her students need her help using the iPad, Laurie replied: "They're better at it than I am, so they haven't really needed too much help." The only persistent technical difficulty that the entire school had been experiencing throughout the academic year was network connectivity issues due to a lightning strike to the building during the fall. Personally for herself, however, she reflected on her need for professional development on how to integrate technology more into teaching English. She said: "I just need more training; I need to find.... various apps... I just need to take time for myself to figure out what would work best."

Prior to working at her current job, Laurie worked in a high school with a one-toone program utilizing laptop computers. When asked if she would have preferred laptops over iPads in her current setting, she confidently replies yes: "I want them to type papers a lot in class, so I could read them; it's hard for me to read their handwriting sometimes. So just for MLA literature purposes a laptop would have been easier..."

4.4.7 TPACK Survey Results This survey was administered last in the data collection process so as not to influence Laurie about the purpose of the study. She rated their knowledge and confidence on a 4-point Likert scale for each of the TPACK constructs of Koehler and Mishra's (2006) framework. Calculating the average for each construct reveals that Laurie is most confident in her Pedagogical Content Knowledge (M=4.0). Table 4 shows that the next highest averages for Laurie are knowledge constructs further associated with content and pedagogy, namely Content Knowledge (M=3.83) and Pedagogical Knowledge (M=3.0). The grand average of the survey is 2.93 which is higher than the average for the items measuring his TPACK knowledge (M=2.0).

Table 1

Case 2 TPACK Survey Results

Case 2 Literature: Laurie		
PCK average	4	
CK average	3	
PK average	3	
TCK average	2	
TPK average	2	
TK average	2	
TPACK average	2	
Grand average	2	

Laurie rates her knowledge and confidence weaker in the knowledge domains associated with technology: Technological Content Knowledge (M=2.5), Technological Pedagogical Knowledge (M=2.43), Technological Knowledge (M=2.14). Table 5 shows her individual responses to each of the survey items for TPK, and Table 6 shows her responses to the survey items measuring TK. Table 2

Case 2 Self-rating of TPK Construct

TPK construct statements	Rating
I can choose technologies that enhance the teaching approaches for a lesson.	3
I can choose technologies that enhance student learning of a lesson.	3
I can adapt the use of technologies to different teaching activities.	3
I can think critically about how to use technology in the classroom.	2
I am able to facilitate my students using technology to plan and monitor their own learning.	2
I am able to facilitate my students using technology to construct different forms of knowledge representation.	2
I am able to facilitate student collaboration with each other using technology.	2

Table 3

Case 2 Self-rating of TK Construct

TPK construct statements	Rating
I can choose technologies that enhance the teaching approaches for a lesson.	3
I can choose technologies that enhance student learning of a lesson.	3
I can adapt the use of technologies to different teaching activities.	3
I can think critically about how to use technology in the classroom.	2
I am able to facilitate my students using technology to plan and monitor their own learning.	2
I am able to facilitate my students using technology to construct different forms of knowledge representation.	2
I am able to facilitate student collaboration with each other using technology.	2

Her weakest confidence level is associated with the Technological Pedagogical

Content Knowledge domain (M=2.0). Table 7 below shows the breakdown of her rating

for each survey item measuring TPACK.

Table 4

Case 2 Self-rating of TPACK Construct

TPACK construct item	Rating
I can use strategies that appropriately combine content, technologies and teaching approaches	3
I can select technologies to use in my classroom that enhance what I teach,	2
how I teach and what students learn.	_
I know how to use technology to create effective representations of content	2
L can provide leadership in helping others to coordinate the use of content	1
technologies, and teaching approaches at my school and/or district.	1

4.5 Case 3 Biology: Seth

"I think it [the iPad] made life easier -- which is something to say -- for me and for them

[the students]."

The lesson observed for this case was a freshman Honors Biology class of seventeen students. Seth describes the students in this class as high achieving and inquisitive, and he was anticipating a great deal of questions from them during the direct observation. When he compares this smaller class of students to his other two sections of Honors Biology, he says that "they get things a little bit faster, and they work more cooperatively within their group." The class is at the beginning of their unit on evolution and natural selection. The previous class was spent on providing background information on people like Charles Darwin and Alfred Russel Wallace. In the lesson observed students were to learn about Darwin's idea of natural selection, some of the conditions that were necessary for it to happen and then deepening their understanding through real-life examples.

Prior to the direct observation Steve provided a copy of the lesson plan and shared the class lecture notes the students were to annotate during the 85-minute class period of the school's block scheduling. The students were also going to use the app called Hungry Birds for the first time to learn content through gaming. In this game the students become birds who fly through virtual forests and try to 'eat' as many peppered moths as they can. Students were to gather their data from the game and collaborate on the analysis from a shared spreadsheet.

4.5.1 Lesson Planning Seth's general approach is to divide the 85-minute teaching block to distinct segments which is evident on his lesson plan document and the field notes of the direct observation. This lesson was divided into five segments: housekeeping, warm-up, lecture, activity, real world connection/reinforcement. The learning goals of the lesson align with the Next Generation Biology Standards (NGSS) and they are directly stated on Seth's lesson plan document as follows:

- HS-LS4-2: Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variations in individuals in a species due to mutations and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.
- HS-LS4-3: Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

3. HS-LS4-4: Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

Seth discussed that his main objective is the last one on this list. Seth explained that the overall goal of this unit on natural selection and evolution is that the students understand how natural selection gave rise to adaptation. Seth hoped that as the lesson progressed students would move from comprehending the concept to being able to apply it: "So we're starting off first by introducing the idea, going over the components of it, and then hopefully by the end of class they'll be able to then describe it and model it as well."

The homework assignment pushes students to go beyond comprehension and application to think critically and create an explanation for a question that can multiple answers. Seth was planning on using this assessment to measure student understanding and retention of content in preparation for teaching the next lesson of the unit.

When asked to reflect on his thinking process when planning his lesson, Seth said he thinks about the learning goals and the content material to teach. The learning goal is the most important, as he believes "There are many different ways to get to the goal and I guess I can change ...how I teach it, based on whether or not they're getting the goals." When asked to rank content, goals, pedagogy and technology in order of importance when it comes to planning lessons, Seth ranked them as follows:

1. goals

- 2. content
- 3. pedagogy

4. technology

He explained how this applies to the lesson of the direct observation:

So ... they get the idea how natural selection works, if they can get that, that's my goal, if they can apply that to any situation....In order to achieve those goals, content and pedagogy probably go together....You know content is very important, so ... that might be second there if I have to pick one.

He mentions with a laugh that although he is a "huge fan" of technology, he still would rank technology last on the list "because you can get there [achieve goals] other ways if you need to." Seth says that technology provides a support to reaching the learning goals, teaching content and choosing instructional methods. Seth has taught this content before, and he admits that he could teach it without technology, but "the technology helps that it's a little boost. ... I think it helps them get it [content] faster, so that you cover more material quicker."

4.5.2 Hungry Birds App This app models the process of natural selection in a quick and straightforward game that can be played in just a few minutes with one round of the game taking just sixty seconds. Seth is integrating the app into the teaching and learning process for the first time for his Honors Biology students, "so it's a new adventure." He taught natural selection without the app in the past years using many visual examples of peppered moths in his class notes. Hungry Birds also features peppered moths, so Seth thought it would be easy to incorporate the app into his lesson. After a few run-through trials of the app, he realized how easy it is to use:

So the reason I'm pretty comfortable using it today is the fact that it's the only function...the purpose is just to touch on moths which is great for this single

use...It's very linear, so there is no other option besides once you press start you fly through [a virtual forest], and when you are done it gives you data and asks you if you wanna start again.

Hungry Birds might seem "a kind of attention-getter" at first; however, Seth believes that playing the game will facilitate a deeper understanding of natural selection. Seth hopes his students will take away that "organisms that are more... camouflaged into their surroundings will be eaten less. And that camouflage is due to natural variation and then we'll talk about natural selection over time." Seth likes the idea of teaching this content with this app because it provides a hands-on experience for his students:

Instead of me telling them that 'Birds will eat moths that don't blend into their environment', they become the bird and they can see it. So they are not taking my word for it... it's them doing something and getting data back that they did it."

Seth had not tell his students in advance about the game, he wanted it to be a surprise: "I didn't tell them yesterday to download it because then they'll be playing with it, and I wanted it to be kind of a surprise and more of a controlled experiment where they don't know what to expect."

When asked what would happen if for some unforeseen reason (for instance, network issues) students cannot download the app, Seth did not seem to worry as he replied: "You know what; I'd have to go back to what I did last year." He described that the lesson than would be more lecture-based with visuals on his presentation and more class discussion with guiding questions.

I would have the pictures of the moths themselves, you know, because there were two variations of the moths, naturally they've varied from a very dark-color peppered to a very light whitish ... peppered. And we talk about Industrial Revolution, bringing the carbon pollution in and how the trees had become darker and you just ... brainstorm, just shoot back and forth...

Seth also believes that technology not only assists him in teaching this content, but the presence of the iPad and using an app like Hungry Birds provides a 'boost' -- an additional motivation to learn -- for some students. "I could do this without technology... it might take longer, it might take longer for certain individuals, I think the tech helps that it's a little boost.

4.5.3 Effective Teaching Techniques When asked to describe his teaching philosophy, Seth admitted that "it's hard to say." After some thinking he said he likes to encourage discussion-based learning where he can demonstrate the relevance of biology using real life examples and analogies. He added that "you can't just teach the content, it becomes boring." He wants his students to go beyond memorizing and the scientific process and be able to apply it in life. Specifically, with the concept of natural selection, Seth says: "I don't care that they'll remember about how certain species have evolved and adapted, it's the process. So that they get the idea how natural selection works, if they can get that, that's my goal, if they can apply that to any situation." To be able to move beyond comprehension of content to application, evaluation, and synthesis, Seth plans in-class activities involving research, then graphing, interpreting, and analyzing its data. Seth encourages his students to engage in scientific and critical thinking "so they have to use the data to then make connections to the future and to the past"

Seth likes to think about the lecture segment of his lessons as guided discussion: "I have all the slides with words on it so the girls who miss class can read it and get the material, but I never read directly from it. We talk about it." Guided discussion was part of the lesson plan documentation under instructional implementation during the various segments of the lesson:

- 1. In the warm-up segment: "Before starting the new topic, the following questions will be discussed as a class to review previous material."
- In the lecture segment: "A discussion on the process of natural selection will take place using the slides as visual references and attention getters."
- In the activity segment: "While looking at the class data, a short discussion will take place about how natural selection was demonstrated in the game [Hungry Birds]...."

The field notes from the direct observation indicate that during the presentation of the new content material (concept of natural selection) Seth called attention to particular slides, asked guiding questions which seemed to help students pay attention, stay on task and jot down important concepts. Seth wants his students to be engaged during these guided lectures. He shared that while students view class notes from the Smartboard, he wants them to be engaged by taking notes (by hand or on the iPad) or annotating the class notes he had shared with them. He believes that this Socrative-type questioning leads to student learning opportunities and teachable moments: "…in some instances I do like them to raise their hands, but sometimes when the question strikes them, I like them to ask and then we build discussion on it."

Seth likes to connect content learning to the real world to show the importance of biology in daily life and also provide motivation for learning. Seth also knows from experience that "You have to take your time and you have to use examples that are relevant to them." The use of visually interesting organisms, such as the brightly-colored dart frogs also captures the students' attention. With the unit of natural selection and evolution Seth included a connection to human evolution as well to show "how it's affected their lives ...things like skin color, lactose tolerance, and things that they really can relate to." Using real-world examples and "creating analogies that makes sense to them allows them to use what they already know and build upon that, and add a new concept."

Seth has learned that he has to be flexible when it comes to teaching biology because some content material can be a challenge for the students. Relying on his eight years of experience, he admits that sometimes he has to adjust his lesson plans on the go, but it has become second-nature to him because "teaching long enough, …you can move around and play around." When his students have difficulty learning content material, Seth admits that "it is a lot of on-the-spot... lesson planning" and "very quick thinking sometimes." While he knows from past experience when and where he can anticipate student difficulties, he says that "you can never predict... their misconceptions."

The greatest student difficulty learning about natural selection and evolution is to overcome what the students had learned in elementary school. Seth believes these concepts are sometimes misunderstood and taught incorrectly by grade school teachers:

A lot of students think that there is a direction that evolution works towards, that it works towards perfection. So they have this idea that evolution is a linear process in which one thing becomes another and not a tree-processing in which one species can give rise to others.

Seth believes a good teaching strategy to clear up student misunderstandings is to scaffold content learning in the form of questioning and checking for understanding in the form of brief formative assessments during the unit. Another effective technique is to slow down the pace of learning which can be a challenge for the teacher who is pressed for time and has curricular demands to meet: "the hard part is … you have to go very slow, piece by piece, so it's more like a checklist" to get feedback on student learning.

4.5.4 Classroom Instruction The field notes indicate that the Honors Biology class atmosphere was relaxed; the freshmen students seemed to feel comfortable asking questions, helping each other and moving about the classroom. They seemed to be engaged in the process of learning during the entire period.

