International Journal of Educational Technology and Learning
ISSN: 2523-0581
Vol. 9, No. 1, pp. 19-38, 2020
DOI: 10.20448/2003.91.19.38

Exploring 1:1 iPad Integration Practices through a TPACK-in-Practice Lens

Kristina Malik[1]
Judy Lambert[2]

[1]*Lourdes University, USA.*
Email: kmalik@lourdes.edu
[2]*University of Toledo, USA.*

Abstract

The TPACK-in-Practice framework of Jaipal and Figg (2013) provides concrete practices that exemplify successful technology integration of teachers. This framework and mixed methods were used to examine the instructional practices of four teachers in a high school where 1:1 iPad integration had been implemented. Findings revealed that three teachers were successful at exhibiting instructional practices considered essential for effective technology integration. One of the teachers, however, only used technology to improve her productivity and therefore, did not see the value in integrating technology in any substantive way in the classroom. The successful teachers transitioned to more student-centered approaches with iPads being used as cognitive tools rather than for productivity purposes only. They were more accepting of risks and became more confident and apt to experiment with a variety of iPad applications. Successful experiences with iPad integration tended to increase motivation and confidence, which led to more integration experimentation.

Keywords:
TPACK
Technology integration TPACK-in-Practice
iPads
1:1 computing.

Publisher:
Scientific Publishing Institute

Received: *3 August 2020*
Revised: *9 September 2020*
Accepted: *18 September 2020*
Published: *1 October 2020*

Funding: This study received no specific financial support.
Competing Interests: The authors declare that they have no competing interests.

1. Introduction

Since the late 1990s, many P-12 schools have implemented the integration of 1:1 (one-to-one) technologies, where all students have access to computing devices throughout the school day. These initiatives were intended to provide students with access to quality technology for learning and most importantly, to encourage teacher adoption of technology. The past three decades, researchers have examined many attitudinal and dispositional factors such as intention to use, agency, openness to change, perceived usefulness, efficacy, and pedagogical beliefs that are influential in the adoption of technology by teachers. In the last decade, many other factors such as problem-solving ability, creativity, motivation, and persistence, among other non-cognitive factors are recognized as equally important in the adoption process (Knezek & Christensen, 2018). Findings such as these have placed far less focus on teachers' attainment of technology skills and more so on their ability to integrate technology into the teaching and learning processes with content-specific pedagogical expertise. Knezek and Christensen (2018) defined technology integration as "the meaningful and effective use of technology to enhance learning in students" (p. 248). Similarly, Lambert and Ennis (2012) defined technology integration as "when teachers design experiences that require students to use technology as part of their learning activities in ways that make learning more active, collaborative, constructive, authentic, and engaging" (p. 4). Recent literature on 1:1 computing provides examples of this expansion in research focusing mainly on the technology integration of teachers.

Research on 1:1 computing has explored mainly the impact of laptops and to some extent, handheld technology devices such as tablets or cell phones (Donovan, Green, & Hansen, 2011; Ifenthaler & Schweinbenz, 2013; Inan & Lowther, 2010). This literature offers valuable insight into teachers' beliefs about using technology during classroom instruction and the resultant outcomes. First, teachers want to see the value in using 1:1 technology. When teachers believe technology can support student learning and add value to the curriculum, they are more likely to use it Adcock (2008); Theo (2011). When 1:1 technology use is perceived as misaligned with the curriculum, teachers are less likely to use it Adcock (2008); Theo (2011). This concurs with Lambert and Gong (2012) who concluded that teachers need to be persuaded of the value of using technology before they adopt its use and this can be achieved by offering training that is content-specific and meets curricular needs. Next, Howard (2011) found that while all teachers perceived some risks (e.g. ability to solve technology issues, loss of time, value to learning) when using 1:1 technology, teachers who were more accepting of risks tended to be more willing to experiment with and value technology integration. A recurring finding of 1:1 computing research is that technology-integrating teachers tend to become more constructivist and student-centered in their teaching approach (Dunleavy, Dexter, & Heinecke, 2007; Harris & Hofer, 2011; Ifenthaler & Schweinbenz, 2013; Lambert & Ennis, 2012; Lambert, Cioc, Cioc, & Sandt, 2018).

Dunleavy et al. (2007) identified other benefits of 1:1 technology integration besides transformation of one's teaching approach that include teachers' increased ability to formatively assess student learning and to individualize instruction, as well as students' increased capacity for self-guided learning. Levin and Wadmany (2006) suggested that 1:1 integration led to teachers having a greater focus on coaching, modeling, reflection and exploration. In all these studies, it is evident that when teachers make the decision to design and teach technology-integrated lessons they are not so much concerned with their technical skill level rather how their pedagogy and the curriculum is affected, as well as whether students learn when technology is included during instruction.

Typically, teachers who are not considered innovators and early adopters of technology have not had the expertise, confidence, or professional development to do what early-adopting teachers have done (Niederhauser & Lindstrom, 2018). Moreover, the rapid rate of technology change has prevented timely recommendations for innovative instructional practices and the delivery of up-to-date teacher professional development in the use and integration of 1:1 technology in the curriculum (Albion & Tondeur, 2018; Angeli & Valanides, 2018). Nonetheless, it is promising to see that technology and curriculum integration, rather than technical skills instruction, has become the primary goal of technology initiatives for teachers, resulting in the emergence of proven models of technology integration. As early as 1989, models of technology integration have been developed including the Apple Classrooms of Tomorrow (ACOT) (Dwyer, Ringstaff, & Sandholtz, 1991) Stages of Adoption of Technology (Christensen, 2002) and the Concerns-Based Adoption Model Level of Use (CBAM LoU) (George, Hall, & Stiegelbauer, 2006). Shulman (1986) on content knowledge led to the development of the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006) which describes a high-integrating teacher. Mishra and Koehler (2006) understood the importance of all factors when they developed the TPACK framework to explain the necessary components of technology integration. Harris and Hofer (2011) applied the TPACK framework to instructional planning and Jaipal and Figg (2013) extended the framework to develop the TPACK-in-Practice model to differentiate between the theory and practice of integrating technology. There is not much literature relating any of these frameworks to how practicing teachers adjust to instructional changes resulting from 1:1 computing. To close this gap, this study sought to describe the instructional planning and teaching practices of four teachers who were integrating 1:1 iPads, and to examine to what extent their teaching practices were aligned with the TPACK-in-Practice framework. Authors present and discuss their findings and provide implications for future practice.

2. Theoretical Framework

Underpinning this study was the TPACK-in-Practice framework developed by Jaipal and Figg (2013) combining the works of Koehler and Mishra (2005); Koehler and Mishra (2008) and Judi Harris and Hofer (2009a); Harris and Hofer (2009b); Harris and Hofer (2011). TPACK-in-Practice offers a way to bridge the gap between the theoretically-defined knowledge components of TPACK and the actions that demonstrate these components in practice. The Technological Pedagogical Content Knowledge (TPACK) framework, proposed by Mishra and Koehler (2006) is based on the interactions of content, pedagogy, and technology. The framework enables technology-using teachers to create "conceptually and epistemologically coherent learning environments" (p. 1034). The framework's seven knowledge domains—Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), and Technological Pedagogical Content Knowledge (TPACK)—represent a 'class' or 'system' of knowledge that is central to teachers' work with technology. According to Koehler and Mishra (2005) "True technology integration...is understanding and negotiating the relationships between these three components of knowledge" (p. 134). At the core of Koehler and Mishra's argument is that content, pedagogy and technology must be considered simultaneously since these are the integral yet overlapping elements of technology integration (Koehler & Mishra, 2005).

Jaipal and Figg (2013) TPACK-in-Practice "refers to the knowledge about how teachers think about representing content using technology in instruction" and identifies teacher actions and teacher knowledge important for successful technology-enhanced teaching (p. 216). The TPACK-in-Practice framework consists of three knowledge constructs:

1. *TPCK-in-Practice*, which is the knowledge about how to design technology-enhanced instruction for different models of teaching, such as direct instruction or problem-based learning.
2. *TCK-in-Practice*, which is the knowledge of content-appropriate technologies and teachers' ability to use the tools.
3. *TPK-in-Practice*, which is the knowledge of practical teacher competencies to plan, prepare and implement instruction (Jaipal & Figg, 2013).

