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DEVELOPING TEACHERS
TECHNOLOGICAL, PEDAGOGICAL, AND CONTENT KNOWLEDGE (TPACK)
THROUGH DESIGN THINKING AND COMMUNITY OF PRACTICE

A Dissertation

Presented To

The Faculty of the Educational Doctoral Program in Educational Leadership

San José State University

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Education

by

Jennifer Gee Huei Wang

May 2020

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The Designated Dissertation Committee Approves the Dissertation Titled

DEVELOPING TEACHERS
TECHNOLOGICAL, PEDAGOGICAL, AND CONTENT KNOWLEDGE (TPACK)
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by

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APPROVED FOR THE DEPARTMENT OF EDUCATIONAL LEADERSHIP

SAN JOSÉ STATE UNIVERSITY

May 2020

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ABSTRACT

DEVELOPING TEACHERS TECHNOLOGICAL, PEDAGOGICAL, AND CONTENT KNOWLEDGE (TPACK) THROUGH DESIGN THINKING AND COMMUNITY OF PRACTICE

by Jennifer Gee Huei Wang

Current professional development programs have been ineffective in developing teachers' technological, pedagogical, and content knowledge (TPaCK). Development of teachers' TPaCK is fundamental for 21st century student-learning. After a series of professional development workshops with the design thinking process, this study examined whether and how the self-selected K-5 teachers in a suburban elementary school in California demonstrated TPaCK in the integration of instructional technologies when they engage in a community of practice (CoP) structured around design thinking. Data was collected by online TPaCK surveys, exit slips after the CoP, audio recordings and field notes from the CoP and focus group interview. This study examined evidence of growth in teachers' TPaCK and the teachers' attitudes and perceptions of the process and outcomes of going through the design thinking method and a CoP.

DEDICATION

I would like to dedicate this dissertation to my grandparents. You have paved the way for my success. Thank you for giving me my name and passing your values of the importance of education and always striving to be the best person I can be. I am proud to say that I'm the first female to achieve a doctoral degree on both sides of the family.

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Chapter 1: Introduction

Overview

The role of professional development programs has become increasingly central to creating educators who are prepared to address the challenges of 21st century learning. The idea that schools should teach a fixed body of knowledge has given way to the understanding that students must learn skills to adapt to the demands of global citizenship, information economies, and a rapidly changing workforce (California Department of Education, 2018). With constant developments and innovations in technology, teachers must remain current in their knowledge to be effective in preparing 21st century students (Henriksen, Richardson, & Mehta, 2017). For example, the presence of educational technology has increased dramatically, with the number of on-site educational devices going from 3 million in 2010 to 14 million in 2017, an increase of 363% in seven years (Bushweller, 2017). Teachers need meaningful professional development to adopt new technological tools, to develop deep pedagogical knowledge of these tools, and become confident enough to adapt to new ways of learning (Enderson & Watson, 2019). Students need skilled teachers to motivate them and help them develop 21st century skills using relevant technologies. For their part, teachers, themselves, need these same skills to make learning timely and relevant. As a result, addressing teacher professional development is critical to ensuring that technology initiatives and intervention programs are successfully implemented (Cheng & Xie, 2018).

All too often, curriculum and technology initiatives are decided by district offices, and professional development fails to adequately address the particular local needs of

teachers tasked with implementing those initiatives (Boshuizen & Wopereis, 2003; Groff & Mouza, 2008; Tondeur, Van Braak, Ertmer, & Ottenbreit-Leftwich, 2017; Vongkulluksn, Xie, & Bowman, 2018). Such initiatives fail when professional development focuses on the content to be learned, rather than the professional learning of the teachers who must use that content (California Department of Education, 2012). In fact, simply providing a program of professional development without actively engaging the teachers' professional knowledge will seldom foster their willingness to experiment with new tools in the classroom (Figg & Jaipal, 2012; Finefter-Rosenbluh, 2016). The nature of professional development and learning is ongoing and continuing in teachers' practice and daily lives. Desimone (2009) identifies five core elements of effective professional development: content focus, active learning, coherence, duration, and collective participation. Connecting content and activities on subject matter content and how students learn should become the focus, which results in increases in teacher knowledge, improvements in practice, and greater student outcomes (Desimone, 2009).