The five different segments of the 85-minute lesson (housekeeping, warm-up, lecture, activity, real world connection/reinforcement) described in Seth's lesson plan document were easy to observe during the direct observation. Seth spent a few minutes taking attendance and giving time for the students to find and download the Hungry Birds app from the app store. The warm-up part of the class consisted of a quick five-minute review of the previous class materials. Seth then proceeded to teach the new content material in the form of a guided lecture. The field notes indicate that this segment took about twenty minutes. Students were instructed to open the shared notes from Google Drive. Starting class this way is a daily "standard procedure" in his class. The field notes indicate that students had no trouble following the teacher's direction about finding the correct class folder in the shared file on Google Drive. Students were paying attention to the teacher-led lecture and annotated the shared presentation with their own

notes and highlights. Two students were observed taking hand-written notes while viewing the class notes on their iPad.

Seth's guided discussion was observed during the entire 85-minute class. The field notes indicate that Seth seemed to be confident and very enthusiastic about biology. Seth called attention to a particular slide with the important concept of "natural variation" and asked the students to highlight that. His guiding questions also helped students pay attention and stay on task.

The Google Slides presentation was visually appealing with lots of pictures and attention-getting facts and figures. Seth's real-world examples also held the interest of his students. He told the class that octopus can have tens of thousands of offspring and from this large number only one will survive. Seth mentioned during the interview that he jokingly uses this analogy in class to clarify the concept of natural selection:

If you and your friend are being chased by a bear, you don't have to run faster than the bear, you just gotta run faster than your friend. There is no sense in running twice as fast as your friend, but *just enough* [emphasis] is good enough.

The next segment of the lesson was the activity using the Hungry Birds app. Field notes show that this segment took about twenty minutes. Seth gave clear and succinct directions to set-up the activity. Students were to open the app and take out a piece of paper. Teacher's preparedness with Hungry Birds and his Technological Knowledge (TK) was observed when he instructed the students to "turn on 'brightness' as high as you can." Seth wanted all students to start at the same time, and asked them to stop and listen to his directions on how to play game. He firmly asked the students who had started playing to pause the game. Students were to play the game three times, each time writing down the data (how many moths they had eaten). Field notes indicate that students were on task and seemed to enjoy the game. There was a slight chatter while playing game as students shared their enjoyment or frustration of not being able to catch enough moths. Seth walked around, helped if needed and asked students to let him know when they were finished.

Working together, students recorded their averaged data on Seth's pre-made Google spreadsheet that he had shared with the class. The spreadsheet from his desktop computer was projected onto the Smartboard. Some students did not have the Google Sheets app on their iPad and Seth's Technological Knowledge (TK) and "quick thinking" he has referred to during the interview was evident when he offered the alternative for the students to go up to his desktop computer and type in the data. The data then could be viewed as a graph to show the number of moths eaten in the 'light' forest versus the 'dark' forest.

At the conclusion of the activity, Seth interpreted the graph from the Smartboard. The conclusion of this hands-on student activity was teacher-directed. Seth did not ask the students what they have discovered, he simply told them that due to adaptation the dark moths blended into dark forest and the light moths blended into light forest. The fact that the students were deprived of reaching these conclusions seems contradictory to his teaching style and his want to facilitate critical and scientific thinking.

The lesson plan documentation indicates that the next segment planned was a reinforcement activity. Seth decided to forgo this segment altogether although there was still twenty-five minutes of class time left. Seth changed his original plan to allow the students to cooperate on the homework instead. He instructed the class to open a shared

Google Document called "Natural Selection - Impostors!" Students could work with a partner to get started on this, but they had to write their own answer and turn in an individual assignment. Students were observed to be on task, talking with their partner (mostly their neighbors) about the assignment. The assignment required critical thinking, and student thinking was guided by vocabulary words (concepts) to keep in mind.

4.5.5 IPad Use in the One-to-One Biology Classroom Seth and his students most frequently use Google apps, such as Classroom, Drive, Slides, and Sheets in his classes. Google Drive contains the folders and files with the shared class materials and in conjunction with Google Classroom, which has the homework assignment, these two apps get utilized daily.

Seth has been using Google Drive for the past three years, but he has only started using Google Classroom when it became available at the beginning of the school year. He plans to integrate it more into his instruction in the future as he says:

This year I just use it as a place to assign and collect class work, as well as a place to leave a few general announcements. While I do collect the work in Classroom, I don't use the grading feature in the app. I will open their assignments and read them digitally, sometimes leaving comments right in their work, and then enter grades in PowerSchool.

Seth mentions that he can check Google Classroom anytime and from anywhere: "I could grade from my phone in fact, … and I can give feedback." He adds that he has set up a Google website for his class at the beginning of the year with the hope of using it, but "as soon as Classroom became available I stopped using it." He admits he would

like to start a website maybe the following school year, but fears that the process of maintaining it could become time consuming.

Seth uses the Google Slides app to put together his class notes. He used to Microsoft PowerPoints, but he has converted those to Google Slides: a format more accessible to students with iPads. Seth is familiar with the Google Slides app to the point of being aware of the app's limitations and having the ability to circumvent them. He makes his class presentations on his desktop computer because he knows that the app only allows him to input text and not visuals onto the slides. He especially finds this limiting when assigning student presentations and his students cannot use the Google Slides app on their iPad. When Seth engages his students in in-class research, they use the Google Sheets app for data presentation and interpretation. He has been using this app more this school year than in the past two years of his teaching with the iPad. He enjoys using the app because it saves instructional time and leads to more accurate data presentation:

You can do on paper, but ... it's very time-consuming to do that. And trying to do a trend line ... it is all subjective on paper, but it is very objective on [the iPad], when you say trend line, it does all the math for you.

In his Environmental Biology class Seth recently assigned researching the average temperatures for the past sixty years for the day of the individual students' birthdays. Seth had created the Google Sheet that would graph the data to save time, but the students had to input their data into the spreadsheet. Looking at their results they were able to draw conclusions about global warming. Seth added that choosing to look up

temperatures on their birthdays made it "personal to them .., plus they can't cheat because there aren't the same birthdays."

Similarly to Google Slides, Seth is aware of the limitations of the Google Sheets app. For instance, the app does not support graphs, but Seth is hopeful that someday it will. Seth once shows his confidence in his Technological Knowledge (TK) when he discusses how he circumvents this issue:

They can put in their data, the numbers, then I take their data because we are all sharing it [the file] together, I can throw it up on the Smartboard and then we can look at each individual person's data as a class.

Seth finds that he has been incorporating the iPad more and more into his teaching with each passing year spent in the one-to-one classroom. Seth has discussed at length how his teaching has changed (and continues to change) due to the presence of the iPad. He also mentioned that the one-to-one classroom might lead to increased student learning.

"I think it [the iPad] made life easier -- which is something to say -- for me and for them [the students]." When asked whether or not his teaching style has changed, he admitted that it had changed "a little bit." He describes what he means:

So you can have more of these spontaneous learning events ... Now I can say, 'Let's find out! Everyone, google it real quick and let's look at our sources, find out and we can discuss it'.... so my strategy has changed more to... it's a little more open now where we can take time for that and get the answer really quickly. Seth mentions that prior to his one-to-one classroom he had to plan in advance

when he wanted his students to conduct an Internet research: "you'd have to have a

laptop cart, so you had to get it, bring it up [to his second floor classroom], plan it..." He said that for a quick game like Hungry Birds it would not even be worth the time to take his students to the resource center.

Seth had also noticed that his perception of utilizing instructional time has changed as well. The setting up of a one-to-one classroom is time consuming, but Seth believes it is worth the effort. While on the one hand he admits that teaching with technology takes more time, on the other hand he has been finding himself with *extra* instructional time towards the end of the school year (regardless of the unusually large number of calamity days experienced by the school during the past two years). He explains that teaching a technical skill of using an app "might cut out twenty minutes of your day [class time]", but he believes that teaching with the iPad "helps them [students] get it [content] faster, so that you cover more material." Using the app Hungry Birds in Honors Biology is a quick and effective way to reinforce content learning because "we can be done with this game in five minutes if you need to be", but Seth hopes that his students go back and play Hungry Birds outside of class time and that "it [content] might stick."

Since students turn in their assignments electronically, Seth does not have to use valuable instructional time on handing back student papers – thus having more time for teaching and learning. Seth further enumerates the benefits of electronic assignment turn-in:

- 1. I don't have to take a bunch of papers home.
- 2. I could grade from my phone, ... and I can give feedback.

- I have more assignments done because it's easier for them to do [electronically].
- 4. It is easier to be accountable between me and the students because it [the assignment] is either there [on Google Classroom] or it's not.
- 5. The girls like it as well because they don't have a lot of papers to carry around.

When asked whether or not the iPad had led to increased student learning, he confesses that it is hard to measure because "every year you have the iPad you try new things, and so I can't compare this year to last year." He thinks that the average tests scores might show a slight increase, but "I don't know if we can attribute that directly to technology."

4.5.6 Challenges of the One-to-One Biology Classroom Seth has learned that "when you give them an iPad, you give them a connection to the Internet; you give then an open connection, an access to the world which involves websites you don't want them to go to." To ensure that his students stay on-task, Seth moves around while he teaches. Seth was observed walking around during class quite a bit – as a matter of fact, he did not sit down at his desk at all – to check if the students were on task with their iPad, but also to guide student learning: "I try to walk around as much as I can, but you could see some of the girls would have games and stuff open."

Over the past three years Seth has learned cues from his students that would indicate them being off-task with the iPad. By interpreting his students' body language he can tell whether his students are on Pinterest (the only social media not blocked) or in their Photo app. During the interview he laughs when he mentions that he can tell "what finger swipes are what." He says when he sees a student constantly scrolling with her thumb, he knows she is on Pinterest instead of looking at Seth's class notes: "My notes aren't that elaborate, so there's no reason to be scrolling like crazy..." In addition, "there's no reason to be swiping like crazy either" which is an indication of a student looking at photographs in rapid succession on her Photo app. Seth has learned that a student with a "tilted chin" is most likely looking at her cell phone in her lap, a device that should be off and in the student's locker during school hours.

Seth admits it is "fun to be able to figure out those patterns", but he has implemented some disciplinary measures for these types of student behaviors. Interestingly, his discipline measures are different for freshmen- and junior/senior-level students. When it comes to his senior students he admits that "I let them go sometimes ... and then when they fall on their rear, I come back and say ... 'Maybe you should make better choices next time'.' He noticed that "it is pretty obvious when test time comes around and who doesn't know their stuff." He knows that his seniors are soon to be college students "with the autonomy to do whatever they want in class", however, right now they are still in high school and "they're still not mature enough to know to make the right decision" about properly using the iPad in class. Seth holds the view that he, as their teacher, has the responsibility to ensure that his students learn the content.

In his freshmen classes Seth has stronger disciplinary actions in place. He does not want students to be off task: "I don't allow it there." When he sees a student being off-task with a game, he comes over and helps the student close it. If the behavior persists over time Seth would have a discussion with the student or ultimately the student

could lose the iPad privilege. Seth says that "I haven't had to take it away from any girls yet this year, but had to have a conversation with a couple of them." Most of the time a gentle reminder is enough for his freshmen: "You know, you were using it earlier, you know, it was not the appropriate time, let's make sure, we focus on the task at hand."

4.5.7 Teacher Technology Knowledge During the interview Seth has talked at length about his experience in the one-to-one classroom, the advantages and disadvantages of the iPad, advantages of Chromebooks, the fragmented nature of technology use school wide, and the challenge of finding a balance when filtering content.

Seth does not believe school-wide technical issues pose a problem for his teaching. He did mention the network connectivity issues with the incident of a lightning strike to the building at the beginning of the school year. Since then he has experienced network problems maybe "less than a dozen times" during the rest of the school year. He says with a tongue-in-cheek that "connecting to Wi-Fi is always fun", but he knows how to work around these difficulties and not cut technology out of the lesson:

Sometimes I just said, "You know what, I'm gonna pull it up on my iPad", and I just screen-casted it. If it wasn't downloading for example, I'd screencast it on the Smartboard. If there is a desktop alternative, I would pull it up on my desktop and we would just talk through it as a class.

When asked about the challenges of integrating the iPad into the teaching and learning process, he laughed when he said about the device that "It doesn't do everything we need it to do." He acknowledged the many pluses of using a mobile device in the classroom. He considered the iPad's portability, the touchscreen feature and integrated keyboard and less breakable parts as well as Apple's support system to be pluses of the device. He also mentioned the myriad of learning apps available for the various content areas. He thinks the iPad has a good appeal when marketing a one-to-one school.

In Seth's view whatever devices a school chooses for their one-to-one program, they are "getting into an ecosystem that you are stuck with." Seth's biggest complaint about mobile devices is that "everything is in beta": apps, such as Google apps, have not been fully developed for mobile devices. He adds that "it's not so much on the iPad, it's development all around." As he mentioned before, the Google Sheets app does not have the graphing capability, Google Slides only allow texts and no images, and the "Google Classroom app is awesome but ...it doesn't have all the options that you would like to have." Another complaint of Seth's is that "iPads don't do flash, so they're very difficult to use" in teaching biology. He knows some good quality websites that run simulations that would be beneficial for student learning. In sum he thinks "there's more limitation with the iPad than there is with a Chromebook, because everything is kinda designed for web browsers..."