TPCK-in-Practice and TCK-in-Practice can be inferred from the thinking processes of teachers while planning their instruction (Jaipal & Figg, 2013). The TPCK-in-Practice refers to designing technology-enhanced instruction for expert teaching in specific content areas (Jaipal & Figg, 2015). This is evidenced by teachers' thinking during the planning and preparation phases of TPK-in-Practice, specifically in their analysis and selection of technology-enhanced activities as well as their decision about the best way to teach and ensure that students learn the content. TCK-in-Practice also can be seen during lesson planning and preparation as teachers' knowledge and competence of content-appropriate technologies (Jaipal & Figg, 2015). During planning, teachers match or repurpose the discipline-specific technology tools to teach their content as well as identify their personal skill level with the tool along with the skills needed by students to engage successfully with the tool.

According to TPCK-in-Practice, Jaipal and Figg (2013); Jaipal and Figg (2015) identified five characteristics of planning needed for the successful design of technology-rich lessons: assessment, learning activity choices, sequencing, differentiation, and backup instruction. Knowledge of assessment refers to a teacher's ability to align the assessment and the learning activity, to create assessment instruments using technology and to use the technology to conduct the assessment (Jaipal & Figg, 2013). For learning activity choices, Jaipal and Figg (2013) relied on Harris and Hofer (2009a) list of technology-enhanced learning activity types in order to gain insight into the nature of teachers' PCK, TPK, TCK, and TPACK knowledge. Harris and Hofer (2009b) found that "By focusing first and primarily upon the content and nature of students' curriculum-based learning activities, teachers' TPACK is developed authentically, rather than technocentrically" (p. 101). Harris and Hofer (2011) also found that a teachers' main consideration was matching the learning activity to the content, followed by considerations of the learning needs of students, class time, and depth of content coverage. If a technology tool "fits" the content, teachers would use it instructionally and this "seemed to be how they [participants] consciously both conceptualized and operationalized TPACK" (Harris & Hofer, 2011).

TPK-in-Practice is reflected in concrete teacher actions such as in the selection and sequencing of technology-enhanced activities, their alignment with learning goals, and the simultaneous and incremental learning of technical and content skills (Jaipal & Figg, 2013). In the preparation phase, Jaipal and Figg (2015) identified two teacher actions for the successful implementation of a technology-enhanced lesson: practicing using the technology and collecting digital resources for instruction. Another successful teacher characteristic in the planning phase of Jaipal and Figg (2013); Jaipal and Figg (2015) TPK-in-Practice framework is differentiating instruction to accommodate the technical competencies of the students. Differentiation may include how teachers decide to introduce, chunk and/or adapt the technical skills and the learning activities. Planning for a technology-enhanced lesson must include an alternate plan without the technology or with the use of an alternate technology with the same or similar function (Jaipal & Figg, 2013).

The implementation phase of TPK-in-Practice consists of two teacher actions: the modeling of the technology use and classroom management (Jaipal & Figg, 2013). Modeling can take the forms of teachers activating student prior knowledge of 'generic' features of similar technology applications, teachers creating samples of the finished technology-enhanced product, and teacher and/or students modeling best practice for technology use (Jaipal & Figg, 2013). When teachers teach with technology, they must know how to minimize issues of classroom management that can arise due to the presence of technology. Deliberate student grouping can help with classroom management as it can facilitate a more purposeful student engagement with the technology (Jaipal & Figg, 2013). A summary of Jaipal and Figgs framework is provided in Appendix B.

The development of the TPACK-in-Practice framework contributes to the paradigm shift from "teaching the tool to thinking how to teach with the tool" (Jaipal & Figg, 2013). Harris and Hofer (2009a); Harris and Hofer (2009b); Harris and Hofer (2011) underscored this concept when they recognized that teachers' decision-making about technology use reveals that PCK, TPK, and TCK are considered concurrently, consciously, judiciously and strategically. TPACK-in-Practice provides a way to understand and examine what technology and content integration means in everyday practice. This study aimed to understand, *"In what ways is teaching with the iPad in a one-to-one classroom setting aligned with the TPACK framework?"* This main research question was examined by investigating the following specific areas:

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

C. What changes have these teachers experienced in their teaching when integrating the iPad?
D. How do teachers rate their TPACK skills associated with teaching with the iPad?

3. Method

This multiple-case qualitative research study (Yin, 2014) was conducted at an all-female faith-based, college-preparatory high school for grades 7-12 in a large urban city in the Midwest. When this study was conducted, the school employed approximately 44 teachers and was comprised of 624 students with demographics largely made up of 62% white, 19% two or more races, and 13% black students (National Center for Education Statistics, 2018). Teacher to student ratio was 14.1%. The school had been utilizing 1:1 iPads for two years. Each case was considered holistically as a single-unit of analysis.

3.1. Context and Participants

Purposive, heterogeneous sampling was used to carefully select cases in order to compare results in teachers of different content areas, teaching styles, and beliefs. Four high school teachers, one from each of the content areas of Mathematics, English Language Arts, Science and Social Studies were included as individual cases in the study. All teachers had at least five years of teaching experience prior to the school's implementation of 1:1 iPad computing and held master's degrees in education or in their particular disciplines. All participants are referred to by fictional names to protect their identities.

Case 1: Mathematics (Jeff)

Jeff held a master's degree in mathematics and mathematics education and had several articles published in Mathematics Teacher Magazine as well as the Ohio Journal of School Mathematics in the past ten years. Jeff had taught at this school for close to 20 years prior to his classroom becoming a 1:1 learning environment. He taught honors-level Geometry, Advanced Placement (AP) Calculus and an International Baccalaureate (IB) Mathematics course for junior and senior students enrolled in the school's IB Diploma Program.

Case 2: English Language Arts (Laurie)

Laurie had 10 years of teaching experience and had taught at this school for eight years. She recently completed a master's degree in literature. Laurie taught honors courses and a college-level IB Literature course for grade 12 students. Initially, Laurie taught the course without the iPad and then transitioned to a 1:1 setting during the previous two years.

Case 3: Science (Seth)

Seth held a bachelor's degree in zoology and biology and a post-baccalaureate degree in secondary education and had taught at this school for eight years. He taught honors Biology and AP Environmental Science.

Case 4: Social Studies (Ashley)

Ashley had a bachelor's degree in human resource management and a master's degree in secondary education with a 7-12 social studies license. She taught American History, Economics, and US Government at this school for the past four years.

4. Data Collection

Data collected for each of the four cases included lesson plans, recorded interviews, and direct observations of classroom instruction. Interviews included two sections: parts A and B, which were conducted either during the teacher's planning period or after school. The open-ended questions in part A of the interview inquired about instructional planning for a specific lesson where iPads were utilized as a teaching and learning tool. Part B of the interview inquired about the changes in instructional planning teachers experienced as a result of iPad integration. An 85-minute classroom lesson in which participants integrated the iPad was observed by the researcher.

4.1. Research Question A

Part A of the interview was designed to answer research question 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?* The interview questions were adapted from Harris, Grandgenett, and Hofer (2012) and Pamuk (2012) and aligned with the following TPACK elements:

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?

4.2. Research Question B

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 (2013) TPACK-in-practice model. The observation instrument, which was based on Jaipal and Figg (2013) TPK-in-practice model for planning, preparing and implementing technology-rich lessons, sought to answer research question B: *How are teachers' actual one-to-one classroom instruction aligned with the TPACK framework?* The instrument focused on the following teaching practices:

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.

4.3. Research Question C

Part B of the interview protocol, which included semi-structured and open-ended questions about the changes in instructional planning teachers experienced as a result of iPad integration, sought to answer research question C? *What changes have these teachers experienced in their teaching when integrating the iPad?* This portion of the interview, which was also adapted from Harris et al. (2012) and Pamuk (2012) included the following questions:

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?

4.4. Research Question D

The TPACK survey measured participants' TPACK knowledge (Appendix A). The survey items were adapted from the studies of Chai, Koh, and Tsai (2011) and Schmidt et al. (2010) and aimed to answer research question D, *How would you rate your confidence level associated with technology and teaching?* The purpose of the 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.

5. Data Collection

Triangulation was used to develop a comprehensive understanding of teachers' technology integration thinking processes and practices through the various sources of collected data. The cases were treated as individual units with identical methods of analysis applied to them. Qualitative analysis of research questions A, B, and C began with the process of pattern matching. Since the line of inquiry centered on exploring how teachers aligned their teaching with the TPACK-in-Practice framework, descriptive coding helped match the empirical findings to the constructs of this framework. Emerging codes were found and organized into code families to facilitate the process of explanation building and the matching of the code families to the TPACK-in-Practice framework. The two main code families were instructional planning and teaching in the 1:1 classroom. Both of these contained the sub-codes of effective teaching, 1:1 classroom management, technical skills instruction, and teacher technology knowledge. In order to analyze how teaching practices were aligned with the TPACK-in-Practice framework the code families and sub-codes were matched to the constructs of TPCK-in Practice, TCK-in-Practice, and TPK-in-Practice.