In addition to Desimone's (2009) core elements, professional development must also engage teachers' technological pedagogical content knowledge (TPaCK) in order to meet the demands of the new curriculum. TPaCK is comprised of technological knowledge, pedagogical knowledge, and content knowledge, as well as their intersection. Content knowledge refers to the subject matter, pedagogical knowledge refers to the methods for teaching and learning the content and technological knowledge refers to the tools and technologies that can assist in learning. Together, these bodies of knowledge can be combined to produce technological pedagogical knowledge, which refers to the

knowledge of how technological tools and resources can enhance teaching and learning in a particular subject matter. For the authentic integration of instructional technology to take place, teachers must have a flexible mindset for developing TPaCK. (Austin, Smyth, Rickard, Quirk-Bolt, & Metcalf, 2010; Sipilä, 2014). The unwavering changes and demands of 21st century learning can overwhelm teachers and by having an open mind, teachers can inquire, problem-solve, and reflect on how technology integration can be applied in the classrooms.

Design thinking, a model originally developed for product design, is beginning to receive recognition for its promise in educational settings (Henriksen et al., 2017; Wrigley & Straker, 2017), particularly as it applies to integrating new instructional technologies (Koh, Chai, Wong, & Hong, 2015; Mosely, Wright, & Wrigley, 2018). Design thinking can be an effective professional development process to develop teachers' TPaCK because it operates on the premise that those utilizing and applying the process must adopt a creative, entrepreneurial mindset and be open minded to a variety of possibilities (Koh et al., 2015). This creative and collaborative approach to problem-solving takes participants through a five-stage process: Empathizing, Defining, Ideating, Prototyping, and Testing. Design thinking may help overcome some of the barriers teachers face in integrating technology by grounding learning in the practical needs that teachers identify in their classroom; defining needs before integrating technological solutions; and encouraging teachers to test and refine ideas iteratively. However, the success of using design thinking, like any other professional development solution, depends on a deep understanding of what opportunities and constraints unfold during

implementation (Bryk, 2009). To date, very little attention has been paid to how teachers engage and refine their TPaCK and expand their use of instructional technologies through professional development activities informed by design thinking.

In this dissertation, I observed teachers as they employ design thinking in a professional development setting, focusing on the ways in which they pose problems and design solutions as they learn to integrate instructional technologies into their curriculum. I also collected information about teachers' perceptions of the approach to gain insights into how best to leverage design thinking to address an important gap in teacher preparation for 21st Century learning.

Problem Statement

When integrating technology into the classroom, teachers face the barriers of their own limited knowledge and skills, their attitudes and beliefs, and the limited support and resources they receive from their school and district (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Vongkulluksn et al., 2018). Teachers' experiences, perceptions, and attitudes correlate to how much technology is being used in the classroom, and whether it is being utilized strategically, overused, or used in ways that duplicate other non-digital resources available to students (Polly & Hannafin, 2010).

Professional development implementation can often be ineffective in developing teachers' TPaCK when teacher beliefs about technology's potentiality (Cheng & Xie, 2018) and relevance to their pedagogy (Figg & Jaipal, 2012; Vongkulluksn et al., 2018) is not taken into account. Since technology integration is a focus in the district, current professional development programs must change to be effective. Effective professional

development models consist of active learning, coherence, content focus, sustained duration, and collective participation (Desimone, 2009). These elements can address teachers' challenges in technology integration and can help with the growth of TPaCK in teacher's pedagogy. The flexibility and differentiated teaching philosophies, styles, and approaches can be addressed in effective professional development programs. One example is by sharing curriculum-based activity types within each discipline area, encouraging teachers to address students' learning needs and preferences, and selecting technologies to address these needs each time they plan a lesson, project, or unit (Harris, Mishra, & Koehler, 2009). Tailoring these professional development programs to teachers' values and allocating effort, resources, and time to improve interest level and the practicalities of technology use can support the increase of technological usage in the classrooms (Cheng & Xie, 2018; Tondeur, Pareja, van Braak, Voogt, Prestridge, 2017).