Because of this "fragmented" nature of app development for mobile devices, Seth believes that it is a challenge for the school to find some common ground and ensure that teachers and students are using the same apps. He knows his students are using various apps, for instance for note taking or presentations, based on what they prefer.

When asked if he would have preferred a one-to-one classroom with a laptop or a notebook, Seth gave a definite yes and added: "...when we had a vote, I actually voted for Chromebooks...." Furthermore, "if you put them on a scale, the laptops would win,

in my content area" because "you can support html files, you can support java apps, you can support different things, flash as well."

Seth's Technological Knowledge is once again evident when he confidently elaborates on school-wide or state-wide technology issues. He believes that there is too much content that is being blocked or filtered at schools state-wide, especially when it comes to biology teaching and learning. Nothing can be researched for instance about genetic disorders, such as breast cancer (because of the word 'breast' is blocked), or hydroponics (because of the association with growing marijuana). He admits it is a challenge to find the right balance for content being blocked and not blocked, but he knows that filtering too much leads to students finding a way around. He discussed that he found out that:

Some of the girls actually found apps and set up VPNs, you know, these tunnels that they can actually connect from their iPads to their home computers, and their home computers to the internet to circumvent all of the blocks, so they can play games, ... watch movies, download apps they aren't supposed to, and go to websites that were blocked. Not that any of those websites, games, apps were inappropriate, it's just a distraction.

4.5.8 TPACK Survey Results This survey was administered last in the data collection process so as not to influence Seth about the purpose of the study. He rated his knowledge and confidence on a 4-point Likert scale for each of the TPACK constructs of Koehler and Mishra's (2006) framework. Calculating the average for each construct reveals that Seth is most confident in his knowledge and expertise in domains relating to technology. His averages were 4.0 for Technological Knowledge, Technological Content Knowledge, and Technological Pedagogical and Content Knowledge (TPACK). He also rated his Pedagogical Content Knowledge as a 4.0. Table 8 shows that the Seth's next highest averages are Content Knowledge (M=3.83) and Pedagogical Knowledge (M=3.8). The grand average of the survey is 3.87 which is lower than the average for the items measuring his TPACK knowledge (M=4.0).

Table 5

Case 3 TPACK Survey Results

Case 3 Biology: Seth	
TK average	4
PCK average	4
TCK average	4
TPACK average	4
CK average	3.8
PK average	3.8
TPK average	3.4
Grand average	3.8

Seth rates his knowledge and confidence as the weakest in the knowledge domain of Technological Pedagogical Knowledge (M=3.43). Table 9 below shows Seth's selfrating for each of the survey items.

Table 6

Case 3 Self-rating of TPK Construct

TPK construct items	Rating
I can choose technologies that enhance the teaching approaches for a lesson	3
L can choose technologies that enhance student learning of a lesson	3
I can choose technologies that emilance student rearring of a ressol.	2
own learning.	3
I am able to facilitate my students using technology to construct different forms of knowledge representation.	3
I can think critically about how to use technology in the classroom.	4
I can adapt the use of technologies to different teaching activities.	4
I am able to facilitate student collaboration with each other using technology.	4

4.6 Case 4: Ashley

"We take for granted that students know everything there is to know about how an iPad

works, but in reality that's not always true."

The lesson observed for this case was a required sophomore American History class of twenty two students (two of them were juniors). Ashley describes her class as "very mixed" with "students that really struggle and that are on the lower end, and I have students that are really high." Many students in this class are mentored students which is this school's way of identifying and offering help to students who struggle academically.

These students have a mentored study hall period built into their schedules where along with having time to study they learn study skills, and email and communication etiquette, as well. These students also often have peer tutors. So Ashley is aware that these students "don't just struggle in my class, but just kind of overall with a lot of their classes." Compared to Ashley's other classes this particular group is not very talkative, "it's kind of a quiet group." While it can be a challenge to get them to participate in class, Ashley says her students are good listeners and work well together. Prior to the direct observation, during the first part of the interview, Ashley discussed that the lesson of the direct observation is an overview of the Cold War. Students have just finished a longer unit on World War II and Ashley is using this brief, two class-period Cold War unit as a bridge to her next bigger unit, the Vietnam War. Ashley had carefully selected important concepts, events, milestones from the time period of 1945-1989 and the students were to conduct a web quest researching these selected events and answering questions on a handout.

4.6.1 Lesson Planning During the interview Ashley discussed that her goal is to make sure her students "have an understanding of how we get from the end of World War II into the Cold War." The actual instructional objectives from her lesson plan document contain these two learning goals:

- 1. Students will understand how the Cold War began and ended and will be able to explain why the U.S. was involved in Cuba, Korea, and Vietnam.
- 2. Students will be able to compare and contrast Cold War events.

The iPad, specifically an Internet browser app, such as Safari or Google Chrome was to be used during the lesson to complete the Cold War web quest. Ashley had shared the worksheet containing the questions the students have to answer after visiting the websites she had selected. The worksheet, in the form of a Microsoft Word document, was shared via Google Drive. Ashley admits she has not been using Google Drive consistently with this group of students – therefore, she anticipates some student questions about accessing the shared document or opening it in a note taking app, such as Notability: "I will have probably a few students that.... not that they're not familiar [with Google Drive or Notability], they just maybe don't use it that often. I'm sure there will

be a few questions. We'll see." She also thinks that some students could also have difficulty with carrying out the basic task of saving their worksheet and sharing it with their teacher.

The web quest is an individual assignment because Ashley wants her students to stay focused and not to be distracted. On the occasions she has referred to studentdirected learning during the interview, she described assignments that the students were working on either individually (such as the web quest) or in groups (such as the followup small group discussion about the web quest that were to take place next class). However, *what* content was to be learned and *how* were decided by Ashley. On the Cold War worksheet for the web quest, Ashley provided websites and a list of questions students needed to answer.

The lesson plan document indicates that after the completion of the web quest, "Students will meet in small groups and discuss their findings. Each group is assigned a topic they will present their findings to the class and discuss." Ashley anticipated that the web quest would take most of the class period and that this group discussion would be moved to the next class. The purpose of this group discussion is to give students a chance to reinforce content learning in a small group setting which feels less intimidating than a whole class discussion:

If they feel like it's overwhelming, if it's a lot of information to go through, or maybe they are not quite grasping... the events that are taking place, then when they talk about it amongst themselves in groups, and having that peer discussion, then that ... will help them process that information a little better.

At the end of the Cold War unit, Ashley is planning to have her students reflect on what they have learned, what they found interesting and what questions they still have about the content. The students will write their thoughts and questions on a small piece of paper Ashley calls an 'exit slip'. These exit slips give Ashley feedback about how well her students understand content before she moves onto the next unit. (Field notes show that the students in this American History course took ten minutes at the very beginning of class to complete an exit slip about World War II.)

When asked to reflect on her lesson planning process and rank the order of importance of learning goals, content material, pedagogy and technology, Ashley said without hesitation that content comes first for her since "obviously you can't teach every single thing" so she is making a selection of important events and themes that she wants her students to take away from a particular era. Content then naturally "ties into the goals. So what's my goal for teaching this particular piece of content?" Ashley's final ranking is as follows:

1. Content

- 2. Goals
- 3. Pedagogy
- 4. Technology

She considers pedagogy third on her list as it is the process by which she is going to teach the content. She believes pedagogy and technology "go hand-in-hand because part of that process then is, you know, "How can I put technology in?" She elaborates on how technology can help her carry out instruction or facilitate student learning: It ... goes with how the process will work, how am I going to teach it, or what are the things that they're going to be doing that will help them learn and meet those goal. So technology is an important piece, so I don't want to say that it's not, but I don't use it for every lesson or activity.

4.6.2 Cold War Web Quest This is the second year of Ashley using this web quest activity for content learning. She used to provide students with a packet containing reading materials and questions about the Cold war. Students had to answer the questions based on what they read in the packet. She considers the Cold War web quest a better assignment to have between her World War II unit and the following Vietnam War unit.

It is a little more interesting for them and it's ... like a scavenger hunt type of web quest, so they're having to go to certain places on the web. And I think it just makes the material stand out a little bit more instead of just, you know, answering from a reading.

Ashley is certain that the web quest has led to increased student learning: "I thought last year they retained the information better. I thought also when we'd taken the final exam in May, I found that they had a lot better retention of what we learned in this." The student worksheet that accompanies the web quest is divided into ten sections, such as "The Marshall Plan", "The Berlin Airlift", or "NASA." There are hyperlinks inserted so the students can easily connect to these websites. Ashley had carefully selected these sites to make sure they were user-friendly, "informative yet interesting and not like just reading documents." She also picked websites that were interactive, but did not require

the use of a flash player as Ashley knows that the iPads do not have flash capability. She looked for websites with pictures and other visuals to help them retain the information.

4.6.3 Effective Teaching Techniques Ashley emphasizes that using various teaching methods is effective for history teaching: "we do a little bit of traditional notes and lecture, ... a lot of group activities with that same material, ... supplemental reading, ... individual brainstorming exercises"..., and she also likes the method of chunking so students are not overwhelmed by content. These various teaching strategies reinforce content learning and lead to increased student learning.

Ashley is anticipating some of her students having difficulties with the Cold War content because "it covers a large timespan and that's why I just try to highlight particular events and information that it won't be so overwhelming." Since her students will be required to read quite a great deal of information, she thought that presenting this content in the form of a web quest is more enjoyable to the students than "when you're just giving them a reading assignment that it's a little cumbersome; some of them struggle with having that much information…"

At the start of a new unit, such as the Cold War, Ashley likes to ask her class what they know about the topic "so a direct class discussion seems to work just to … get their minds working a little bit." The lesson plan document indicates this direct discussion at the start of the observed class: "As a class (teacher led), students will engage in a class review about the end of WW2 and U.S. relations with the Soviet Union."

Ashley wants her students to complete the web quest as an individual assignment "because it is too distracting for students to work with someone or to work in a group, because they're not then concentrating and focusing." After this individual assignment,

Ashley prefers a whole class discussion to "go over some of the things that they do" and ensure that students are understanding content. Ashley believes these strategies work because: "it's repetitive, so it's like we're talking about it, they are doing something, they're discussing what they've learned, and then we're talking about it again in class as a group."

4.6.4 Classroom Instruction After completing the exit slips for the World War II unit, the lesson began with Ashley asking her students what they know about the Cold War. Students gave answers indicating that they have bits of knowledge about Cold War. Ashley then proceeded to give directions about the web quest by instructing her students to take out their iPads and look for a document on Google Drive that she had shared with them. Ashley asked her students whether they know what hyperlinks were and all affirmed that they did. She asked if they had a Wi-Fi connection and luckily, the network had no issues during this class.

After finding the shared Microsoft Word document, Ashley recommended opening it in Notability, an app all students (and teachers) have on their iPads in the school. Some students experienced a problem opening a Microsoft Word document in Notability. Others, who did open it, found out that the hyperlinks were not active through the note taking app. One student successfully opened her document in the Pages note taking app and she was making her success known to the whole class. Ashley gave directions for all students to open the document in Pages, instructing students to download the app if they did not have it.

Further student difficulties ensued when the very first hyperlink did not direct students to the website where Ashley wanted them to go. Ashley walked around and

helped several students navigate to the first website. The field notes indicate that on one occasion, Ashley took the iPad from a student to make adjustments and navigate to where student needed to be.

The field notes show that while working on the Cold War web quest "Students are engaged in task, completing it on their own. Teacher helps the few students who need help to get to websites." This activity took up the rest of the 85-minute period. Students were on task, discussing their answers to some of the questions on the handout. Ashley walked around to monitor their work and offer help if needed, but students were working independently.

4.6.5 IPad Use in the One-to-One History Classroom Ashley believes her teaching style has changed slightly because of the presence of the iPad. She had become more flexible in her teaching: "... a lot of times, especially when you are having a class discussion, that certain things just ...come up or it ... just changes the flow of what you are doing." She said that this flexibility offers more spontaneous learning moments in class:

If you kinda get on a tangent or something that is about whatever you are talking about, but not necessarily what you were gonna cover that day, and someone has a question about it, you know, I might say "Look it up!" and it's right there.

With the iPads there is no need for advanced planning so that her class can have access to a computer or the Internet. There is no need to reserve the schools' computer lab in the resource center and using up class time to take her students from her third floor classroom to the first floor or to check out a laptop cart and bring that up to the third

floor. She remembers that it used to be a challenge to plan "way in advance" and reserve the resource center because many teachers wanted to use the computer lab.

In the one-to-one classroom Ashley uses the iPad mainly for browsing the Internet. She only occasionally uses apps relating to learning or history content. She and her students use Google Drive for file sharing but not systematically in all her classes. When it comes to file sharing class materials Ashley says "I don't use that 100% of the time, I'm not a paperless classroom." However, with certain assignments, such as writing assignments, she prefers typed essays and "usually I have them do that electronically, so they are sharing those assignments with me."

Sometimes Ashley assigns her students research using a web browser app on their iPad. These research assignments that Ashley incorporates throughout the school year give her the opportunity to teach history skills to her sophomore students: "I think at that level I try to direct them and then by the end of the year they are finding those sites on their own." For her junior- and senior-level classes, she admits that she assumes "that the older girls know what a good website is for research, … in Government, I tell them they are seniors and they should understand the difference between … what's a good quality website versus what's not."