Descriptive statistics was used to analyze the survey data collected for question D. For each case, the mean score for each construct of the TPACK framework (CK, PK, TK, CPK, PCK, TPK, and TPACK) was calculated. In the cross-case analysis the mean for each construct was calculated. 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 Chai et al. (2011); Jaipal and Figg (2013); Hashim (2014); Schmidt et al. (2010).

6. Results and Discussion

6.1. TPCK-in-Practice and TCK-in-Practice: Knowledge of Design, Pedagogy, and Technology

TPCK-in-Practice and TCK-in-Practice are inferred by the thinking processes of teachers as they plan for instruction (Jaipal & Figg, 2015). During interviews, participants were asked to discuss their thinking processes as they planned their technology-integrated lessons in order to gain insights about their TPCK- and TCK-in-Practices.

According to Jeff, he had always tried to emphasize to his students that mathematics was a journey towards discovering interesting phenomena. He found it easier to convey this belief in a 1:1 classroom as illustrated by his comment, "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." Teaching in a 1:1 setting had prompted Jeff to explore iPad apps related to mathematics education on his own time. He found the GeoGebra app, an alternative to the PC geometry program Sketchpad, and decided to integrate this iPad application into his Geometry classroom instruction. While Jeff enjoyed exploring apps for education, he confessed that he used technology in his personal life only when he deemed it necessary.

While planning his technology-integrated lesson, Jeff said that he deliberately and simultaneously considered the learning goals, content, pedagogy as well as other factors, such as time constraints relating to the course scope and sequence. The semi-structured interview questions helped reveal Jeff's thinking process and decision-making about technology and content integration. Jeff selected the technology tool and the activity while reflecting on his goal for the lesson, the application and extension of previously-learned procedural knowledge. TPCK-in-Practice characteristics leading to successful lesson implementation were evident in Jeff's explanation for selecting GeoGebra: "it's difficult to convey the …enjoyment and satisfaction of experimentation and self-discovery without the use of the app …." Jeff shared that "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 displayed the TCK-in-Practice characteristics of matching a discipline-specific tool to content as well as competence with a content-appropriate technology. Jeff had tried GeoGebra and realized it was user-friendly: "I try to play … with it like a kid … and if it works easily then it seems appropriate. If it's really cumbersome then … there is this time-balance … and it may not work out in our favor." He considered GeoGebra uniquely well-made and better quality than other apps for geometry or mathematics.

Laurie explained in her interview that "all of my classes are more discussion based, not really lecture" and she mostly used the "guide on the side" approach, which she explained 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." When asked whether the presence of the iPad had changed Laurie's teaching or teaching philosophy, she replied that "…in terms of the actual classroom teaching I'm pretty much the same." In terms of content-specific apps, Laurie admitted, "I haven't really found many apps for literature that are really helpful …." She stated, "My subject matter doesn't lend itself… as much to technology use" as some other subjects. Laurie also allowed her students to choose their own preferred apps for presentations or note taking because she was not

very familiar with the features of various apps for productivity. Laurie owned a laptop and a smartphone and like Jeff, she admitted to only using technology when she needed it in her personal life.

Laurie's thinking process did not reveal any characteristics of TPCK-in-Practice or TCK-in-Practice. Laurie believed it was a challenge to teach literature with technology and she admitted not having any knowledge of content-specific apps. One year she tried sharing various translations of Beowulf via Google Drive, but it was not very successful and Laurie went back to distributing paper copies of the book to her students. Laurie revealed that she did not know much about note taking or presentation apps. She let her students choose the presentation app for a project as she confessed, "I'm not very good at that." When she referred to students using a note taking app during the lesson, she did not know which app students would use as evidence by her comment, "I'm not sure if they [students] are going to open it in Notability or … whichever app they prefer." When asked if her students needed her help using the iPad, Laurie replied, "They're better at it than I am, so they haven't really needed too much help." Laurie was aware of her need for professional development on technology and content integration as she noted, "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."

During the interview, Seth stated, "you can't just teach the content, it becomes boring." He facilitated discussion-based learning to demonstrate the application of biology via real life examples and analogies. Seth encouraged his students to engage in scientific and critical thinking "so they have to use the data to … make connections …." Seth believed that learning with technology increased student motivation and aided student comprehension. Setting up a 1:1 learning environment enabled Seth to move toward a paperless classroom eliminating class time spent on collecting and passing back papers and gaining precious minutes to spend on teaching and learning. Seth was a technology-enthusiast in education as well as in his personal life. He enjoyed using technology as a convenience in his personal life and kept up with technology news on the latest gadgets.

Seth's TPCK-in-Practice was evident as he discussed his consideration of the learning goals and the content prior to selecting the technology-enhanced activity. Based on the conceptual knowledge his students were to learn, Seth believed the Hungry Birds game was an effective technology-based instructional activity. Hungry Birds would initially serve as an attention-getter, but playing the game would facilitate a deeper understanding of the concept of natural selection. The game was also a hands-on and student-directed activity. Seth said that technology assisted him in teaching the concept more efficiently. He also thought that student comprehension and achievement of the learning goal might take less time with the Hungry Birds app than without the technology. Seth's description of how he matched the use of Hungry Birds to the concept of natural selection revealed his TCK-in-Practice knowledge. Furthermore, his competence with the app was evident when he described that after a few run-through trials of the game, he realized it was very easy to use. Since the game had only one function, he determined that students required no instruction on the technical skills of using the app before they could start playing. Seth's TPACK-in-Practice knowledge was evident as he described how this technology-enhanced activity fit into his unit scope and sequence as he planned to move beyond comprehension and application of content to evaluation and synthesis.

According to Ashley, she believed that using various teaching methods was effective for social studies teaching because they helped reinforce content learning. According to Ashley, "We do a little bit of traditional notes and lecture … a lot of group activities with that same material, … supplemental reading, … individual brainstorming exercises." Ashley said her teaching style had become more flexible in her 1:1 classroom allowing her to incorporate spontaneous student-directed learning by letting her students browse the Internet to explore topics and find answers. She occasionally used apps relating to social studies content learning. She used Google Drive for sharing resources and moving towards a paperless classroom. In her personal life, Ashley enjoyed using technology and she kept up with the news on the latest gadgets.

Ashley's TPCK-in-Practice was evident in her selection of a web quest as an effective technology-based social studies activity after her reflection of the type of knowledge to be learned. She wanted her students to become familiar with the significant events during the Cold War in order to provide prior knowledge for the subsequent unit on the Vietnam War. Ashley believed the web quest, similar to a scavenger hunt, was more interesting to her students and made the learning material stand out. She carefully selected websites with reliable information, interesting visuals and easy navigation. Ashley had taught this lesson using the web quest in the previous school year and student performance on the assessment showed that this technology-based activity led to better retention of content. TCK-in-Practice was evident in Ashely's ability to repurpose a generic tool (web quest) to match her social studies content. However, she did not identify the technical skills her students needed to implement the web quest successfully even though she was aware of her students' varying technical abilities and potential difficulties using the iPad. Ashley viewed this as a challenge of teaching in a 1:1 classroom and she did not plan to identify and systematically teach the technical skills needed to resolve problems when using the web quest in the future.

Jeff, Seth and Ashley exhibited components of TPCK-in-Practice, specifically having a repertoire of technology-enhanced activity types representing their content and having the knowledge of content-based models of teaching appropriate for the technology-enhanced activity types. These three participants also showed competence with their content-appropriate technologies as they were able to identify the technical skills needed for their discipline-based tool. However, only Jeff and Seth made implicit decisions about

technology skill instruction students would need in class, whereas Ashley did not see this instruction as a necessary component of teaching a technology-integrated lesson.