Communities of practice (CoP) in education have been shown to be an effective context for professional development because they are a group of people who come together to deepen their knowledge and expertise in an area of common concern by interacting on an ongoing basis (Ng & Tan, 2009; Wenger, McDermott, & Snyder, 2002). CoPs actively, collectively, and critically reflect on educational goals and values while also taking the initiative to learn (Ng & Tan, 2009). Collaboration and discussion through collaborative communities allow teachers to analyze and reflect about their teaching practices and students' learning, which then contribute to teachers' professional development. This creates a space where teachers can reflect on practice in ways that sustain instructional improvement. In fact, studies have shown that, both novice- and

inexperienced teachers become more participative, reflective, and confident as they participate in CoPs over time (Woolway, Msimanga, & Lelliott, 2019).

Combining design thinking and CoP might produce a context for teachers to engage, explore, and expand their TPaCK and integration of technology. The importance of instilling positive value beliefs in technology will help overcome teachers' resistance to technology integration by making learning relevant to them. The CoP could support and instill teachers' beliefs and applications of technological usage in the classroom and give them the ability to reflect and develop their professional learning (Wieczorek, 2017). In professional learning, reflection, discourse, and teacher differentiation must be considered given teachers' prior experiences and knowledge of technology usage (Ciampa & Gallagher, 2013). Opportunities of effective professional learning in the professional development workshops with CoP and the design thinking process will engage reflection, collaboration, and discourse that can contribute to technological teaching and learning experiences in the classroom. When teachers lead the process to create, present, and collaborate in professional development activities, teachers' growth and student learning outcomes can occur (Wieczorek, 2017).

Purpose of the Study

This study will examine whether and how teachers demonstrate TPaCK in the integration of instructional technologies when they engage in a community of practice (CoP) structured around design thinking. In particular, this study will involve K-5 teachers at Laurelwood Elementary (pseudonym), a suburban elementary school in the San Francisco Bay Area of California.

Research Questions

1. Is there evidence of growth in teachers' TPaCK and technology integration over the course of time? If so, what is the nature of this growth?
2. In what ways do teachers' TPaCK and technology integration emerge as they engage in design thinking in a community of practice?
3. How do teachers evaluate the process and outcomes of this experience?

Definition of Terms

Technological Pedagogical and Content Knowledge (TPaCK). TPaCK is an understanding that emerges from interactions among content, pedagogy, and technology knowledge. TPaCK is the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones" (Koehler & Mishra, 2009, p. 66).

Effective professional development. Garet, Porter, Desimone, Birman, and Yoon (2001) provide evidence that in order for professional development to be effective in improving teaching practice and student learning, at least five features must be in place:

- Content focus: activities that are focused on subject matter content and how students learn that content

- Active learning: opportunities for teachers to observe, receive feedback, analyze student work, or make presentations, as opposed to passively listening to lectures
- Coherence: content, goals, and activities that are consistent with the school curriculum and goals, teacher knowledge and beliefs, the needs of students, and school, district, and state reforms and policies
- Sustained duration: professional development activities that are ongoing throughout the school year and include 20 hours or more of contact time
- Collective participation: groups of teachers from the same grade, subject, or school participate in professional development activities together to build an interactive learning community (Desimone & Garet, 2015, p. 253)

Community of practice (CoP). According to Wenger (2011), a CoP is a group of people “who share a concern or a passion for something they do and learn how to do it better as they interact regularly” (Wenger, 2011, p. 1). CoP affects educational practices along three dimensions:

- Internally: How to organize educational experiences that ground school learning in practice through participation in communities around subject matters?
- Externally: How to connect the experience of students to actual practice through peripheral forms of participation in broader communities beyond the walls of the school?
- Over the lifetime of students: How to serve the lifelong learning needs of students by organizing communities of practice focused on topics of continuing interest to students beyond the initial schooling period?

Design thinking. A five-phase process of creative problem-solving developed by the Hasso-Plattner Institute of Design at Stanford University. The five phases of Design Thinking are as follows:

- Empathize with your users. This is the phase of setting aside assumptions to gain insight into the needs of users.
- Define your users' needs, their problem, and your insights by reviewing information gathered from the Empathy stage.
- Ideate by challenging assumptions, finding alternative ways to look at the problem, and developing innovative solutions.
- Prototype solutions. The prototype phase explores ideas developed in the Ideate stage. Solutions are iteratively inspected, accepted, improved, and reviewed.
- Test solutions and find the best solution to the problem. This last phase is to reconsider the problem and inform the understanding of the users with all the parameters such as the conditions of use, how people think, behave, and feel, and to emphasize.