When asked about her preferring a one-to-one classroom with laptops or notebooks, she said "I don't know, I think I'm ... 50-50 on it." After taking a moment to think about this, she said that since she is using the iPad mainly for Internet browsing, it would be easier to navigate through the web using a mouse. She also thinks that that a laptop would be preferable "in terms of lessening technical difficulty at least from a software or student perspective." She mentions with a laugh that a disadvantage of a

laptop is that "you're in kind of a little box; it doesn't allow you a lot of experimentation with stuff." She admits that she likes the different apps on the iPad and "that in some ways it's a little more user-friendly that the laptop."

Ashley discussed that there are only a few students who prefer to have all their learning materials on the iPad. Ashley shares all learning materials with these students at the beginning of a new unit. These students "take everything on the iPad" from taking their notes using the Notability or the Pages app to completing Ashley's study guides for each unit.

Ashley thinks her file sharing on Google Drive helps with her students' ability to learn. She believes that students like the accessibility and the convenience of having the materials at their fingertips especially when a student is absent from class. "I feel that having something on Google Drive that they can just have at their home, puts less stress and pressure on them trying to... get a handout or something that was taken in class. ."

Ashley talked at length about students using the electronic versions of their textbooks in her American Government and Economics classes. Both textbooks are from the same publishing company and Ashley thinks these are quality products and this company "does a really great job with their e-books." These e-textbooks are userfriendly and her students like the many different features: "… you can highlight, you can make notes; it is really interactive. It also has an audio function so the students can have the text read to them." The students do not have to bring the hardcover copy of their book to class; they can just use the e-version. Ashley mentions that "some of them still bring their book to class because that's what they are used to", but she has a couple of

students that did not want a hardcover textbook issued to them at the start of the school year and they "only have e-books because that's what they wanted."

The students mainly use the book for studying outside of their class time but sometimes Ashley says they use it in class "....it usually is a reference so they can look something up, and it's convenient because the iPad's right there." Ashley believes the interactive features of the book aid her students' reading comprehension and they are more prepared for class and can increase their participation during class discussions.

The Internet research assignments her students engage in not only develops and strengthens their research skills , but Ashley says these assignments are "self-directed in a lot of ways, so they are having to think about, you know what they're doing." As group assignments they lead to student collaboration and cooperation – and they are more fun. She shares a recent example of a research assignment coupled with a creation of a presentation resembling a Facebook page.

Last week they worked on a Civil Rights movement project with a partner in which they were creating ...what we called 'Fakebook' profile page of Civil Rights either activist or leader, and they drew a name at random. And so I just gave them the parameter of "You just have to find 3 reliable sources." And so by this point in the year, since we are almost at the end of school, they know what a reliable source is. So they are looking for pictures and then information about that person, and then they are applying that onto the framework of a profile page. Like for example on Facebook you have the 'events', so on their event list it should be something that was historically accurate, so it could have been an event
that they were a part of, it could be an event that they organized and created themselves.

4.6.6 Challenges of the One-to-One History Classroom Ashley thinks one of the biggest challenges of the iPad is the problems with the school's wireless network. Similarly to the three participants in the previous cases, Ashley referred to the incident of the lightning strike at the beginning of the school year. Since she mainly uses the iPad for accessing the Internet, she says that "if you can't get wireless, … that might change what I'm doing that day." The wireless seemed to function properly in more recent times: "knock on wood, we've been successful. But, you know, that's always something we don't know until we go to do it." She confesses that "…sometimes I'm hesitant about having a lesson that's totally reliant on the iPad for those reasons because if that happens then, you have to have a backup plan." When asked if that had happened to her, she said yes and described her two backup plans:

I usually see if we can go down to the Resource Center, if that's open. And now that we have the iPads, that [the Resource Center] is more readily available so that's kinda nice in a way that that is my first backup. If that's not available then I usually have to change on the fly what we are doing.

Her second biggest challenge is the difficulties many of her students have using the various features and apps of the iPad. While a few of Ashley's students are very independent on their iPad and have the technical skills to navigate to places, many of her students do not have these skills. Some of the students "I don't feel that are extremely familiar with... they don't use Google Drive even though it's available to all students."

During the interview Ashley mentioned her worry about some of the students not even having the Google Drive app on their iPads for the direct observation although she had asked them to download it. She also knows that some of her sophomore-level students do not know how to share a file or open a document in certain apps and "I'd had to show them how to do that." The field notes indicate that the students had trouble using the Notability app to open the shared file and some had issues using the hyperlinks on the document. The field notes describe that Ashley tried to provide assistance she did not seem able to assist all who needed help. Some of the students stepped in to help each other learning how to type into the Pages app instead of Notability.

We take for granted that students know everything there is to know about how an iPad works, but in reality that's not always true. We have a lot of students that don't know what they're doing and that's time consuming.

While she does try to assist her students during class she admits that sometimes she just does not have time to do that. Assisting students with technology takes time away from content learning: "there are times where I have to step in and assist them. And usually it's simple things, but again, that's difficult when you have a big class." Ashley thinks that it would be beneficial if the school offered a mandatory iPad training seminar for students to attend either before or at the beginning of their freshman year: "… if we expect our students to be using iPads then they should at least have a basic knowledge of, specifically, … some of the apps that all of us use, like Google Drive or Notability…"

Ashley also mentions the issues she has been experiencing with classroom management since the very beginning of her one-to-one classroom. While she considers the iPads capability to take pictures and video as learning tools, she dislikes the texting

feature because "it also creates another headache that you have to watch out for." She also knows some of her students are off-task during her classes because they play games on their iPad, but she mostly complains about the texting because it "drives me nuts."

4.6.7 TPACK Survey Results This survey was administered last in the data collection process so as not to influence Ashley about the purpose of the study. She rated his knowledge and confidence on a 4-point Likert scale for each of the TPACK constructs of Koehler and Mishra's (2006) framework. Calculating the average for each construct reveals that Ashley is most confident in her Content Knowledge (M=4.0) and Pedagogical Content Knowledge (M=4.0). Ashley's next highest averages are Pedagogical Knowledge (M=3.6) and Technological Knowledge (M=3.5). Table 10 shows that the other constructs relating to the knowledge domain of technology received lower scores.

Table 7

Case 4 TPACK Survey Results

Case 4 History: Ashley	
CK average	4
PCK average	4
PK average	3.6
TK average	3.5
TCK average	3.5
TPACK average	3.2
TPK average	3.1
Grand average	3.8

Ashley rated her knowledge and confidence level the lowest in the domain of Technological Pedagogical Knowledge (M=3.1). Table 11 shows that she had consistently given herself a 'somewhat confident' rating for all items of the construct, except for "I am able to facilitate student collaboration with each other using technology"

where she rated herself as having a 'high degree of confidence'.

Table 8

Case 4 Self-rating of TPK Constructs

TPK construct items	Rating
I can choose technologies that enhance the teaching approaches for a lesson	3
I can choose technologies that enhance student learning of a lesson.	3
I am able to facilitate my students using technology to plan and monitor their	3
own learning.	
I am able to facilitate my students using technology to construct different	3
forms of knowledge representation.	
I can think critically about how to use technology in the classroom.	3
I can adapt the use of technologies to different teaching activities.	3
I am able to facilitate student collaboration with each other using technology.	4

4.7 TPACK Survey Cross-Case Analysis Table 12 below shows that all the

participants have confidence (3.6 or higher on a scale of 4.0) in their Content

Knowledge (M=3.9) and Pedagogical Knowledge (M=3.6), as well as their Pedagogical

Content Knowledge (M=3.9).

All four teachers rated their confidence levels associated with the constructs of

technology lower than any of the other constructs. Their Technology Knowledge TK,

Technological Content Knowledge (TCK), Technological pedagogical Knowledge

(TPK), and Technological Pedagogical and Content Knowledge (TPACK) levels were

lower than their CK, PK, and PCK confidence.

Table 9

TPACK Survey Averages for All Cases

TPK construct items	Rating
I can choose technologies that enhance the teaching approaches for a lesson.	3
I can choose technologies that enhance student learning of a lesson.	3
I am able to facilitate my students using technology to plan and monitor their	3

I am able to facilitate my students using technology to construct different	3
forms of knowledge representation.	
I can think critically about how to use technology in the classroom.	3
I can adapt the use of technologies to different teaching activities.	3
I am able to facilitate student collaboration with each other using technology.	4

Table 13 below depicts the group means and their standard deviation associated with each of the technology constructs. Overall, the four participants rated their Technological Content Knowledge the strongest, followed by their Technological Knowledge, and their Technological Pedagogical and Content Knowledge. The weakest confidence was shown in the area of Technological Pedagogical Knowledge with the smallest standard deviation. Koehler and Mishra (2006) define TPK as the understanding of how technology can enhance pedagogical designs and teaching strategies. However, Jaipal and Figg (2013) argue that there is a practical way TPK is utilized by teachers and they include in their concept of 'TPK-in-practice' all the practical teaching competences, such as lesson planning and preparation, classroom instruction, assessment, and classroom management.

Table 10

Technology	Group	Standard
construct	mean	deviation
TCK	3.2	0.65
TK	3.1	0.82
TPACK	3	0.83
TPK	3	0.42

Group Means and Standard Deviation

Table 14 below show how the teachers rank in their knowledge and confidence in each construct. While there is a variation in their ranking in the constructs *not including* technology (CK, PK, PCK), the ranking becomes uniform for all the constructs *including* the domain of technology with Seth exhibiting the highest level of confidence followed by Ashley, then Jeff. Laurie has the least amount of confidence in her knowledge relating to the domain of technology.

Table 11

Participant Ranking in TPACK Construct

	1	2	3	4
СК	Jeff/Ashley	Seth/Laurie	-	-
РК	Seth	Laurie/Ashley	Jeff	
PCK	Seth/Laurie/Ashley	Jeff	-	-
TK	Seth	Ashley	Jeff	Laurie
TCK	Seth	Ashley	Jeff	Laurie
TPK	Seth	Ashley	Jeff	Laurie
TPACK	Seth	Ashley	Jeff	Laurie

4.8 Overview of Chapter 5

Chapter 5 presents the discussion of the data for each case aligned with the TPACK framework and provides the answers to the research questions. The chapter will start with an individual discussion on each of the four cases, comparing and contrasting the qualitative and quantitative data findings and supporting them with findings from the literature. The individual case analyses will be followed by a cross-case analysis where the similarities and the differences of each case will be discussed and aligned with the theoretical TPACK framework and the practical TPACK-in-practice framework. The cross-case analysis also presents the answers to the research questions and the implications of this study for practicing and pre-service teachers, as well as for teacher professional development.

Chapter Five

Discussion

This chapter presents the discussion and provides the answers to the research questions on how each case is aligned with the TPACK framework. The chapter starts with an individual discussion on how the quantitative TPACK survey data supports the findings of the qualitative data for each case. Contrasting findings between the two types of data will also be discussed. Each case analysis in Chapter 4 was preceded by a quote from the participating teacher. These quotes are included at the beginning of the individual case summaries in this chapter to help illuminate the uniqueness of each case based on the individual participant's beliefs and values when it comes to teaching in a one-to-one setting.

The individual case analyses will be followed by a cross-case analysis where the similarities and the differences of the cases will be discussed and aligned with the theoretical TPACK framework and the practical TPACK-in-practice framework. The chapter ends with a concluding discussion and implications of the study for the field of educational technology, teacher professional development and one-to-one computing.

5.1 Case 1 Mathematics: Jeff

"Math is still kind of an open-ended pursuit.... My goal is to get them to appreciate geometry as a living subject...."

Jeff believes that student-centered discovery is the most effective pedagogy when teaching mathematics. It is not known whether Jeff had held this view prior to teaching in the one-to-one classroom or whether constructivism was brought about by the presence of the iPad as it was suggested by Levin and Wadmany (2006) and Ifenthaler and Schweinbenz (2013). Mueller et al. (2008) and Harris and Hofer (2011) also found that one's teaching practice could gradually change to a more student-centered one as a result of integrating technology.

There are parallels between Jeff and the reform-oriented teacher identified in Palak and Walls' (2009) study. One teacher out of the 113 studied demonstrated technology integration in a student-centered environment. The researchers explained that while this particular teacher's beliefs and technical abilities did contribute to this reformoriented teaching, it was also the contextual conditions of teaching a small group of gifted students in a high-achieving school. Jeff discussed his constructivist beliefs and the importance of facilitating student discovery as an effective method of teaching and learning. Jeff also only teaches honors, Advanced Placement and International Baccalaureate classes – all of these are for highly-motivated and advanced learners.

Jeff is very confident in his content knowledge and pedagogical skills when it comes to teaching mathematics. The quantitative survey data indicates that he rated himself most confident in his Content Knowledge domain (M=4.0). The field notes from the direct observation also show that during the lesson Jeff was very confident and comfortable teaching content. Jeff ranked his knowledge constructs associated with pedagogy the second highest, namely Pedagogical Content Kowledge (M=3.75) followed by Pedagogical Knowledge (M=3.4). The field notes from the direct observation and the interview data corroborate Jeff's pedagogical knowledge. He based his decisions about content learning and delivery, similarly to the findings of Harris and Hofer (2011) on time considerations, the depth of content coverage (this lesson was a 'wrap-up' of the

geometry unit) and his past experience. During the lesson Jeff used a variety of instructional techniques, such as modeling, guiding, and questioning to facilitate student learning.