6.2. TPK-in-Practice Construct: Practical Competencies of Planning and Preparation

Characteristics of the planning and preparation phases of TPK-in-Practice are reflected in concrete teacher actions and were noted during classroom observations. TPK-in-Practices identified in Jeff's lesson planning were his assessment type, activity choices and his technology practice. Jeff had the knowledge to select a technology-enhanced assessment activity that aligned with his curriculum goals. By deciding on the GeoGebra app, Jeff stated, "The kids like using the app, and so I searched for interesting geometry problems to allow us to justify such play." Jeff also knew that completing these math problems without technology would have been cumbersome and time-consuming. Jeff wanted to reinforce that mathematics consisted of surprise discoveries and he expressed, "it's difficult to convey the need and enjoyment and satisfaction of experimentation and self-discovery without the use of the app..." A practical TPK-in-Practice competency exhibited by Jeff during lesson preparation was his practice with the GeoGebra app. This allowed him to discover the constraints and affordances he might encounter in the classroom (Jaipal & Figg, 2015). Jeff did not sequence content and technology skill learning or differentiate for technical competence because his students had previously used GeoGebra. He also did not have a backup instructional plan with alternate activities without the technology because he knew he had successfully taught a similar lesson to the same group of students before.

Laurie's lesson planning displayed only one but important teacher action from the planning category of TPK-in-Practice by considering learning goals prior to content selection. She then selected pedagogical approaches that best facilitated her students to reach the learning goals. One of the two characteristics of the preparation category present in Laurie's instructional planning was her use of digital classroom resources. Being in a 1:1 setting Laurie could share documents and other resources via Google Drive with her students, reducing time spent copying and preparing materials for her students. During this lesson, students used their iPads to access sample essays Laurie had shared via Google Drive. Laurie valued the iPad as a productivity tool and did not consider curriculum and technology integration as evidenced by her comment, "My subject matter doesn't lend itself, I don't think, as much to technology [as some other subjects]." Laurie believed that people preferred to read paper copies of books, therefore, she admitted, "finding a way … to incorporate more technology is my last thought."

Seth's lesson planning process showed three characteristics of the planning phase and one of the preparation phase of Jaipal and Figg (2013); Jaipal and Figg (2015) TPK-in-Practice construct: activity choice, sequencing, backup instruction, and technology practice. Seth's lesson planning began by identifying curriculum and learning goals followed by selecting the technology-enhanced activity. Seth chose the Hungry Birds app for his lesson, a game that models the processes of natural selection. He believed the game would facilitate student comprehension of the concept of adaptation. Seth knew that the game was very simple and required a minimal learning curve so he decided to build technology and content skills simultaneously during the lesson. Seth's backup lesson plan was a more lecture-based Google Slide presentation from the previous year containing visual examples of adaptation.

The characteristics of the planning and preparation categories of TPK-in-Practice identified in Ashley's lesson planning were her activity choices that included a preselected collection of digital resources for learning, differentiation strategies to ensure the technical competence of her students, and the presence of a backup lesson plan. Ashley started with content selection and then determined her learning goals. Ashley's learning objectives were that students would be able to explain how World War II led to the Cold War and to describe reasons the U.S. was involved in Cuba, Korea, and Vietnam. Ashley also wanted her students to compare and contrast Cold War events. Ashley had shared a worksheet via Google Drive containing questions and links to various websites. While preparing for this lesson, Ashley had selected the relevant web sites because they were user-friendly, informative, interactive, and included visual media. According to Ashley, she thought a scavenger hunt type of web quest "makes the material stand out a little bit more instead of just … answering questions from a reading." Ashley did not consistently use Google Drive and she anticipated needing to differentiate instruction by way of providing students with individualized help such as opening, saving, or sharing documents. In the prior lesson conducted in a more traditional setting, Ashley had prepared a text-based packet with reading passages followed by comprehension questions. She hoped she did not have to rely on this packet but it was her backup plan in case of technical difficulties.

Lesson planning and preparation had changed for all of the participants in this case study to some degree. All participants exhibited at least one teacher action identified by Jaipal and Figg (2013); Jaipal and Figg (2015) in the planning and preparation categories of TPK-in-Practice. The most commonly occurring teacher action was in the preparation category of TPK-in-practice, the use of digital classroom resources. All four participants discussed using Google Drive for sharing collections of digital classroom resources with their students. This supports previous research indicating that teachers may initially use a networked device as a productivity tool prior to moving on to device integration as a cognitive tool (Hennessy, Ruthven, & Brindley, 2005; Palak & Walls, 2009). Literature teacher, Laurie explained that "things [preparing learning materials] are more efficient for me to share" but she also admitted, "In terms of the actual classroom teaching I'm pretty

much the same." She was the only participant who exhibited only one of the characteristics or teacher actions identified by Jaipal and Figg (2013); Jaipal and Figg (2015) TPK-in-Practice framework. Teaching in a 1:1 setting did not change her lesson planning process. As in her past planning, Laurie considered her learning goals prior to content selection and she then selected pedagogical approaches that would best reach the goals. However, her planning and preparation only minimally included technology by the sharing of documents in Google Drive with her students. Laurie seemed to have little desire or vision of how the use of various technologies could enhance student cognition and learning of literature.

The characteristic from the planning category exhibited by three of the four participants was the selection of a technology-enhanced learning activity that aligned with the learning goals. Jeff, Seth and Ashley believed the iPad could add value as a cognitive tool to help them design and deliver instruction (Weston & Bain, 2010). They spent time exploring various apps and/or online resources for their content areas. Two of the four participants, Seth and Ashley also planned backup instruction in the form of alternative lesson activities using another type of technology or no technology at all as a method of differentiation. Jeff and Seth exhibited teacher actions from the preparation category as they practiced using their app prior to instruction. Overall, three of the four participants displayed teacher actions in lesson planning that underscore the trend of moving away from the 'technocentric' planning of instruction. This planning is more focused on curriculum and student-centeredness where curriculum, technology and student needs are considered concurrently (ChanLin, 2005; Forssell, 2012; Harris & Hofer, 2009b; Lin, Tsai, Chai, & Lee, 2013). This is in contrast to previous times when teachers considered technological affordances before content learning goals. Even Laurie considered learning goals prior to content selection and then selected her pedagogical approaches. However, she failed to consider ways that some form of technology may have enhanced student learning but instead, she only made use of Google Drive and the Smartboard in ways to increase her teaching productivity.

6.3. TPK-in-Practice Construct: Practical Competencies of Teacher Implementation

Both characteristics of teacher actions from the implementation category of TPK-in-Practice were identified in Jeff's geometry class instruction. Jeff utilized various modeling techniques for technology use as well as classroom management strategies to integrate the GeoGebra app into the teaching and learning processes. At first, he modeled the process of solving a math problem in the GeoGebra app displayed on the Smartboard with an Elmo projector. He then let a student model one of the problems for the class. For classroom management, Jeff used grouping techniques that engaged students in meaningful tasks using GeoGebra. He knew that his students were motivated to solve the challenging math problems so he let them choose to work alone or collaborate with others. Jeff walked around and guided student discovery. At one point during the lesson, Jeff identified a student who was ahead of the others as an "expert" to whom classmates could turn with their questions. At another point Jeff asked a student to model a newly discovered feature of GeoGebra on the Elmo projector. The class atmosphere was relaxed and students were on-task at their seat or moving around the room to share their progress or to help each other discover the useful features of GeoGebra.

The only teacher action from the implementation category of TPK-in-Practice identified in Laurie's instruction was modeling. The iPad's Google Drive app was used as a productivity tool that provided easy access to learning materials. Using the Smartboard to mirror her computer, Laurie modeled how to access files from a shared Google Drive folder. All class materials were shared on Google Drive and Laurie organized the class folder by topics. Students accessed the files on their iPads with ease and needed no help from the teacher. They were on task throughout this portion of the lesson as they used their iPads to read and evaluate sample essays.

A successful characteristic of Seth's action that aligned with the implementation category of TPK-in-Practice was classroom management. The 25-minute Hungry Birds activity followed Seth's Google Slide presentation and guided discussion on natural selection, took place in the middle of the 85-minute class period. The Hungry Birds app required almost no learning or preview, so Seth did not model using the app; he only gave directions verbally on how to use it. Seth's classroom management was successful because playing the game was a meaningful task that provided a deeper and hands-on understanding of the content Seth had taught at the beginning of the lesson. Students interacted with the technology to apply and extend their knowledge of natural selection and they were on-task and excited about the game.