Design thinking operates on the premise that those utilizing and applying the process must adopt a creative, entrepreneurial mindset to become open minded to a variety of possibilities. Design thinking, originally a model for product design, is beginning to receive recognition for its possibilities in education settings (Henriksen et al., 2017; Koh et. al., 2015; Wrigley & Straker, 2017).

Background and Role of the Researcher

I am currently a fourth-grade teacher and my research focus inherently questions established patterns of professional relationships, responsibilities, and, ultimately, power structures. I have past experience designing and facilitating professional development with instructional coaches, administrators, and other teacher leaders. Over the past 14 years, I have facilitated app-of-the-month technology updates, the design of the literacy curriculum, and the selection of English language development strategies. From my experience, many teachers have grown tired of a top-down model of curriculum training and implementation because they don't feel respected as active participants in the changes being proposed. Over time this mindset becomes fixed and when opportunities arise that allow teachers to have a say and make a positive change, their mindset hinders any new development.

After being involved in designing and facilitating professional development programs in literacy, English language development, and technology, it was obvious to me that teachers also have just as much responsibility for making opportunities for further meaningful learning to their art and craft of teaching.

Chapter 2: Literature Review

Teachers face the barrier of integrating technology of their own limited knowledge and skills, their attitudes and beliefs, and the limited support and resources they receive. Teachers' knowledge and attitudes correlate to technology use in the classroom. Professional development implementation can be ineffective in developing teachers' knowledge, beliefs, and attitudes. The chapter starts with the background of technology in the classroom and the resistance of professional development, effective professional development, TPaCK, Design Thinking, followed by the connections between TPaCK, Design Thinking, and CoP. The following research questions guide this investigation:

1. Is there evidence of growth in teachers' TPaCK and technology integration over the course of time? If so, what is the nature of this growth? (RQ1)
2. In what ways do teachers' TPaCK and technology integration emerge as they engage in design thinking in a community of practice? (RQ2)
3. How do teachers evaluate the process and outcomes of this professional development experience? (RQ3)

Unfortunately, schools have been rather slow in embracing the use of technology when it comes to signature pedagogies within specific content areas. This is significant, as education cannot hope to meet the demands of a globalized, knowledge-based society without leveraging available 21st-century communication technologies that serve as both the delivery mechanisms for instruction as well as the future platforms in which students will work and perform. (Crippen & Archambault, 2012, p. 158)

Technology in the Classroom

The generation coming of age in our school systems today operates with a digital vocabulary and reservoir of technological knowledge and skills that cannot be ignored. In

response, teachers must learn to integrate this new paradigm meaningfully into the curriculum both to engage students and to prepare them to engage with a changing world. The demands of our increasingly technological and online world increase the expectations we put on our students to develop digital literacy, including basic hardware understanding, word processing skills, typing, online test taking, and navigating and understanding a variety of User Interface (UI) experiences for educational purposes and outcomes. The majority of students are up to the task as many participate in these skills in their personal interaction with technology, but they must also learn to apply these skills in academic and professional contexts that extend beyond their prior experience.

Crippen and Archambault (2012) suggest that research in educational technology needs to be integrated into the curriculum because of the potential impact on students' scientific knowledge and their interest in science, technology, engineering, and math-related career paths. To address these new demands on students' learning, teachers need to learn how to use digital technologies and evolve their teaching practices (Harris et al., 2009; Meyer, Abrami, Wade, & Scherzer, 2011) so they can keep up with 21st Century Learning (Niess, 2011; Sipilä, 2014).

Technology has become more widely utilized in the classroom in the past ten years. Students have become more inclined to use technology overall, and access to technology in school has surged. Laptop, tablet, and Chromebook use has increased by 363% over the past seven years from three million devices in 2010 to fourteen million in 2017 (Bushweller, 2017). Ninety-percent of available technologies in the classroom are personal computers (PCs), 59% are interactive whiteboards, 36% are handhelds including

cell phones, and 35% are tablets and e-readers. More than two-thirds of teachers want more technology for the classroom; 74% of teachers use technology to reinforce and expand content knowledge, motivate students, and respond to a variety of learning tasks (Murray, 2017).