The quantitative survey indicates that Jeff rated his confidence the weakest in the domains associated with technology. His lowest confidence rating was in his Technological Knowledge (TK=2.86), followed by his identical ratings for his Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK) and Technological Pedagogical and Content Knowledge (TPACK) (M=3.0). Koehler and Mishra (2008) define Technological Knowledge as the knowledge of using the more widely used and better known technologies. Jeff is highly confident about troubleshoot technical problems associated with hardware, and confident about addressing various computer issues relating to software. He is also confident he can assist students with technical issues. He is least confident when it comes to creating web pages or using social media.

While the TPACK survey results show that overall Jeff rated himself the least confident on constructs associated with the technology domain, the qualitative data about the observed lesson indicate that Jeff exhibited a high-degree of knowledge and confidence in the domains associated with technology. When Jeff discussed his selection of the GeoGebra app and how he planned to integrate it into his teaching it was evident that he knew how to use the app, therefore, possessing TK. He tried the app on his own and realized its user-friendly nature but also its value as a cognitive tool to help him design and deliver his lesson (Weston &Bain, 2010). He evaluated the app based on what it offered for the subject matter (TCK) and decided on best practice (TPK) during

instruction. Harris and Hofer (2011) found that if the technology affected more selfdirected and engaging learning, teachers would more likely integrate it. Jeff's Technological Knowledge of GeoGebra *facilitated* the evaluation of the app for its value to teach and learn content. The simplified steps on how Jeff had gained TPACK knowledge to integrate the iPad for this lesson would look like this:

- 1. Learn how to use GeoGebra (TK)
- 2. Evaluate GeoGebra's usefulness for content learning (TCK)
- 3. Evaluate GeoGebra's usefulness for teaching content (TPK)
- 4. Integrate GeoGebra into lesson planning and instruction (TPACK)

However, the qualitative data indicate that gaining TPACK was not a linear process for Jeff: his TK and TCK about GeoGebra developed simultaneously. Jeff played around with it "like a kid would", but he evaluated it for content and pedagogy like a teacher would. Harris and Hofer's (2011) study back up this finding as they also found that teacher's decision making on technology use based on their overall TPACK knowledge reveal that PCK, TPK, and TCK are considered concurrently, consciously judiciously and strategically. It is interesting to note this simultaneous development of TK and TCK because there is little is reported in the literature about TCK itself. One study by Graham et al. (2009) found that their participants ranked lowest in their TCK domain. The study by Harris and Hofer (2011) could report little about teachers' TCK beyond the notion that content drives the selection of technology. However, Koehler and Mishra (2008) emphasize the importance of the TCK domain. The results of this study support their argument: teachers not only need to master their subject matter, but they must have an understanding of how technology can facilitate a deeper understanding of the subject matter and lead to increased student learning (Koehler & Mishra, 2005).

The reciprocal relationship of content and technology as described by Koehler and Mishra (2005) also means that a teacher can decide *not* to use technology because it does not lead to enhanced teaching and/or student learning. Jeff does not use technology for technology's sake. When he evaluated the possibility of students creating an iMovie for this geometry unit, he said ."..there is not much point to that..." because his students learning have already happened with GeoGebra and any future use of the iPad to further teach this content .".. is not a good use of our class time." Shi and Bichelmeyer (2007) found that teachers, like Jeff, evaluate the worth of a piece of technology based on whether or not it helps with the teaching and learning process. As Adcock (2008) claims technology-assisted pedagogy depends on the teacher's understanding of what the technology can contribute to the learning environment.

While Jeff's technological Knowledge (M=2.86) is the second lowest among the four participants, he has a positive attitude about his personal explorations on the iPad and he has set personal goals for himself to improve his Technological Knowledge. This is in contrast with Hammonds et al. (2013) and Ertmer and Ottenbreit-Leftwich (2010) who explain that the low levels of technical ability could lead to a teacher's lack of self-efficacy and the development of resentment towards technology. Jeff proves quite the contrary for he has been using the iPad more and more each year in his one-to-one classroom. He has set small learning goals for himself to improve his knowledge of apps in one branch of mathematics at a time.

5.2 Case 2 Literature: Laurie

"Things [class materials] are more efficient for me to share so I spend a lot less time at the copier, but in terms of the actual classroom teaching I'm pretty much the same."

As the quote indicates Laurie values the presence of the iPad because it makes the teaching process more efficient by mostly the utilization of Google Drive for file sharing with her students. Her acknowledgments about the benefits of the iPad for her students relate to efficiency as well. Her students take less class time typing the vocabulary words into the app called Quizlet, therefore, saving instructional time. Typing lessens spelling errors and improves the legibility of student work – benefitting both teacher and students.

There is a great deal of evidence in the literature of teachers utilizing technology because it increases their productivity and leads to time-saving (Galligan et al., 2010; Gorder, 2007; Harris & Hofer, 2011; Hutchison & Reinking, 2011; Palak & Walls, 2009; Theo, 2011). By scanning documents with her iPad Laurie decreases her paper usage leading to cost savings for her school (Foote, 2012).

Since consensus does not exist in the literature on the definition of technology integration, some would consider Laurie's use of the iPad as a productivity tool (Hennessy, Ruthven & Brindley, 2005, Palak & Walls, 2009); however, others would argue that technology integration means the facilitation of student critical thinking (Lim & Khine, 2006). The latter part of Laurie's quote above indicates that Laurie does not believe she has changed her instructional methods because of being in the one-to-one classroom. Technology is not utilized to help Laurie deliver content better or to help the students have a deeper understanding of content material. She continues to rely on her

repertoire of pedagogical methods to teaching literature as she had prior to the arrival of the iPad.

Her pedagogical techniques during the observed lesson centered on her main goal of the lesson, the facilitation of critical thinking: from her students' evaluating sample essays to their writing of complex thesis statement to the class discussion on the interpretation of the ending of The Handmaid's Tale. Laurie's choice to be the "guide on the side" was also an appropriate and effective technique for facilitating student critical thinking so students drew their own conclusions about the novel and worked towards creating their own thesis statements.

On the quantitative TPACK survey Laurie rated her knowledge and confidence highest in constructs relating to pedagogy and content, namely her PCK (M=4.0), CK (M=3.83) and PK (M=3.0). Koehler and Mishra (2008) believe PCK indicate how the subject matter is transformed for the purposes of teaching. The teacher knows the best teaching methods for that particular content material. She possesses pedagogical techniques to successfully facilitate student learning. The fact that Laurie rated herself most confident in the content- and pedagogy-related knowledge domains was also evident when she discussed student difficulties with the content and the IB Literature course and how she facilitates her students overcoming these difficulties. During the interview she talked at length about issues relating to pedagogy and content and much less about the iPad and technology. Her knowledge of instruction is evident from the way she chunks the long class periods of block scheduling and even uses the iPad to signal a move from one segment of her lesson into the next. Her content knowledge is evident when she discussed the inclusion of The Handmaid's Tale over other novels into

her IB Lit curriculum. She used her content area expertise to select this particular novel so it complemented the other three literary works she has selected.

Of the technology-related knowledge domains Laurie rated herself most confident about her Technological Content Knowledge (M=2.5), but the qualitative data shed light on the fact that Laurie does not use the iPad to teach literature content. She confessed that she has not found content-specific apps and after an unsuccessful attempt to teach Beowulf via the iPad she reverted to teaching this content without technology.

Laurie's rating of her Technological Pedagogical Knowledge (M=2.43) is slightly lower than her TCK. Laurie's weak confidence in her TPK was evident during the interview when she discussed her difficulty in facilitating collaboration among her students during group assignments and her need to improve classroom management by having a school-wide iPad screen monitoring system in place. Her weak confidence rating can also be observed in her rating of the following survey items measuring TPK:

- 1. I am able to facilitate student collaboration with each other using technology.
- 2. I can think critically about how to use technology in the classroom.
- 3. I am able to facilitate my students using technology to plan and monitor their own learning.

Laurie's Technological Knowledge (M=2.14) is significantly lower than her TCK and TPK averages. The survey indicates that Laurie has a high degree of confidence using social media, but she lacks confidence assisting students with troubleshooting technical problems with their iPad and troubleshooting technical problems associated with hardware. During the interview Laurie admitted that she lets her students choose how to use the iPad for projects, because they are more knowledgeable about it than she is.

Laurie confessed that she needs to take the time to find content-specific apps and to learn more about the integrating the iPad. The research literature discusses at length that the number one reason for the lack of technology integration into the teaching and learning process is lack of time for teachers to learn how to do it (McGrath et al., 2011; Padmavathi, 2013; Vannatta & Fordham, 2014). Since Laurie owns a laptop and discussed her positive experience in being in a one-to-one setting with a laptop and her preference of it for the literature class, she might not think it a priority to invest time into learning how to integrate the iPad.

5.3 Case 3 Biology: Seth

"I think it [the iPad] made life easier -- which is something to say -- for me and for them [the students]."

This quote only partly describes how Seth views teaching and learning in his oneto-one classroom. Similarly to Laurie, Seth is using the iPad as a productivity tool to be more efficient in his teaching as he shares files with his students or facilitates the electronic turn-in of assignments. Seth enjoys the flexibility of teaching and learning in the presence of the iPad. He believes he has changed as a teacher because of teaching in a one-to-one setting. He has become more flexible in his instructional methods because there are more spontaneous teaching and learning opportunities with the iPad. He allows his students to ask questions freely during the discussion-based lessons and these moments often lead to increased student interest in the content and motivation to learn. Research by Levin and Wadmany (2006) found that teachers could experience a change in their classroom practice before they are realize a change in their educational beliefs. It is also possible that Seth's teaching practice is changing as a result of being in the one-to-one classroom (Ifenthaler & Schweinbenz, 2013).

On the quantitative TPACK survey Seth shows a high-degree of confidence in three of the four technology-related constructs, namely Technological Knowledge (M=4.0), Technological Content Knowledge (M=4.0) Technological pedagogical Content Knowledge (M=4.0). Seth is also highly confident in the Pedagogical Content Knowledge (M=4.0). His high-degree of confidence in the technology-related constructs was evident in the qualitative interview data. Seth spent a great deal of time discussing not only how he uses technology in his one-to-one classroom, but also elaborated on school-wide and state-wide issues relating to technology use of schools.

His Technological Knowledge was also evident when he gave examples of how he is able to find solutions to potential technology issues that arise during class. He can navigate the available classroom technologies, such as desktop computer, his iPad, Smartboard, and student iPads to find solutions to most technical issues. He is familiar not only with the functions of the Google apps he and his students use, but more importantly with the *limitations* of the apps. For instance, he creates Google Slides presentations on his desktop computer in order to have visuals included. He also knows the graphing limitations of the Google Sheets app and during the observed lesson he used his desktop version of Google Sheets in conjunction with having his students use their iPad google Sheets app to create graphs.

It is interesting to note that Seth rated his confidence level high on all items of the TCK and PCK domains, while his Content Knowledge confidence was slightly lower

(CK=3.83). From the six items measuring CK on the TPACK survey, Seth rated himself having a "high degree of confidence" for all statements about his subject matter knowledge except for the item "I can create materials that map to specific district/state standards." He was only "somewhat confident" with this. The lesson plan documentation, however, shows that the observed lesson was aligned with the Next Generation Biology Standards and Seth was able to discuss those during the interview. His instructional strategies during the observed lesson worked towards the facilitation of achieving those learning goals.

The lowest TPACK framework domain was Technological Pedagogical Knowledge (M=3.43) which is defined by Koehler and Mishra (2006) as the understanding of how teaching and learning is affected by the use of a piece of technology. It is in essence the enhancement of pedagogical techniques and developmentally appropriate teaching strategies via technology use. The item-by-item analysis of this TPACK construct of the survey shows that Seth rated himself "somewhat confident", but not having a "high degree of confidence" in the following areas:

- 1. I can choose technologies that enhance the teaching approaches for a lesson.
- 2. I can choose technologies that enhance student learning of a lesson.
- 3. I am able to facilitate my students using technology to plan and monitor their own learning.
- 4. I am able to facilitate my students using technology to construct different forms of knowledge representation.

Comparing the survey data to the qualitative data, specifically the interview data, it can be noted that for the lesson of the direct observation Seth exhibited a high degree of confidence in choosing the Hungry Birds app to enhance his teaching approach. It was not assessed during the observed lesson whether student learning was enhanced by playing Hungry Birds, but Seth definitely used a 'fun' approach to learning content thus resulting in his students being actively engaged and on task. The item "I am able to facilitate my students using technology to plan and monitor their own learning" also received a "somewhat confident" rating. Seth sharing materials, using Google Classroom to post assignments give students a way to plan and monitor their learning. Absent students have access to class materials, and all students can plan to turn-in assignments on time.