During her lesson, Ashley did not display any teacher actions identified by Jaipal and Figg (2013); Jaipal and Figg (2015) as successful characteristics of the implementation category of TPK-in-Practice. She did not model the technology use nor adapted her general classroom management strategies for the technology-enhanced American History lesson. Ashley placed in the Google Drive shared class folder a Microsoft Word document consisting of questions and hyperlinks to various websites on the Cold War. The students located the document with ease on their iPads. Ashley recommended students opening the document in Notability, a note-taking app used school-wide. Some students did not know how to open the document in Notability and others who could open it found that the hyperlinks were not active. One student succeeded in opening the document in another iPad app, Pages, and found that the hyperlinks worked in this app. Ashley then gave directions for the class to use the Pages app, instructing students to download the app if they did not have it. Some students experienced further technical difficulties when the first hyperlink did not direct them to the

website Ashley intended. She walked around and helped students individually to navigate to the first website. Afterwards students were engaged in the task and Ashley walked around to monitor their work.

Jeff and Seth exhibited teacher actions of TPK-in-Practice that led to the successful implementation of their technology-enhanced lessons. Jeff and Laurie utilized various modeling techniques to demonstrate the technology use even though Laurie's lesson could not be considered technology-enhanced since she used technology only to enhance her own productivity. She did model the technical functions of using Google Drive that exist across platforms and Jeff modeled best practices for GeoGebra as well as shared teacher- and student-created exemplars (Jaipal & Figg, 2015). Jeff, Seth, and Ashley prepared meaningful and engaging tasks using GeoGebra, Hungry Birds, and a web quest respectively. These teachers provided opportunities for their students to use the technology to construct knowledge (Jaipal & Figg, 2015). Ashley's implementation would have been more successful had she practiced using Notability during her lesson preparation. By doing so, she would have discovered the problems of broken hyperlinks and file incompatibility, which could have prevented the loss of valuable time for student learning during class. See Appendix C for a summary of teacher thinking and actions relevant to the TPACK-in-Practice framework (Jaipal & Figg, 2013; Jaipal & Figg, 2015).

6.4. TPACK Survey Results

The purpose of the TPACK survey was to make inferences about participants' TPACK skills associated with teaching with the iPad. Mean scores were calculated for each TPACK construct for each participant (See Table 1). Cross case analysis was then examined (See Table 2).

Table-1. TPACK survey results.

TPACK Construct	Jeff (Math)	Laurie (Literature)	Seth (Biology)	Ashley (History)
CK	4.00	3.83	3.83	4.00
PCK	3.75	4.00	4.00	4.00
PK	3.40	3.60	3.83	3.60
TCK	3.00	2.50	4.00	3.50
TPK	3.00	2.43	3.43	3.10
TPACK	3.00	2.00	4.00	3.20
TK	2.86	2.14	4.00	3.50
Grand Average	3.29	2.93	3.87	3.80

Table-2. TPACK survey cross case analysis.

Participants	CK	PCK	PK	TCK	TPK	TPACK	TK	Grand Average
Jeff	4.00	3.75	3.40	3.00	3.00	3.00	2.86	3.29
Laurie	3.83	4.00	3.60	2.00	2.43	2.00	2.14	2.93
Seth	3.83	4.00	3.83	4.00	3.43	4.00	4.00	3.87
Ashley	4.00	4.00	3.60	3.50	3.10	3.20	3.50	3.80
Mean	3.91	3.94	3.61	3.13	2.99	3.05	3.13	3.47

Jeff. Jeff was most confident in his content knowledge (CK) (M = 4.00) and Pedagogical Content Knowledge (PCK) (M = 3.75). He was less confident in domains associated with technology with the lowest score being his Technological Knowledge (TK) (M = 2.86), which is the construct measuring one's knowledge about utilizing the more widely-used technologies. Observation of Jeff's lesson demonstrated his confidence and comfort with teaching math content. According to his interview, Jeff based his decisions about content learning and delivery, similar 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. While the TPACK survey showed that overall Jeff rated himself the least confident on constructs associated with technology, the qualitative data from the observed lesson indicate that Jeff exhibited a high-degree of knowledge and confidence in these domains. 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 self-directed and engaging learning, teachers would more likely integrate it. Jeff's TK of GeoGebra facilitated the evaluation of the app for its value to teach and learn content.

Additionally, qualitative data indicate that gaining TPACK was not a linear process for Jeff as his TK and TCK related to 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 (2011) study support 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 data 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 that 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).

Laurie. 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, Laurie talked at length about issues relating to pedagogy and content and much less about the iPad and technology. Her knowledge of instruction was evident from the way she chunked the long class periods and used the iPad to signal a move from one segment of her lesson into the next. Laurie's content knowledge was also evident when she discussed the inclusion of The Handmaid's Tale over other novels into her IB Literature curriculum. Her content area expertise enabled Laurie to select this particular novel so it complemented the other three literary works she had selected. The qualitative data revealed that Laurie did not use the iPad to teach literature content. She confessed that she had not found content-specific apps. Laurie's lack of 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. Laurie confessed that she needed to take the time to find content-specific apps and to learn more about integrating the iPad. The research literature discusses at length that the number one reason for the lack of technology integration is lack of time for teachers to learn how to do it (McGrath, Karabas, & Willis, 2011; Padmavathi, 2013; Vannatta & Fordham, 2004). Laurie discussed her preference for being in a one-to-one classroom with a laptop rather than an iPad. This most likely was a factor in the lack of time she invested in learning to integrate the iPad in her literature course.

Seth. Seth demonstrated a high-degree of confidence in three of the four technology-related constructs, and was highly confident in PCK. His high-degree of confidence in the technology-related constructs was evident during the qualitative interview. Seth spent a great deal of time discussing not only how he used technology in his one-to-one classroom, but also elaborated on school-wide and state-wide issues relating to technology use of schools. His TK was evident when he gave examples of how he was able to find solutions to potential technology issues that were encountered during class. He could navigate the available classroom technologies, such as desktop computer, his iPad, Smartboard, and student iPads to find solutions to most technical issues. Seth was familiar with the functions as well as the limitations of the Google apps he and his students used. For instance, he created Google Slides presentations on his desktop computer in order to have visuals included. He also knew 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. Seth rated himself as 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, showed that the observed lesson was aligned with the Next Generation Science Standards and Seth was able to discuss those standards during the interview. His instructional strategies during the observed lesson also facilitated student achievement of the stated learning standards. 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. By sharing materials and using Google Classroom to post assignments, Seth was able to give students a way to plan and monitor their learning. Absent students had access to class materials, and all students could plan to turn-in assignments on time.

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 (Belland, 2009; Davies, 2011) 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) discussed the three tiers of technology integration from the most basic awareness level to the adept phronesis level, but he emphasized that technology integration was not a one-time achievement. It required the continuing education and *re*-education in the use of technology.

Ashley. The qualitative data affirmed Ashley's CK and PCK as she relied on her knowledge of the Cold War to create a web quest that offered 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 interview also confirmed Ashley's PCK expertise 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. Since Ashley was less confident in her PK than in her CK, it was not a surprise that she rated her overall confidence level the weakest in TPK. Ashley responded with an only 'somewhat confident' answer to six of the seven items measuring this domain.

Ashley's greatest frustration with teaching in a one-to-one setting was her students not having the knowledge of how to use the iPad. Ashley believed that basic iPad training should be offered to all students at the freshmen level and include instructions on how to use the apps that are on all iPads at the school.

Similar to Seth, Ashley appreciated the spontaneous learning opportunities the iPad provided. Student questions were encouraged and answers were just a few clicks away. Ashley and Seth noticed that student interest and motivation had increased with the use of iPads, which corroborates 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 when iPads were present. Ashley's main concerns were her larger class sizes and her students' difficulties with using their iPads. Palak and Walls (2009) have identified these factors as some of the many internal and external variables that affect teachers' perceptions and value systems when it comes to integrating technology. Ashley was hesitant and somewhat anxious to plan an entire lesson using the iPad based on her past 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.

7. Discussion and Conclusions

This study investigated ways that having 1:1 iPads in the classroom would compel teachers to adapt their practices of lesson planning, preparation, implementation of classroom instruction. It was assumed, based on the TPACK model of technology integration (Mishra & Koehler, 2006) and the TPACK-in-Practice framework (Jaipal & Figg, 2013; Jaipal & Figg, 2015) that having 1:1 iPad technology would necessitate instructional changes that are distinctly different from teaching in a traditional classroom setting without the use of these technologies. This is particularly true if teachers use technology as a cognitive tool to enhance student learning in contrast to using it simply to improve their own productivity. The TPACK-in-Practice framework extended the TPACK theoretical model by identifying the thinking processes and concrete practices that should be a part of a technology-using teacher's instructional repertoire. Lesson plans, interviews, and classroom observation notes were aligned with the TPACK-in-Practice framework to examine how the instructional practices of four teachers was different as a result of having 1:1 iPads in their classrooms. Aligning teachers' thinking processes and concrete actions to the components and characteristics of the TPACK-in-Practice framework revealed a great deal of variation in these four teachers.