Despite these statistics, the benefits of instructional technology are not being leveraged by most teachers (Groff & Mouza, 2008; Wood, Mueller, Willoughby, Specht, & Deyoung, 2005; Vongkulluksn et al., 2018). That is, although teachers are using technology in their classrooms, they are not strategically using it to develop 21st-century skills. According to Murray (2017), the most commonly used technological resources for teachers are online lesson plans (48%) and web-based interactive games and activities (45%). While 44% of teachers use technology to deliver class information, and 43% of teachers use technology as online videos, images, and articles (Murray, 2017), students report that their classroom technologies are used primarily for practice and rote activities, rather than critical thinking (Bushweller, 2017).

Educators may need to adapt to the current times, but they also need to have a critical eye on the technology being used in our schools (Kimmons & Hall, 2018). Because limiting screen time is considered important for students' well-being (Merga & Williams 2016; Scoggin & Vander Ark, 2018), making strategic use of technology in the classroom becomes even more vital. Although some teachers are struggling with technology integration, changes in access, student characteristics, and curriculum may drive teacher's efforts (Ertmer et al., 2012).

And yet, despite all of these changes, teachers must begin with what they know in order to meaningfully integrate new technologies. Being able to draw on their pedagogical experience and consider what is good practice will help educators understand educational technology and its place in teaching and learning (Niess, 2011; Selwyn, 2008). Educators design experiences and learning environments from their pedagogical beliefs and valued practices, which ultimately influence their understanding and use of technological tools. Also, educators who use technology as a strategic tool help shape and enhance learning tasks by connecting content, technology, and pedagogy within their practice (Dillon & Åhlberg, 2006; Loveless, 2011; Luckin, 2008). Professional development for educators should involve modeling technology integration in context and within learning communities (Loveless, 2011; Pea, 1993; Turner, Simon, Pickering, Daly, & Pachler, 2007). Knowledge and understanding are promoted through cognitive learning processes at individual, group, and systemic levels. In education, providing pedagogically-grounded learning methods and tools is ultimately more important than introducing any particular new technology (Niess, 2011; Sipilä, 2014).

Professional Development

Earlier research has found that, for teachers, the motivation to improve upon existing practices increases with age (Kooij, de Lange, Jansen, Kanfer, & Dikkers, 2011; Kooij, & de Lange, 2015; Van der Heijden, Van Vuuren). This phenomenon may be due to older teachers having more confidence in using a variety of strategies and practices that are tried and true to them. In contrast, younger teachers are still building their repertoire of methods in the classroom and may not even consider the need for technology integration

until they master the basics. Newer teachers also may not see much of a need for more professional development in technology as they may already be comfortable with technology use. However, familiarity with technology in daily life may not always translate to classroom integration (Russell, Bebell, O'Dwyer, & O'Connor, 2003). New teachers transitioning from a teacher-preparation program to classrooms can also have a hard time finding ways to successfully use technology to enhance learning (Russell et al., 2003; Tondeur, Pareja, et al., 2017).

A variety of approaches to promoting educational technology have been taken over the years, such as software-focused initiatives; demonstrations of sample resources, lessons and projects; technology-based educational reform efforts; structured/standardized professional development workshops or courses; and technology-focused teacher education (Harris et al., 2009; Starkey, 2011; Tondeur, van Braak, et al., 2017). However, technology in education is not just a new strategy or tool, but a new paradigm; it is a tall order to expect that teachers can become comfortable with integrating technology effectively with the status quo of professional development. To meet the challenge, professional development in technology requires strong support from the local professional community, including principals, instructional coaches, and administrators (Wieczorek, 2017; Kimmons & Hall, 2018; Vongkulluksn et al., 2018). In addition, it requires measurability plans that recognize and support these efforts (Fabry & Higgs, 1997; Groff & Mouza, 2008; Hardy, Rönnerman, Moksnes Furu, Salo, & Forsman, 2010; Vongkulluksn et al., 2018; Wood et al., 2005).

Technology itself, however, can drive the collaboration needed to understand the technology tools adopted. Therefore, teachers should themselves use technology collaboratively, to understand how to apply it to classroom collaboration (Austin et al., 2010; Ciampa & Gallagher, 2013; Starkey, 2011). “Technology expands interactivity and the ability to create and share information; its adoption legitimates its use. Thus, we see traditional activities reinvented for the technological age in order that previously agreed subject matter might be better learnt” (Adams, 2011, p. 30). This can either be a tool that is used indefinitely within a school or district, such as the Google Suite, or it can be something grade-level teams do for a short period of time in order to gain knowledge of its inner workings. For example, Padlet can be used to facilitate idea sharing among teachers, and Sutori can be used to share lesson plans in a timeline fashion. By using various apps, programs, and technology for their own professional purposes, teachers gain valuable insight into how these applications can be applied to student learning. Even though teachers may be aware that collaborative learning is key to being a 21st-century educator, collaborative learning among teachers has to be purposeful with useful outcomes. Professional development must reflect attention to the different kinds of knowledge and values that will increase and enhance teachers’ collaborative learning (Austin et al., 2010).