Why is there a discrepancy between the quantitative and qualitative data? While the various types of qualitative data collected for the selected lesson indicate that Seth displayed a high degree of confidence in all the domains of TPACK: content, pedagogical and technological knowledge, and the overlapping domains, yet he seemed less confident on the TPACK survey. The literature reveals that technology integration is very complex (Davies, 2011; Belland, 2009;) and require complex instructional and pedagogical decisions from the teacher. It is quite possible that spending three years in a one-to-one setting is not long enough of a time period – even for a teacher as tech-savvy as Seth – to exhibit a high degree of confidence in technology integration at all times. Davies (2011) discusses the three tiers of technology integration from the most basic awareness level to the adept phronesis level, but he emphasizes that technology integration is not a one-time achievement. It requires the continuing education and *re*education in the use of technology.

5.4 Case 4 History: Ashley

"We take for granted that students know everything there is to know about how an iPad works, but in reality that's not always true."

Ashley's greatest frustration with teaching in a one-to-one setting is her students not having the knowledge of how to use the iPad. As the quote indicates, she believes that teachers and administrators should not assume that if the students receive an iPad they will know how to use it. Ashley believes that there should be a basic training for all students at the freshmen level. This training should include the teaching of how to use those apps that are on all the iPads at the school, such as Google apps, like Drive and Classroom, and the note taking app called Notability.

Similarly to Seth, Ashley appreciates the spontaneous learning opportunities the iPad can create. Student questions are encouraged and the answers are just a few clicks away. Ashley and Seth noticed that student interest and motivation have increased in the presence of the iPad corroborating Foote (2012) who reported that eighty-nine percent of the students surveyed felt that they had wanted to gain deeper knowledge of the subject matter because of presence of the iPad.

The iPad is mainly used for Internet browsing and file sharing in Ashley's classes. Using the Internet was also found to be one of the main uses in the one-to-one classroom identified by the Berkshire Wireless Initiative in Maine (Bebel & Kay, 2010) and file management was identified in the South Dakota one-to-one initiative (Gorder, 2007).

The quantitative data from the online TPACK survey indicates that Ashley has a high degree of confidence in her Content Knowledge (M=4.0) and Pedagogical Content Knowledge (M=4.0). The qualitative data affirms this as Ashley has relied on her knowledge of the Cold War to create a web quest that offers a succinct overview of this time span as well as a bridge to the study of the Vietnam War. The selection of content was chosen deliberately in order to prepare students for the next unit. The qualitative data also shows Ashley's evident PCK as she confidently discussed why she chose a web quest as her instructional method. Her pedagogical decision was based on her knowledge of this particular group of students and her past experience using this activity which had led to increased student learning. She also contrasted the learning activity involving packets of reading materials before teaching with the iPad and decided that the web quest on the iPad facilitated a more interactive student learning.

Ashley rated her confidence level the second highest in her Pedagogical Knowledge (M=3.6). She rated herself having a high degree of confidence in three out of the five survey statements measuring this domain. The two that received a 'somewhat confident' rating were listed below.

- 1. I know how to adjust teaching methodology based on student performance/feedback.
- 2. I know how to organize and maintain classroom management. (All participants talked about the issue of one-to-one classroom management and it will be discussed in detail in the cross-case analysis.)

Since Ashley is less confident in her Pedagogical Knowledge than in her Content Knowledge, it is not a surprise that she rated her overall confidence level the weakest in Technological Pedagogical Knowledge (M=3.14). Ashley responded with an only 'somewhat confident' answer to six of the seven items measuring this domain. The only item receiving a high degree of confidence rating was Ashley knowing how to facilitate student collaboration using technology.

Similarly to Jeff and Laurie, Ashley rated her confidence in the technologyrelated constructs lower than in the domains of content and pedagogy, namely Technological Knowledge (M=3.57, TCK=3.5), and Technological Pedagogical Content Knowledge (M=3.25) There are many factors to consider when integrating technology. Ashley's main concerns – her larger class sizes and her students' difficulties with their iPad – have been identified in the literature by Palak and Walls (2009). They argue that these are only two of the many internal and external variables that affect teachers' perceptions and value systems when it comes to integrating technology.

Ashley is hesitant and somewhat anxious to plan an entire lesson using the iPad based on her past experience with difficulties with the school network. She experienced times when she had to use her backup plan of going to the school's resource center lab or there were times when she had to abandon the teaching with the technology altogether and change her lesson plans on the spot.

5.5 Cross-case Analysis

5.5.1 Lesson Planning Aligned with the TPACK Framework Jeff, Laurie, Seth, and Ashley consider lesson planning a routine activity based on their past experience and mainly organized and communicated by content learning goals (Harris & Hofer, 2011; John, 2006; Yinger, 1979). The reason why each participant was asked to describe their thinking process when it comes to lesson planning was to gain an insight into what teachers think about. Jaipal and Figg (2013) call this thinking process of teachers "TPACK-in-practice" to distinguish it from the theoretical explanation of Koehler and Mishra's (2006) TPACK framework. Harris and Hofer (2011) indicated that very little is revealed in the research literature about how teachers integrate digital technologies into their lesson planning.

When asked to rank the order of consideration and importance of content, goals, pedagogy and technology, all participants noted the primary importance of content and goals. Jeff and Ashley considered content more important than goals and Laurie and Seth ranked goals ahead of content. All four participants ranked pedagogy third on their list. Technology was the fourth and final item they consider when planning a lesson for their one-to-one classroom. Harris and Hofer (2009b) suggest that the selection of technological tools or technology-rich learning activities should happen *after* the curriculum-based learning goals are chosen. This indicates a move away from the 'technocentric' planning of instruction – a direction change deemed very necessary by some researchers (ChanLin, 2008; Forssell, 2012; Harris & Hofer, 2009b; Lin et al., 2013). The technology-rich learning activities – Jeff's geometry activity with GeoGebra, Seth's biology game with Hungry Birds, and Ashley's Cold War web quest – were placed into the lesson planning process *by choice* after content and learning goals were determined.

One-to-one devices as technological or productivity tools versus cognitive tools have been documented in the research literature (Hennessy, Ruthven, & Brindley, 2005; Palak & Walls, 2009; Weston & Bain, 2010). Jeff, Seth and Ashley consider the iPad a 'cognitive tool' that helps them design and deliver instruction and it contributes to

reaching their learning goals. Their use of the iPad is judicious based on careful consideration. Jeff and Ashley sometimes choose *not to integrate* when they believe content learning goals have been met. Seth acknowledges that he knows how to achieve the learning goals without the iPad, so he uses it when it adds value to the teaching and learning. Contrary to Jeff, Seth and Ashley, Laurie considers the iPad a productivity tool that increases her efficiency as a teacher, as well as makes in-class learning more efficient for students. The apps she uses relate to teacher and/or student productivity: Genius Scan app to save time copying materials, Google Drive to share files instead of preparing and distributing handouts, Notability for students to decrease errors due to handwriting.

Why did Jeff, Seth and Ashley make the choice to integrate the iPad as a cognitive tool and Laurie as a productivity tool during their lessons? Jeff took the initiative to find an alternative to the geometry PC program and Seth learned about the Hungry Birds app when it became available. Ashley had done scavenger hunt activities with her students and her knowledge of technology enabled her to design a web quest handout with hyperlinks to interactive websites. Their cases suggest that it was their Technological Content Knowledge (TCK) associated with their particular subject matter at hand that prompted them to make the choice to integrate the iPad into lessons that they could have also successfully taught without the iPad. The quantitative TPACK survey data reveal that Jeff, Seth and Ashley rated themselves more confident than Laurie in their Technological Content Knowledge. In fact Laurie's confidence level was the weakest among the participants in the other three constructs associated with technology, namely Technological Knowledge (TCK), Technological Pedagogical Knowledge (TPK)

and Technological Pedagogical and Content Knowledge (TPACK). This indicates that lower confidence levels in the domains of technology constructs make a difference in the actual way the one-to-one classroom instruction is carried out.

Jeff, Seth and Ashley indicated the pedagogy and technology 'go together' as the selection of technology influences the pedagogy in a positive way. Teachers will judge the worth of any piece of educational technology based on whether or not it will directly help students with the learning process or help teachers meet the needs of their students (Shi & Bichelmeyer, 2007). When teachers believe that technology can support learning and add value to the curriculum, they are more likely to use it (Adcock, 2008; Penuel, 2006; Teo, 2011). Harris & Hofer (2011) explain that in their study teachers' pedagogical decisions about the utility of a particular technological tool were based on whether the tool affected deeper, more self-directed and more engaging learning: in other words, teachers used the tool if they saw that it would enable them to do a better job. However, what enabled the teachers in Harris & Hofer's (2011) study to make the choice to integrate technology in the first place was their Technological Content Knowledge.

Koehler and Mishra (2005) define Technological Content Knowledge (TCK) as the *understanding* of how technology and the subject matter impact one another in a reciprocal manner. TCK-in-practice is defined by Jaipal and Figg (2013) as a type of *thinking process*, specifically "the knowledge teachers use to select and think about how to use content-appropriate technologies." (p. 218) Jeff's thinking process can be seen when he explained he wanted to incorporate the GeoGebra app into his lesson because the app helps him convey his belief and his main goal of mathematics teaching, namely that one can enjoy and derive satisfaction from mathematical experimentation and

discovery. Seth explained that integrating the Hungry Birds game would facilitate a deeper understanding of the concept of natural selection and provide hands-on learning. Ashley planned the web quest as the learning activity in her history classroom because she knew from past experience that her students retained content better.

5.5.2 One-to-One Classroom Instruction Aligned with the TPACK

Framework Koehler and Mishra (2008) argue that effective teaching with technology requires the understanding of the constructs of the TPACK framework. Both types of data indicate that that all four participants feel very confident in their Content Knowledge (M=3.92), Pedagogical Knowledge (M=3.6) and Pedagogical Content Knowledge (M=3.94). These teachers have confidence in their Content Knowledge as they welcomed student questions or encouraged class discussions during the observed lesson.

The field notes indicate their enthusiasm for their subject matter, as well. Their discussions about effective teaching techniques in their content areas reveal that each of them prefers discussion-based classes where student critical thinking is encouraged. Jeff believes the best way to make his students understand that mathematics is a process is through student-centered discovery. Seth has a similar view of biology and biology learning as well. Laurie fosters critical thinking in her higher-level IB Literature class by guiding student discussion. Ashley's approach to teaching of history is the utilization of a variety of instructional methods to help reinforce content learning. There described teaching methods were evident during the lesson observation and the field notes show that Jeff, Seth, Laurie and Ashley not only 'talk the talk', but 'walk the walk'.

The TPACK survey data show that the participants have confidence in their Technological Knowledge (M=3.14; SD=0.82) with Seth (M=4.0) then Ashley (M=3.57) being the most confident, followed by Jeff (M=2.86) and Laurie (M=2.14). Even though Jeff and Laurie rated their TK confidence the weakest of the four, the field notes show that all were confident in using their classroom technologies, such as their desktop computer, Smartboards, Elmo (Jeff), and their own iPads. Their use of Google Drive for file sharing and instructing students to access the shared materials also demonstrated that the teachers and the students in these classes use Google Drive on a regular basis. Ashley was the only teacher who anticipated problems with students accessing her shared web quest handout because she does not use Google Drive consistently in that American History class; however, the students did not encounter any difficulties.

The TPACK survey show that from all the constructs associated with the domain of technology these teachers are most confident in their Technological Content Knowledge (M=3.25, SD=0.65) with Seth (M=4.0) then Ashley (M=3.5) being the most confident, followed by Jeff (M=3.0) and Laurie (M=2.0). Laurie and her students used the iPad as a productivity tool; therefore content learning did not take place with the aid of technology, so there was no evidence of Laurie's Technological Content Knowledge during the observed lesson.

Jeff, Seth and Ashley taught content using the GeoGebra and the Hungry Birds apps, and a web quest. Their preparedness and their technical skills using the app and creating the web quest were evident in the way they incorporated these tools into their teaching. Jeff and Seth tested and learned using their apps by playing with them and Ashley had previously selected the content and she was looking for user-friendly, interesting, visually-appealing websites to link that did not require flash player.

The domain of Technological Pedagogical Knowledge (TPK) was the weakest construct for all participants on the TPACK survey (M=3.0, SD=0.42). Seth (M=3.43) and Ashley (M=3.14) still were most confident, followed by Jeff (M=3.0) and Laurie (M=2.43). However, their confidence in their pedagogy relating to the use of the iPad was observed during their lessons in the way students responded to their teaching. Jaipal and Figg's (2013) TPK-in-practice framework refers to teachers' practical competencies when it comes to their teaching with technology. These researchers have identified teacher characteristics that lead to the successful incorporation of technology into the instructional process. One such characteristic is the modeling of the technology use by the teacher and/or the students. Jeff used this technique as he modeled using GeoGebra by placing his iPad under the Elmo and projecting his work onto the Smartboard. Jeff also selected a student with exemplary work to model using GeoGebra for the whole class. Seth did not model using Hungry Birds because the game was very simple to play; instead he gave straightforward directions about how to play and how many rounds the students should play.