There was only one characteristic of the TPACK-in-Practice framework displayed by all four teachers, the use of digital classroom resources, from the preparation category of the TPK-in-Practice construct. During lesson planning and preparation, three of the four teachers considered their learning goals, content, pedagogy and technology simultaneously. Those three teachers showed a great deal of confidence in their content and pedagogical knowledge and were reasonably confident in their technology knowledge, which was exhibited in the creative uses of technology and student-centered changes in teaching practices. They displayed a great deal of knowledge of technology-based activities and competence of content-based technologies in their respective content areas of math, science, and social studies. Laurie, who was the least confident in using technology, utilized the iPad only as a productivity tool to access shared files. Research has shown that many teachers initially use technology as a productivity tool prior to moving on to using technology as a cognitive tool (Hennessy et al., 2005; Palak & Walls, 2009). However, this was the second year that Laurie had been using 1:1 iPads and it remains a question as to why she had not moved beyond the productivity stage in her adoption of using technology. Perhaps her preference for using a laptop as opposed to an iPad influenced her motivation to integrate the iPad meaningfully in her literature courses. Laurie said that she had experienced very little change in her pedagogy over the course of two years as a result of having the 1:1 iPads. Jeff, Seth and Ashley expressed how their teaching style had changed because of teaching with 1:1 iPads. This concurs with previous research showing that when teachers start to incorporate technology as a cognitive tool there is a change in their existing teaching practice towards a more student-centered approach (Ifenthaler & Schweinbenz, 2013; Lambert & Ennis, 2012; Lambert et al., 2018; Levin & Wadmany, 2006; Palak & Walls, 2009). The successes these three teachers experienced with iPad integration provided positive reinforcement and motivation to explore more technology-enhanced content-based activities and increased their personal competence with the various technologies. Jeff and Seth evaluated their own teaching practice while

successfully using their content-specific applications of GeoGebra and Hungry Birds. Ashley had prior knowledge and experience with using a web quest in social studies that resulted in better student retention of content, motivating her to use it in subsequent years. Jeff and Seth also acknowledged their increasing use of the iPads each year. As evidenced, successful experiences tend to build confidence, which in turn, motivate more desire and intention to integrate technology in newer and creative ways related to specific content. For this to happen, teachers must have confidence in their teaching ability and possess expert knowledge of their curriculum before they can experience reasonable success in using technology to support their teaching and content. This might explain why the experiences of Jeff, Seth, and Ashley motivated them to learn and explore more ways of teaching with the iPad. In contrast, Laurie evaluated her initial attempt to teach content with the iPad as unsuccessful and as a result, she reverted to teaching without the devices. Her unsuccessful attempt contributed to her lack of motivation and confidence to explore the other uses of the iPad in the literature classroom, thereby limiting her desire for change and growth in technology integration practices. Once again, this supports prior research indicating that teachers must understand the value of integrating technology (Lambert & Ennis, 2012) and believe that technology can support student learning and add value to the curriculum to be motivated to make it a regular practice (Adcock, 2008; Theo, 2011).

This study echoes the findings of Howard (2011) regarding teachers' technology-related risk perceptions. Jeff and Seth demonstrated more acceptance of technology-related risks, had a higher computer-efficacy, and displayed a more positive affect towards technology. Conversely, Howard (2011) found that teachers showing less acceptance of technology-related risks have a lower computer-efficacy and a negative affect towards technology integration, both of which were characteristic of Laurie. Also in concurrence with Howard's study, Ashley's concerns about integrating the iPad were not explained by her lack of pedagogical and technological knowledge, but rather, by her anxiety over students' lack of technical skills and her own belief that she need not spend time on teaching these skills. Due to her large class sizes and instructional time constraints, Ashley believed she did not have time to teach technology skills to her students in conjunction with teaching content. It was also noted that Ashley's iPad integration was affected by external factors such as time and class size, also identified by others (Kim, Kim, Lee, Spector, & DeMeester, 2013; Kirkscey, 2012; Palak & Walls, 2009) as barriers to technology integration that have nothing to do with TPACK.

Figure 1 shows the cycle of continuous experiences and learning necessary in order to move forward with technology integration. This diagram reinforces Davies (2011) conclusion that attaining technology literacy is not a one-time achievement, as it requires continual education and re-education in the use of new and familiar forms of technology. Successful experiences with using technology as a cognitive tool, lead to understanding the value of integrating technology. These experiences, in turn, help teachers develop positive attitudes that motivate them to seek even more and innovative experiences when using technology. All these are required for teachers to gain TPACK skills (Mishra & Koehler, 2006) that include expertise and interactions among pedagogy, content or curriculum, and technology. When one of these components is missing or not considered simultaneously, teachers are less likely to integrate technology successfully or see the value in doing so.

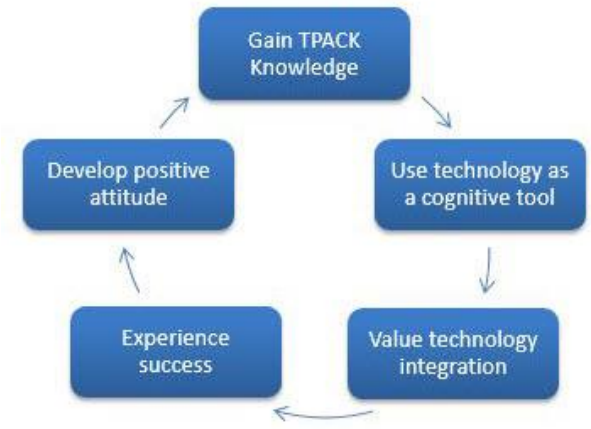

Figure-1. Cycle of technology integration.

Davies (2011) emphasized that becoming adept at technology integration is only possible through the application of technology in *authentic* situations, such as the 1:1 classroom. He called this the "phronesis" level in which teachers possess sufficient technology knowledge and literacy to reflect on why they choose to use, or not use technology. At this level, the teacher must clearly understand the learning task and purposefully select the technology because he or she recognizes the way the technology facilitates the attainment of student learning goals. Jaipal and Figg (2013); Jaipal and Figg (2015) TPACK-in-Practice framework describes the characteristics and teacher actions leading to the phronesis level. Jeff, Seth and Ashley demonstrated the phronesis level through their reflection on their teaching and their purposive selection and matching of the

technology tool to content learning. Jeff, Seth and Ashley exhibited characteristics from all the subcomponents of TPACK-in-Practice, specifically TPK-in-Practice, TCK-in-Practice and TPCK-in-Practice. It was clear that Laurie possessed knowledge of her curriculum and had pedagogical expertise. However, she was still lacking the ability to consider how the technology component could relate effectively to these other two components.

This study shows that the TPACK-in-Practice model is an important practical framework for understanding how teachers make the transitions in their instructional practices when challenged with 1:1 iPad integration in their classrooms. Teachers tend to change from traditional to more student-centered approaches when all students have a networked device. Teachers who are more accepting of risks find that they are more confident, creative, and apt to experiment with different types of activities that incorporate iPads. As these teachers gradually experience successful 1:1 iPad integration, they became more motivated to explore other options in teaching, have positive attitudes, and value technology's potential for teaching and learning. These teachers used technology mainly as cognitive tools, and understood that 1:1 iPad integration was an opportunity to improve their own knowledge of pedagogy and content. As discovered in previous research, there are still barriers to 1:1 iPad integration such as time and class size that have little to do with teachers' knowledge of frameworks or models. However, for teachers who have accepted iPads and the changes these devices require in the classroom, barriers will become part of the continuous learning cycle that need resolution for teachers to become more proficient at 1:1 iPad integration.

This research can inform the types of professional development needed by schools that have adopted 1:1 iPads classrooms. Educational technologists might consider the value of introducing teachers to the TPACK-in-Practice frameworks to prepare them for 1:1 integration. The study can also offer administrative decision-makers valuable information about the impact of iPads on teachers before they move into 1:1 classroom adoption and the value of getting teacher feedback before decisions are made. Additionally, suggestions for facilitating field experiences of preservice teachers in 1:1 classrooms might be gleaned from the study. Future research should examine more closely the iPad integration experiences of teachers in specific content areas. Another area for further study is the investigation of how teachers conceptualize their own technology integration abilities when they are already familiar with TPACK. A limitation of the study is that the researcher worked in the school where the study was conducted so colleagues may have volunteered their participation to highlight their utilization of iPad integration. Additionally, the study should not be generalized to other settings outside the college-preparatory high school in which it was conducted.