Technology never should be a placeholder for learning minutes in the school day, but rather a tool to enhance and redefine the process of learning (Gibson, 2001; Harris et al., 2009). To understand how a new technology tool would work in this capacity, educators would benefit from exploring what the tool has to offer. The Common Core Standards’

main goal is to create students that are ready for the rigors of college and careers. We will want their use of technology to mirror that goal. In 2015, the National Assessment of Educational Progress reported 61% fourth-grade reading teachers had received training in how to integrate technology in classroom instruction, up from 64% in 2009 (Bushweller, 2017). Although this upswing is promising, it may not be sufficient to meet the demands. The lack of professional development in this area is one of the most cited reasons for not implementing and integrating new technology (Fabry & Higgs, 1997; Figg & Jaipal, 2012; Groff & Mouza, 2008; Russell et al., 2003; Vongkulluksn et al., 2018). Despite efforts over the past twenty years, creating confident and willing educators that are prepared to implement technology in meaningful ways remains challenging.

Resistance to Professional Development

Even as teachers encounter increased access to technology, many continue to resist change (Fabry & Higgs, 1997; Groff & Mouza, 2008). Howard (2013) found that teacher resistance to technology is due, in part, to uncertainty and risk perception. He recommends that teachers be supported by professional development that addresses these real and perceived risks and provides continuous school-based support. Also, he suggests that professional development should give teachers time to gain familiarity with technology tools to reduce anxiety. Teachers need the time to work with the tools within a safe environment before being able to evaluate and discover their possible benefits for teaching and learning (Crippen & Archambault, 2012; Russell et al., 2003; Wood et al., 2005). In order to minimize risks, technology integration and learning objectives need to be aligned and well communicated within the school (Austin et al., 2010; Howard, 2013).

It was found that teachers' use of technology was based on their assumptions and beliefs about teaching, learning, and technology in general (Austin et al., 2010). In other words, the meaningful integration of technology comes only when it is consistent with and situated within teachers' pedagogical understanding. Technology integration must therefore be situated in the context of pedagogy and learning outcomes, rather than being presented as an end itself (Figg & Jaipal, 2012; Meyer et al., 2011; Price & Kirkwood, 2014).

While students forge ahead with technology in their personal lives, teachers, on the other hand, struggle with integrating technology meaningfully into their pedagogy (Koehler et al., 2011; Underwood & Dillon, 2011). Even new teachers, who should be more adapted to using technology, have a hard time finding ways to successfully use technology for learning outcomes (Tondeur, Pareja, et al., 2017). For many teachers, there is no clear or defining direction given by district and state agencies. Teachers are stuck in the middle of a dance between the state standards, district technology plans, decontextualized professional development, and inadequate pre-service training, leaving them hesitant to experiment in the classroom (Fabry & Higgs, 1997; Groff & Mouza, 2008; Vongkulluksn et al., 2018; Wood et al., 2005). To be successful, these efforts must be coordinated.

Alenezi (2017) discovered that when teachers implemented technology in the classroom, they felt that they lacked support. For example, when they attempted to implement or use the new innovations in their classroom, some teachers expressed that policies and security restrictions hindered their practice of new technologies and

innovations in the classroom. Teachers also mentioned that inaccessibility to resources, like computers, wireless networks, and other special devices, like iPads, or digital cameras also hinders implementation (Tondeur, van Braak, et al., 2017). According to one study, teachers do not want to lose instructional time to technology issues that may impede their effectiveness or student performance in class or on state assessments (Wood et al., 2005). This study also found that teachers feel that additional time is needed to create lesson plans that integrate technology with the right balance. At times, districts do not have enough funds to support access to technology for every staff member, teacher, and student in the classroom.