The field notes reveal that the class atmospheres of all participants were relaxed and students looked comfortable being there. The selection each teacher made about instructional techniques, such as grouping of their students or varying the instructional methods, resulted in student engagement in the learning tasks. Jaipal and Figg's (2013) TPK-in-practice framework identifies classroom management techniques that could enhance the teaching with technology. One such technique is using grouping techniques

that support the development of technical skills or content learning. Ashley chose to make the web quest an individual assignment because she knew her students would learn best this way. Her choice of her students working alone resulted in their full engagement in the web quest with occasionally asking each other or the teacher questions. Jeff gave his students the option to work alone or in groups, and several students chose to work by themselves. Others left their seat to interact with each other, but all were observed to be on task and engaged. Seth's use of varied instructional methods was identified by Jaipal and Figg (2013) as a successful ability to engage students with the technology during a lesson. Seth's guided discussion, the individual game of Hungry Birds, and the cooperative classwork of data input and analysis resulted in student engagement during the 85-minute period. Laurie's students were also on-task during the different segments of her lesson as well. Laurie discussed that the iPad is sometimes used to signal a move from one segment of class to the next. When Laurie instructs her students to put the device away, it is so that they can fully participate in a segment, such as a discussion.

The TPACK survey data show that the participants rated themselves 'somewhat confident' in the TPACK construct (M=3.06, SD=0.83). Seth (M=4.0) and Ashley (M=3.25) lead the way feeling most confident, followed by Jeff (M=3.0) and Laurie (M=2.0). Mishra and Koehler (2006) argue that knowledge of TPACK enables teachers to possess the following competencies:

- 1. Knowledge of how to represent concepts with technologies
- 2. Knowledge of pedagogical techniques that use technology in constructive ways to teach content
- 3. Knowledge of what makes concepts difficult or easy to learn

- 4. Knowledge of how technology can help student learning
- 5. Knowledge of students' prior knowledge
- 6. Knowledge of how technology can be used to build on existing knowledge

While only a "somewhat confident" rating in TPACK on the survey, triangulating the qualitative data indicates that all four participants displayed these competencies listed above for the lesson: from planning to actual classroom instruction. Jeff's TPACK and his student-centered teaching philosophy were evident during his instruction when he identified a student as an "expert" to whom the others could turn with their questions. Jeff used words to empower his students to be in charge of their own learning, work at their own pace, and determine when and how much help they needed from him. Seth's activity using the Hungry Birds app is a testament to his TPACK during his classroom teaching. Seth knew the game would not only get his students' attention but help learn the content of natural selection. While students were playing Hungry Birds Seth chose to walk around and monitor learning and manage the classroom. Students stayed on task and worked collaboratively as a whole class, moving to Seth's desktop to record their data and create graphs.

Ashley's TPACK was evident in her thinking process of discussing the Cold War content selection as a 'bridge' to her next unit and choosing the web quest as her instructional method based on her past experience with increased student learning. Like Jeff and Seth, Ashley also chose to move around the classroom to offer help, answer questions, and ensure students stayed on task. Laurie's students were also on task and Laurie chose to circulate among her students as well. While Laurie's use of the iPad was as a productivity tool, it was effortlessly integrated into her lesson: neither she nor her students encountered any technical challenges.

5.5.3 Changes in Teaching When Integrating the iPad

5.5.3.1 Change in Teaching Style When participants were asked whether their teaching style has changed because of the presence of the iPad, three out of the four teachers said that the iPad has affected the way they teach. The response from Seth and Ashley were similar as they discussed how they have become more flexible with their instruction. They have even used the same phrasing to describe the change that the presence of the iPad and the access to the Internet had brought on when they said that teaching in a one-to-one setting offers "more spontaneous" learning events. Reflecting on his three years in the one-to-one classroom Jeff admitted that he had been using the iPad more each year. The technology helps him reinforce his constructivist teaching philosophy and his belief about the discovery process in mathematics. Using the iPad in math – specifically the GeoGebra app – offers satisfaction and a more enjoyable way of learning that Jeff could not have achieved without the technology. He feels good about his exploration of using the iPad for instruction and he searches for quality apps on his own or networking with colleagues from the mathematics department.

Laurie was the only participants who said that having been in the one-to-one classroom setting with the iPad for the past three years did not change her teaching style. The iPad in her classroom contributes to teaching more efficiently; therefore utilizing instructional time more efficiently, as well. She explained, however, that students have become more efficient because they type their assignments in class and at home in apps that help them lessen spelling and grammatical errors.

Some studies have indicated a shift in teacher belief towards constructivism as a result of teaching with technology (Dunleavy et al., 2007; Levin & Wadmany, 2006) while Palak and Walls (2009) have found that this shift did not necessarily occur with all the participants, rather it was unique to the teacher with a reform-oriented mindset who taught gifted students. Ifenthaler and Schweinbenz (2013) claim that with persistent use and the accumulation of relevant expertise, the integration of technology could lead to a change in teacher practice and to the transformation of teachers' philosophical beliefs. Harris and Hofer (2011) and Levin and Wadmany (2006) indicate that not all teachers significantly changed their views in their studies, and caution that technology must not be viewed as a 'unitary' concept, rather an individual process or journey that is unique to each teacher. None of the studies mentioned above were longitudinal ones except for Levin and Wadmany's (2006) three-year study in a technology-rich school. Could a longer time spent in a one-to-one setting lead to a change in educational beliefs towards a more student-centered teaching philosophy?

5.5.3.2 Using Online Resources and Document Sharing Dunleavy et al. (2007) found that there is an increased capacity for networked communication and materials management in the one-to-one classroom. All four participants have been using cloud storage and document sharing via Google Drive. This makes instructional preparation more efficient as it reduces time spent on copying materials. Seth and Laurie have created folders organized by content material with class notes and handouts that they share with the students. Seth also started using Google Classroom, the learning management system Google offers. While he is only using Google Classroom to post and collect assignments online, Seth is hoping to explore its grading and other features

next year. Ashley also mentioned that she wants her students to turn in certain assignments electronically by sharing the document with her on Google Drive. The benefits of electronic assignment management was summed up by Seth when he said that he carries less papers home, has a lesser chance of misplacing them, and can even grade them from his cell phone.

Ashley and Jeff also use document sharing via Google Drive with their students which helps the students who are absent, but it also gives students 'anytime, anywhere' access to the learning materials. Seth hoped that his students go back and play Hungry Birds outside of class time and that their additional playing would reinforce content learning. Researchers found that one-to-one computing contributes to the effectiveness of the learning environment since the students have ubiquitous, 24/7 access to their device (Bebell & Kay, 2010; Dunleavy et al., 2007; Gorder, 2007; Penuel, 2006). They can consult a wide array of resources, communicate with their peers and their teachers, access teacher websites, play games, take and/or annotate notes, edit papers, etc. Ashley and Jeff discussed the use of online textbooks in their history and math classes. Jeff shared that freshmen, sophomore and junior students study from online textbooks that are shared with them via Google Drive. Ashley's students in American Government and Economics classes also read and study from user-friendly online textbooks that have many features to aid learning comprehension, such as highlighting, annotating and an audio feature where the text can be read to the learner. In the literature classroom some of Laurie's students have also opted to read an electronic version of The Handmaid's Tale on their iPad.

Dunleavy et al. (2007) discussed that teachers' and students' increased ability to access online resources is a value brought on by one-to-one computing. Access to the Internet provides students and teachers with information at their fingertips and Jeff, Seth, and Ashley encourage their students to find answers to their own questions by looking things up during class or on their own. All four participants echoed the findings of Penuel (2006) when they discussed the cumbersome nature of facilitating access to the Internet prior to their one-to-one teaching. Scheduling the computer lab in the school's resource center required very advanced planning of lessons and moving the laptop cart into the classroom from the first floor of the building to the second or third floor classrooms were a challenge and sometimes not worth the effort. Jeff said he had made the decision not to use the PC program called Sketchpad because of the time-consuming nature of facilitating computer access for the students. Penuel (2006) discussed that teachers found the logistics of the students being transferred to the computer lab cumbersome and this limited access to the computer lab has been one of the main reasons for not utilizing computers in education.

5.5.3.3 Instructional Time Utilization References to instructional time usage in the one-to-one classroom were made by all four participants; however, the literature contains little discussion on the issue. Seth, Jeff, and Laurie talked about instructional time saved because of using the iPad. The setting up of a one-to-one classroom is time consuming, as it takes time to set up Google Drive and Google Classroom, but Seth believes it is worth the effort. While on the one hand Seth admits that teaching with technology takes more time, on the other hand he has been finding himself with extra instructional time towards the end of the school year (regardless of the unusually large number of calamity

days experienced by the school during the past two years). Seth and Jeff believe it is worth spending the additional class time to teach how to use the app, like Hungry Birds and GeoGebra because they have found that their students learn content faster and are more engaged than during a more direct instruction. Laurie's technique of letting her students type their vocabulary words into Quizlet saves her instructional time because she does not have to repeat the vocabulary words as the students are more efficient typing them.

Ashley viewed instructional time use differently than the other three participants. In her case, as Palak and Walls (2009) indicate external factors, such as class size and student ability can contribute to teachers choosing *not* to integrate technology. Ashley was frustrated about the lack of technical skills among her sophomore students and the time-consuming nature of teaching technical skills to her classes. Due to her larger class sizes, she finds it a challenge to help students individually – even with minor technical issues.

5.5.3.4 Classroom Management in the One-to-One Setting During the first part of the interview when the participants discussed the lesson planning and teaching associated with the direct observation they were asked if they have any classroom management issues with the group of students in the classes. All four participants indicated that they do not. However, during the second part of the interview when they were asked to discuss their experience with teaching with the iPad, all of them shared their challenges of making sure their students stay on task with their iPad. Jeff, Seth, Laurie and Ashley are aware that their students are sometimes off-task with the iPad. Jeff and Seth admit that it is worth risking them being off-task as opposed to not using the

iPad at all. They believe that the educational benefits of teaching and learning with the iPad outweigh the risk of his students being distracted with their device.

What are the consequences for students being off task on their iPad? Laurie, Jeff and Seth talked about letting the consequences be natural, especially with junior and senior students. If the students choose to be off-task with her iPad then their grades will suffer in the long run. Seth believes, similarly to Foote (2012) that for senior students learning how to manage their device in high school could prepare them to be more responsible with it in college. However, Seth has a system of disciplinary measures in place – ranging from gentle reminder to one-on-one discussion to taking the device away – when his freshmen students misuse the iPad.

The TPACK survey shows that Seth was most confident in his Technological Pedagogical Knowledge (M=3.43) and Laurie was the least confident (M=2.43). Seth monitors student body language while on their iPad and moves around in his classroom to make sure students stay on task. Laurie discussed the difficulty of her moving around due to the set-up of desks in her classroom; however, her classroom was more spacious than Jeff's or Ashley's. It could be that the one-to-one classroom requires adjustments to the physical space and the true-and-tried set up of student desks. While Seth has developed his own classroom management techniques, Laurie wants a school-wide iPad screen monitoring system. Could the difference in Seth and Laurie's TPK confidence levels contribute to their differing beliefs and actions when it comes to one-to-one classroom management? The examination of how they rated themselves on the constructs *not* relating to technology reveals that both Seth and Laurie felt most confident in their Pedagogical Content Knowledge (M=4.0 for both), followed by their Content Knowledge (M=3.83 for both), then Pedagogical Knowledge (M=3.8 for Seth, M=3.6 for Laurie). When Laurie said she has no disciplinary issues with her students she did not consider student misuse of the iPad being part of her classroom management. Her concept of 'classroom management' is different than Seth's: in Laurie's case student not paying attention is the consequence of the *presence* of the technology in the classroom, not her lack of Pedagogical Knowledge. An indication of having the iPad *present* but not an *integral* part of teaching and learning is Laurie's view of the school-level (not her own classroom-level) solution to the iPad issue evidence by her expressed need for a school-wide iPad monitoring system.

5.6 Conclusions

In what ways is teaching with the iPad in a one-to-one classroom setting aligned with the TPACK framework? This study finds that knowledge and confidence in the TPACK constructs associated with the domain of technology are very important for integrating the iPad in the one-to-one classroom. All four participants showed a great deal of confidence in their Content Knowledge, Pedagogical Knowledge and Pedagogical Content Knowledge domains. Laurie, the participant showing the weakest confidence in the technology domains, specifically the domain of TPACK, only utilizes the iPad as a productivity tool. The other three participants, Jeff, Seth and Ashley also utilize the iPad for productivity *and* as a cognitive tool, as well. It is also interesting to note that Jeff, Seth and Ashley have noticed a change in their teaching style as a result of teaching with the iPad and Laurie is the only participant who remained the same in her pedagogy. It can be concluded from the story of Jeff, Seth and Ashley that as they incorporate the iPad as a cognitive tool, there is a change in their existing teaching practice towards a more
student-centered approach (Levin & Wadmany, 2006; Palak & Walls, 2009; Ifenthaler & Schweinbenz, 2011).

This study also shows that while having confidence in the technology domains associated with content and pedagogy may be considered an important starting point for technology integration, there are other contributing factors to a teacher's journey in his or her one-to-one classroom. The successes of integrating the iPad provide a positive reinforcement and the motivation for teachers to keep learning and exploring the constantly and rapidly growing field of technology integration. Jeff evaluated his teaching with GeoGebra as a success and Ashley knew her web quest had led to greater student learning during the past school year. Seth experienced his students having fun learning with Hungry Birds, as well. Laurie evaluated her attempt last year to teach content via the iPad as unsuccessful and for this academic year and she reverted to teaching without the device. She admitted that she has not taken the time to look for ways to integrate the iPad as a cognitive tool. Her unsuccessful attempt could also contribute to her lack of motivation to explore the utilization of the iPad in the literature classroom.