References

Adcock, P. (2008). Evolution of teaching and learning through technology. *Statistics NeerlandicDelta Kappa Gamma Bulletin*, *74*(4), 37-41.

Albion, P., & Tondeur, J. (2018). Section introduction: Professional learning and development of teachers. In J. Voogt , G. Knezek, R. Christensen, & K. W. Lai (Eds.) (pp. 381-396): International Handbook of Information Technology in Primary and Secondary Education.

Angeli, C., & Valanides, N. (2018). Knowledge base for information and communication technology in education. In J. Voogt , G. Knezek, R. Christensen, & K. W. Lai (Eds.) *International Handbook of Information Technology in Primary and Secondary Education* (pp. 396-413).

Archambault, L., & Crippen, K. (2009). Examining TPACK among K-12 online distance educators in the United States. *Contemporary Issues in Technology and Teacher Education*, *13*(1), 71-88.

Belland, B. R. (2009). Using the theory of habitus to move beyond the study of barriers to technology integration. *Computers & Education*, *52*(2), 353-364. Available at: 10.1016/j.compedu.2008.09.004.

Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2011). Exploring the factor structure of the constructs of Technological Pedagogical Content Knowledge (TPACK). *The Asia-Pacific Education Researcher*, *20*(3), 595-603.

Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2011). Exploring the factor structure of the constructs of technological, pedagogical, content knowledge (TPACK). *Asia-Pacific Education Researcher*, *20*(3), 595-603.

ChanLin, L.-J. (2005). Development of a questionnaire for determining the factors in technology integration among teachers. *Journal of Instructional Psychology*, *32*(4), 287-292.

Christensen, R. (2002). Effects of technology integration education on the attitudes of teachers and students. *Journal of Research on technology in Education*, *34*(4), 411-433. Available at: https://doi.org/10.1080/15391523.2002.10782359.

Davies, R. S. (2011). Understanding technology literacy: A framework for evaluating educational technology integration. *TechTrends: Linking Research and Practice to Improve Learning*, *55*(5), 45-52.

Donovan, L., Green, T., & Hansen, L. E. (2011). One-to-one laptop teacher education: Does involvement affect candidate technology skills and dispositions? *Journal of Research on technology in Education*, *44*(2), 121-139. Available at: https://doi.org/10.1080/15391523.2011.10782582.

Dunleavy, M., Dexter, S., & Heinecke, W. F. (2007). What added value does a 1: 1 student to laptop ratio bring to technology-supported teaching and learning? *Journal of Computer Assisted Learning*, *23*(5), 440-452.

Dwyer, D. C., Ringstaff, C., & Sandholtz, J. H. (1991). Changes in teachers' beliefs and practices in technology-rich classrooms. *Educational Technology*, *48*(8), 45-52.

Foote, C. (2012). Learning together: The evolution of a one-to-one iPad program. *Internet@Schools*, *19*(1), 14-18.

Forssell, K. (2012). *When Knowing Leads to NOT Doing: Reasoning as evidence of TPCK*. Paper presented at the Paper presented at the Proceedings of Society for Information Technology & Teacher Education International Conference 2012, Chesapeake, VA.

George, A. A., Hall, G. E., & Stiegelbauer, S. M. (2006). *Measuring implementation in schools: The stages of concern questionnaire.* Austin, TX: SEDL.

Graham, C. R., Burgoyne, N., Cantrell, P., Smith, L., St. Clair, L., & Harris, R. (2009). Diagramming TPACK in practice: Using an elaborated model of the TPACK framework to analyze and depict teacher knowledge. *Techtrends: Linking Research & Practice To Improve Learning, 53*(5), 70-79. Available at: 10.1007/s11528-009-0328-0.

Harris, J., Grandgenett, N., & Hofer, M. (2012). *Testing an instrument using structured interviews to assess experienced teachers' TPACK. In C. D. Maddux, D. Gibson, & R. Rose (Eds.), Research highlights in technology and teacher education 2012.* Chesapeake, VA: Society for Information Technology & Teacher Education (SITE).

Harris, J., & Hofer, M. (2009a). Grounded tech integration: An effective approach based on content, pedagogy, and teacher planning. *Learning & Leading with Technology, 37*(2), 22-25. Available at: https://doi.org/10.1016/j.tate.2004.04.006.

Harris, J., & Hofer, M. (2009b). Instructional planning activity types as vehicles for curriculum-based TPACK development. *Research Highlights in Technology and Teacher Education, 2009*, 99-108.

Harris, J. B., & Hofer, M. J. (2011). Technological pedagogical content knowledge (TPACK) in action: A descriptive study of secondary teachers' curriculum-based, technology-related instructional planning. *Journal of Research on technology in Education, 43*(3), 211-229. Available at: https://doi.org/10.1080/15391523.2011.10782570.

Hashim, Y. (2014). Preliminary study on teachers' use of the iPad in bachelor of education program at a private university in Malaysia. *Techtrends: Linking Research & Practice To Improve Learning, 58*(2), 14-19.

Hennessy, S., Ruthven, K., & Brindley, S. (2005). Teacher perspectives on integrating ICT into subject teaching: Commitment, constraints, caution, and change. *Journal of Curriculum Studies, 37*(2), 155-192. Available at: https://doi.org/10.1080/0022027032000276961.

Howard, S. K. (2011). Affect and acceptability: Exploring teachers' technology-related risk perceptions. *Educational Media International, 48*(4), 261-272. Available at: https://doi.org/10.1080/09523987.2011.632275.

Ifenthaler, D., & Schweinbenz, V. (2013). The acceptance of Tablet-PCs in classroom instruction: The teachers' perspectives. *Computers in human Behavior, 29*(3), 525-534. Available at: https://doi.org/10.1016/j.chb.2012.11.004.

Inan, F. A., & Lowther, D. L. (2010). Factors affecting technology integration in K-12 classrooms: A path model. *Educational Technology Research Development, 58*(2), 137-154. Available at: https://doi.org/10.1007/s11423-009-9132-y.

Jaipal, K. J., & Figg, C. (2013). *The TPACK-in-practice workshop approach: A shift from learning the tool to learning about technology-enhanced teaching.* Paper presented at the Proceedings of the International Conference on e-Learning.

Jaipal, J. K., & Figg, C. (2015). The framework of TPACK-in-Practice: Designing content-centric technology professional learning contexts to develop teacher knowledge of technology-enhanced teaching. In C. Angeli & N. Valanides (Eds.), Technological pedagogical content knowledge: Exploring, developing and assessing TPCK (pp. 137-163). New York: Springer.

Kim, C., Kim, M. K., Lee, C., Spector, J. M., & DeMeester, K. (2013). Teacher beliefs and technology integration. *Teaching and Teacher Education, 29*(1), 76-85.

Kirkscey, R. (2012). Secondary school instructors' perspectives on the integration of information and communication technologies (ICT) with course content. *American Secondary Education, 40*(3), 17-33.

Knezek, G., & Christensen, R. (2018). *The evolving role of attitudes and competencies in information and communication technology in education. In J. Voogt , G. Knezek, R. Christensen, & K. W. Lai (Eds.) International handbook of information technology in primary and secondary education.*

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge. *Contemporary Issues in Technology and Teacher Education, 9*(1), 60-70.

Koehler, M. J., & Mishra, P. (2005). What happens when teachers design educational technology? The development of technological pedagogical content knowledge. *Journal of Educational Computing Research, 32*(2), 131-152. Available at: https://doi.org/10.2190/0ew7-01wb-bkhl-qdyv.

Koehler, M., & Mishra, P. (2008). *Introducing technological pedagogical content knowledge.* Paper presented at the Paper Presented at the Annual Meeting of the American Educational Research Association, New York City.

Lambert, J., & Ennis, J. (2012). *Promoting 21st century skills and thinking with classroom technology.* El Cajon, CA: National Social Science Press.

Lambert, J., & Gong, Y. (2012). Measuring the effectiveness of a one-to-one laptop initiative in a rural school district. *Journal of Technology Integration in the Classroom, 3*(3), 63-75.

Lambert, J., Cioc, C., Cioc, S., & Sandt, D. (2018). Making connections: Evaluation of a professional development program for teachers focused on stem integration. *Journal of STEM Teacher Education, 53*(1), 3-15.

Levin, T., & Wadmany, R. (2006). Teachers' beliefs and practices in technology-based classrooms: A developmental view. *Journal of Research on technology in Education, 39*(2), 157-181. Available at: https://doi.org/10.1080/15391523.2006.10782478.

Lin, T.-C., Tsai, C.-C., Chai, C. S., & Lee, M.-H. (2013). Identifying science teachers' perceptions of technological pedagogical and content knowledge (TPACK). *Journal of Science Education and Technology, 22*(3), 325-336.

McGrath, J., Karabas, G., & Willis, J. (2011). From TPACK concept to TPACK practice: An analysis of the suitability and usefulness of the concept as a guide in the real world of teacher development. *International Journal of Technology in Teaching & Learning, 7*(1), 1-23.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054.

National Center for Education Statistics. (2018). Private school universe survey: Notre dame academy.

Niederhauser, D., & Lindstrom, D. (2018). Instructional technology integration models and frameworks: Diffusion, competencies, attitudes, and dispositions. *Handbook of Information Technology in Primary and Secondary Education*, 1-21.

Padmavathi, M. (2013). An overview of barriers in technology integration in schools and their interrelationships. *Indian Streams Research Journal*, *3*(9), 1-7.

Palak, D., & Walls, R. T. (2009). Teachers' beliefs and technology practices: A mixed-methods approach. *Journal of Research on Technology in Education*, *41*(4), 417-441. Available at: https://doi.org/10.1080/15391523.2009.10782537.

Pamuk, S. (2012). Understanding preservice teachers' technology use through TPACK framework. *Journal of Computer Assisted Learning*, *28*(5), 425-439.

Schmidt, D., Baran, E., Thompson, A., Koehler, M., Mishra, P., & Shin, T. (2010). Technological pedagogical content knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education*, *42*(2), 123-149.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4-14. Available at: https://doi.org/10.3102/0013189x015002004.

Theo, T. (2011). Factors influencing teachers' intention to use technology: Model development and test. *Computers & Education*, *57*(4), 2432-2440. Available at: https://doi.org/10.1016/j.compedu.2011.06.008.

Vannatta, R. A., & Fordham, N. (2004). Teacher dispositions as predictors of classroom technology use. *Journal of Research on Technology Education*, *36*(3), 253-271.

Weston, M. E., & Bain, A. (2010). The end of techno-critique: The naked truth about 1: 1 laptop initiatives and educational change. *Journal of Technology, Learning, and Assessment*, *9*(6), n6.

Yin, R. (2014). *Case study research: Design and methods*. Thousand Oaks: SAGE Publications.

Appendix-A. TPACK Knowledge Survey.

TPACK knowledge domains (will not appear on actual survey)	**High degree of confidence**	**Somewhat confident**	**Weak confidence**	**Not at all**
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 enhance the teaching approaches for a lesson.				
I can choose technologies that enhance student learning of a lesson.				
I can think critically about how to use technology in the classroom.				
I can adapt the use of technologies to different teaching 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.				

Source: The survey items were adapted from the studies of Archambault and Crippen (2009), Chai, Koh, and Tsai (2011), and Schmidt et al. (2010).

Appendix-B. Summary of Jaipal and Figg (2013); Jaipal and Figg (2015) Framework.

TPCK-In-Practice Constructs	Definition	Thinking & Actions
TPCK-in-Practice (Inferred by thinking processes of teachers while planning instruction)	Knowledge about **how to design technology-enhanced instruction for different models of teaching**, such as direct instruction or problem-based learning	• Analysis and selection of technology-enhanced activities • Decisions about how best to teach the content
TCK-in-Practice (Inferred by thinking processes of teachers while planning instruction)	Knowledge of **content-appropriate technologies and teachers' ability to use the tools**	• Match or repurpose the discipline-specific technology tools to learn content • Identify their personal skill level with the tool as well as the skills needed by students to engage successfully with the tool
TPK-in-Practice (Reflected in concrete teacher actions)	Knowledge of **practical teacher competencies to plan, prepare and implement instruction**	• **Planning**: Selection and sequencing of technology-enhanced activities, alignment of activities with learning goals, simultaneous and incremental learning of technical and content skills, differentiating instruction, alternate lesson plan without using technology • **Preparation**: Practice using technology, collection of digital resources for instruction • **Implementation**: Modeling of technology use, classroom management

Source: Jaipal and Figg (2013); Jaipal and Figg (2015) TPACK-in-Practice Framework.

Appendix-C. Summary of Teacher Thinking and Actions Relevant to the TPACK-in-Practice Framework.

TPACK-In-Practice Constructs	Thinking & Actions	Teacher Evidence
TPCK-in-Practice (Inferred by thinking processes of teachers while planning instruction)	• Analysis and selection of technology-enhanced activities • Decisions about how best to teach the content	**Jeff**: Deliberately and simultaneously considered the learning goals, content, pedagogy as well as other factors, such as time constraints relating to the course scope and sequence; selected the technology tool and the activity while reflecting on his goal for the lesson, the application and extension of previously-learned procedural knowledge, used GeoGebra to aid students' experimentation and self-discovery of math, competence with using app, repertoire of technology-enhanced activity types representing their content, knowledge of content-based models of teaching appropriate for the technology-enhanced activity types, made decisions about technology skill instruction **Laurie**: Believed it was a challenge to teach her content area with technology, had no knowledge of content-specific apps or how to enhance curriculum
TCK-in-Practice (Inferred by thinking processes of teachers while planning instruction)	• Match or repurpose the discipline-specific technology tools to learn content • Identify their personal skill level with the tool as	

	well as the skills needed by students to engage successfully with the tool	with technology, little experience with using technology for instructional purposes **Seth**: Considered learning goals and content prior to selecting the technology-enhanced activity, selected Hungry Birds app because it would facilitate a deeper understanding of the concept of natural selection, competence with using app, technology-enhanced activity fit into his unit scope and sequence as he planned to move beyond comprehension and application of content to evaluation and synthesis, repertoire of technology-enhanced activity types representing their content, knowledge of content-based models of teaching appropriate for the technology-enhanced activity types, made decisions about technology skill instruction **Ashley: S**election of a web quest as an effective technology-based activity after her reflection of the type of knowledge to be learned, analyzed use of a web quest from a prior year noting how it was more interesting to students, knowledge of content-based models of teaching appropriate for the technology-enhanced activity types, did not view technical skills as something to be taught to students, repertoire of technology-enhanced activity types representing their content
TPK-in-Practice (Reflected in concrete teacher actions)	• **Planning**: Selection and sequencing of technology-enhanced activities, alignment of activities with learning goals, simultaneous and incremental learning of technical and content skills, differentiating instruction, alternate lesson plan without using technology	**Jeff:** Assessment type aligned with curriculum goals, activity choices; no sequence of activities, no differentiation, no alternate plan **Laurie:** Considered learning goals prior to content selection, selected pedagogical approaches to best reach goals but no integration of technology for learning purposes **Seth**: Activity choice, sequencing, backup instruction, identified curriculum and learning goals followed by selecting the technology-enhanced activity, built technology and content skills simultaneously during the lesson **Ashley**: Activity choices, differentiation of individualized help, started with content selection and then determined her learning goals
	• **Preparation**: Practice using technology, collection of digital resources for instruction	**Jeff:** Technology practice with GeoGebra App and use of Google Drive **Laurie**: Use of digital resources by sharing files through Google Drive **Seth**: Technology practice with Hungry Birds app and use of Google Drive **Ashley:** Use of digital resources and use of Google Drive, lack of practice resulting in loss of time for student learning
	• **Implementation**: Modeling of	**Jeff:** He and student modeled use of GeoGebra to solve math problems, grouping for classroom

	technology use, classroom management	management, student expert used for peer assistance, meaningful use of GeoGebra allowed students to construct knowledge of math **Laurie:** Modeling on use of Google Drive to share files, technology used only for productivity purposes rather than for student learning **Seth:** Explained use of Hungry Birds, hands on use of Hungry Birds required little classroom management strategies, meaningful use of Hungry Birds app allowed students to construct knowledge of science **Ashley:** No modeling, meaningful use of web quest allowed students to construct knowledge of social studies

Source: Jaipal and Figg (2013); Jaipal and Figg (2015) TPACK-in-Practice Framework.