Howard (2011) conducted an interesting by bringing together the fields of risk theory and educational technology in order to explore teachers' technology-related risk perceptions. He discovered that teachers perceived the same risks associated with technology integration, such as the ability to problem-solve, *but varied in their perception of these risks*. The teachers who showed more acceptability of technologyrelated risks had higher computer-efficacy and a more positive affect towards technology. In this study, Jeff and Seth would be considered teachers who fall into this category. Conversely, Howard (2011) found that the group showing less acceptability of technology-related risks had lower computer-efficacy and a negative affect towards technology integration. They, similarly to Laurie's case, felt that it was not worth their time and frustration to change their teaching practice to incorporate technology. Ashley's feelings of anxiety about integrating the iPad can also be explained by Howard's (2011) study. Ashley's evaluation of the risk associated with iPad integration is considered *experiential evaluation* based on her personal feelings of anxiety and discomfort about using the technology (Howard, 2011). Her hesitation to integrate the iPad is not about her own pedagogical and technological knowledge – which would be considered an analytical evaluation by Howard (2011) – but her personal anxiety about possible network issues in the school and her students' lack of technical skills.

Ashley's iPad integration is also affected by other external factors identified by Kim et al. (2013) and Kirkscey (2012), and Palak and Walls (2009) such as time and class size. Due to her large class sizes and instructional time constraints, Ashley believes she does not have sufficient time to teach technology skills to her students in conjunction with teaching content.

Jeff, Seth displayed a positive attitude about teaching and learning in the one-toone classroom, because of their successful attempts of integrating the iPad. Their feelings of success motivate them to read, explore and learn about using the iPad or to set personal goals for their own professional development, like Jeff does. Both teachers admitted to using the iPad more and more each year in their classes. Therefore, teachers must possess at least a basic level of Technological Knowledge, Technological Content Knowledge and Technological Pedagogical Knowledge in order to have confidence and more importantly success in trying to integrate a mobile device like the iPad. The success generates positive attitudes and the motivation to improve one's TK, TCK and TPK. The diagram in Figure 10 below shows the cycle of continuous education necessary in order to move forward with technology integration. This diagram reinforces the conclusions made by Davies (2011) concludes that attaining technology literacy is not a one-time achievement as it requires maintenance, or the continual education and reeducation in the use of new and familiar pieces of technology.



Figure 10. Diagram of continuous technology integration depicted as a cycle to illustrate that a teacher must experience classroom success in teaching with the technology in order to recognize its value, and with a positive attitude increase one's TCK, TCK, and TPK.

As teachers experience in the one-to-one classroom grows, so should their skills of technology integration as Davies (2011) also emphasizes that becoming adept at technology integration is only possible through the application of technology in authentic situations, such as the one-to-one classroom. Davies (2011) calls this highest level the phronesis level where teachers possess sufficient levels of technology knowledge and literacy to reflect on why they choose to use – or not use – a piece of technology. At this level the teacher must clearly understand the learning task, purposefully select the technology because he or she recognizes the way the technology will facilitate the attainment of the learning goal (Davies, 2011).

While Koehler and Mishra's (2006) theoretical TPACK framework provides a description of the knowledge domains, Jaipal & Figg's (2013) practical interpretation of the framework shows the steps and characteristics leading to the phronesis level. Having TPK in theory means that the teacher has an understanding of how teaching and learning are affected by the use of a particular piece of technology and how this technology can enhance pedagogy (Koehler & Mishra, 2006). Having TCK in theory means that the teacher understands how technology and the subject matter impact one another (Koehler & Mishra, 2005). What do TPK and TCK mean in actual planning and teaching? How were these knowledge domains evident in the cases of the four participants in this study?

TPACK-in-practice model developed by Jaipal and Figg (2013) helps identify the specific teacher actions and methodologies used for successful technology integration. The list below shows what using one's TPK in the authentic one-to-one classroom settings of Jeff, Seth and Ashley mean:

- Select technology-enhanced activities based on subject matter learning outcomes and goals
- 2. Incorporate technology-enhanced activity
- 3. Build technology and content skills within the lesson

- 4. Develop technical skills in increments through content activities
- 5. Model best practice of technology use
- 6. Have students model technical skills
- Use grouping techniques to support technical skill development and content learning (Jaipal & Figg, 2013, p. 218-220).

All participants rated their confidence levels the lowest in the TPK construct among the domains relating to technology (M=3.0, SD=0.42). The TPK-in-practice component of Jaipal and Figg's (2013) TPACK-in-practice model therefore can provide specific steps to build and strengthen practicing and pre-service teachers' TPK, especially when it comes to the issue of classroom management in the one-to-one setting. The four teachers in this study are very confident in their classroom management techniques for the traditional setting and three out of the four expressed some kind of difficulties in managing the students having the device in the classroom. Another interesting finding comes from the participant's view of teaching technical skills to their students. While Jeff and Seth have systematically integrated the teaching of these skills, Ashley's case sheds light to her view of technical skills development as something to be done in a separate class and not in content area classes. Having knowledge of specific TPK-inpractice steps could provide the teacher with the confidence in classroom management, as well as the teaching of technical skills.

Similarly, the TCK of Jeff, Seth and Ashley manifested in the actions below when they discussed how they plan to integrate the iPad into their lessons.

1. Match discipline-specific tools to the content being learned

- 2. Identify technical skills needed for discipline-based tool use
- 3. Identify personal skill levels of tool use (Jaipal & Figg, 2013, p. 218).

To be able to match discipline-specific tools to the content being learned the teacher must have a basic understanding of how a particular piece of technology can aid in reaching the learning goals (Jaipal & Figg, 2013). Seth knew that using the Google Sheets app aids in generating scientific data and graphing. Jeff first introduced the basics of GeoGebra to his students, thus identifying the initial technical skills needed for tool use before moving onto the more complex functions of the app. Jeff and Seth also learned to use their content specific apps prior to integrating it into their lesson.

5.7 Implications of the Study

The implication of this multiple-case study is that practicing teachers must possess Technological Knowledge (TK) that leads to their development of Technological Content Knowledge (TCK) and Technological Pedagogical Knowledge (TPK). This is important for the design of continuing education and professional development workshops in the field of educational technology. Content-specific professional development can contribute to practicing teachers' TCK knowledge by learning about discipline-specific tools that facilitate the achievement of learning goals (Jaipal & Figg, 2013).

The professional development sessions must also provide teachers with the opportunity to have hands-on experiences with the tools in order to feel confident in their personal skills of using the tool but also to identify the technical skills needed by the students to be able to use the tools. To facilitate growth of TPK, the hands-on and

content-specific continuing education sessions must incorporate learning about how content-specific teaching methods can be enriched with technology. Research by Harris and Hofer (2009a; 2009b; 2011) can help provide learning activities and pedagogical techniques based on subject matter.

As this study suggests, the more time teachers spend in the one-to-one classroom the more they integrate the iPad, and also possibly move from iPad integration as a productivity tool toward it being used as a cognitive tool. In order to ensure that teachers continue to educate and reeducate themselves on the use of technologies, they must have experiences of success in their one-to-one classroom. This not only requires their continuing professional development, but school-level IT and educational technology support, as well as content area networking opportunities with colleagues.

For pre-service teachers and teacher training programs the implication of this study is that besides the development of the content and pedagogical constructs of the TPACK framework the constructs relating to technology, namely TK, TCK, TPK, and TPACK must be fostered in authentic settings, as well. Having experience in the one-toone college classroom they can gain insight to learning as students in one-to-one settings and could benefit from the model teaching with technology. Facilitating field experiences in one-to-one or technology-rich settings can further ensure that the educational technology experiences of student teachers parallel their pedagogical skill development.

5.8 Significance of the Study

This research study contributes to the literature on one-to-one computing in K-12 education. It was conducted in authentic classroom settings with teachers who have had

experience teaching in the traditional as well as in the one-to-one setting. While the individual cases explored teaching with the iPad in the one-to-one mathematics, literature, biology and history classrooms, the cross-case analysis contributes to the growing research literature attempting to evaluate the TPACK framework and the usability of its individual and overlapping knowledge constructs for technology integration.

This mixed-method multiple-case study sheds light on some of the ways teaching with the iPad in an authentic setting is aligned with the TPACK framework, as well as with Jaipal and Figg's (2013) more practical TPACK-in-practice framework. One significant finding of this study is that knowledge and confidence in the TPACK constructs associated with the domain of technology are important starting points for technology integration; however it is the individual teacher's day-to-day success of integrating the iPad that provides the positive reinforcement and the motivation to keep learning and exploring technology integration in the one-to-one classroom.

5.9 Limitations of the Study

This multiple-case study was conducted in an all-girl college-preparatory high school. The lessons prepared and the classes observed for three out of the four teachers were for honor students and students in the high-level International Baccalaureate program. Conducting this research with teachers teaching students in the mainstream could provide different results based on teacher experience and belief.

These participants have been colleagues of the researcher and they might have volunteered for the study possibly to showcase their utilization of the iPad or were motivated by altruism to help the researcher colleague; nevertheless, their selection from a small pool of volunteer teachers was randomized. In order to overcome researcher bias during the analysis phase, each participant was referred to by their pseudonym from the start of the data analysis process. I have applied the process of continuous self-reflection during the write-up of the data in order to avoid evaluating and assessing the instructional methods of the participants.

5.10 Recommendations for Future Research

This study aimed to explore how *teaching* in a one-to-one setting with the iPad has changed teachers' lesson planning process and classroom instruction at the high school level. Future studies could explore how middle-school and elementary school teachers' planning and instruction are aligned with the TPACK framework.

Future research studies could also investigate *learning* in a one-to-one setting with the iPad (or any other networked device). How do students, especially in the later years of K-12 schooling, view the usefulness of a mobile device and the concept of "anytime, anywhere" learning? What are the benefits and the drawbacks of learning with a networked device? More studies are needed to investigate the impact of learning in a one-to-one classroom, specifically focusing on measuring the changes in student learning in the various content areas.

Classroom management in the one-to-one setting is also worthy of further study as this study found significant differences in the participants' views and beliefs about classroom management when it came to teaching and learning with a mobile device. Since ubiquitous computing is a relatively new phenomenon, research is needed in all aspects of education pertaining to all the stakeholders – teachers, students, administrators, parents, etc. – in order to successfully move forward with authentic ways to integrate technology into the twenty-first-century school.

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Appendix A

TPACK Knowledge Survey

TPACK knowledge domains	High	Somewhat	Weak	Not at all
(will not appear on actual survey)	degree of	confident	confidence	
	confidence			
I can troubleshoot technical				
problems associated with				
hardware (e.g., network				
connections).				
I can address various				
computer issues related to				
software (e.g., downloading				
appropriate plug-ins,				
installing programs).				
I can assist students with				
troubleshooting technical				
problems with their personal				
computers.				
I am able to use t least one				
type of social media (e.g.				
Blog, Wiki, Facebook).				
I can learn technology easily.				
I am able to create web pages.				
I frequently play around with				
technology.				
I have sufficient knowledge				
about my content area.				
I think about my content area				
as a subject matter expert.				
I can create materials that map				
to specific district/state				
standards.				
I have the ability to decide on				
the scope of concepts taught				
within in my class				
I know how to plan the				
sequence of concepts taught				
within my class.				
I have the ability to develop				
deeper understanding about				
my content area.				
I can use a variety of teaching				
strategies to relate various				

concepts to students.		
I know how to adjust teaching		
methodology based on student		
performance/feedback.		
I can assess student learning		
in multiple ways.		
I can adapt my teaching style		
to different learners.		
I know how to organize and		
maintain classroom		
management.		
I can comfortably produce		
lesson plans with an		
appreciation for the topic.		
I can select effective teaching		
approaches to guide student		
thinking and learning.		
I am familiar with common		
student understandings and		
misconceptions within a topic.		
I know how to assist students		
in noticing connections		
between various concepts.		
I can use appropriate		
technologies (i.e. multimedia,		
visual demonstrations, etc.) to		
demonstrate specific concepts		
in my content area.		
I can use at least one type of		
learning management systems		
(i.e. Moodle, Google		
Classroom, Edmodo, wikis,		
etc.) to deliver instruction.		
I can choose technologies that		
ennance the teaching		
approaches for a lesson.		
anhanaa atudant laamina af a		
leasen		
Lean think aritically about		
how to use technology in the		
classroom		
L can adapt the use of		
technologies to different		
teaching activities		
icacining activities.		

I am able to facilitate my		
students to use technology to		
plan and monitor their own		
learning.		
I am able to facilitate my		
students to use technology to		
construct different forms of		
knowledge representation.		
I am able to facilitate my		
students to collaborate with		
each other using technology.		
I can use strategies that		
appropriately combine		
content, technologies and		
teaching approaches.		
I can select technologies to		
use in my classroom that		
enhance what I teach, how I		
teach and what students learn.		
I know how to use technology		
to create effective		
representations of content that		
depart from textbook		
knowledge.		
I can provide leadership in		
helping others to coordinate		
the use of content,		
technologies, and teaching		
approaches at my school		
and/or district.		