Many teachers pointed to obstacles in obtaining adequate professional development in technology, which included not being able to attend due to scheduling, the burden of having too many other obligations, and a general lack of comfort with technology. Interestingly, many teachers who were viewed as relative experts in the use of technology stated they rarely participated in voluntary or school-sponsored professional development. These self-taught teachers had an innate drive to tinker and experiment with new technologies on their own time and in the classroom. But teachers who are not able to support themselves in this way may not have the time, information, support, or incentives to continuously improve from year to year. The support of school leaders and continuous professional development are critical to helping teachers to implement new instructional strategies in line with legislative and district initiatives (Fabry & Higgs, 1997; Price & Kirkwood, 2014; Sanders & Hembrick-Roberts, 2013).

Teacher's beliefs about learning, teaching, and knowledge affect their teaching practices, and these teaching practices in turn affect the use of digital technologies. In *Teacher Beliefs and Technology Integration Practices: A Critical Relationship*, (Ertmer et al., 2012), the authors examine the external barriers that may impede pedagogically-integrated technology practices in the classroom. Their main goal in examining these barriers is to ultimately gather a clearer understanding of how the pedagogical beliefs of teachers align with their technology practices in the classroom. Their focus was built on earlier research that indicated that “external forces and expectations” and “pre-determined curricular or assessment practices” are barriers that stand between teachers’ pedagogical ideals and their actual technology integration (Ertmer et al., 2012). In their own study, Ertmer and colleagues (2012) found that the small percentage of teachers (45 of 516 surveyed) who overcame such obstacles did so by rearranging their curriculum and adjusting their pedagogy in the classroom. Technology, of course, is constantly changing. The authors, therefore, frame their conclusions around the idea that it is paramount to pedagogically integrate technology in a way that promotes deeper thinking skills and helps students to choose the right tools to solve complex problems. In short, pedagogical ends must be established to justify the means.

Defining Effective Professional Development

Given these many challenges, what can be done to help teachers develop professionally in the area of educational technology? Blank and de las Alas (2009) conducted a meta-analysis on the elements of effective professional developments based on gains in student achievement. They concluded that effective programs included

coaching, mentoring, internship, professional network, study group, coursework, and in-service. Among 16 studies, evidence showed that active learning involves discussions with colleagues, observing other teachers, and developing professional networks.

Previous studies have mentioned that “effective” professional development has three characteristics: (1) it is consistent with a teacher’s school curriculum or learning goals and/or aligned with district standards; (2) it is consistent with the day-to-day operations of schools, and (3) it is compatible with instructional practices and pedagogical knowledge (Blank, de las Alas, & Smith, 2007). If these three parameters are met, it results in improvements in teaching and the long-term sustainability of practices. The integration of technology and professional development will become more effortless when problems—such as access, platform incompatibilities, and teachers’ attitudes of online collaborative work as being ‘technological game playing’—get ameliorated, but it will also take conscious effort to align technology integration with the curriculum.

Desimone (2002) argues that a common conceptual framework of teachers’ professional development would help the general understanding of how to create learning opportunities for teachers. Desimone (2009) goes on to argue that, based on empirical research, the core features of effective professional development are content focus, active learning, coherence, sustained duration, and collective participation. Content focus refers to activities that focus on subject matter content and how students learn that content. Active learning refers to opportunities for teachers to observe others, receive feedback, and analyze student work. Coherence involves content, goals, and activities that are consistent with teacher beliefs, student needs, school curriculum, and school, district, and

state goals. Sustained duration refers to professional development that is continuous throughout the school year and includes 20+ hours of contact time. Collective participation involves groups of teachers from the same grade, subject, and school to build an interactive learning community. Based on these core features, Desimone (2009) offers five observations. First, changing classroom procedures and behavior is easier than improving content knowledge or inquiry-oriented instruction techniques. Second, teachers have different responses when given the same professional development. “Differentiated” professional development should be given to select their area of needed improvement and include collective participation. Third, professional development is more successful when linked to classroom lessons. Professional development is less effective when there is an imbalance of teachers’ pedagogy and alignment with teachers’ guidance, support, and lesson plans. Fourth, professional development research and implementation must address urban contexts (students and teachers mobility). Fifth, leadership plays a key role in supporting and implementing ideas and strategies from professional development.

The author then defines what is considered professional development. At times, professional development has formal and informal communities of learning, which cause conflicts in the measurement of effectiveness. Some types of professional development are embedded and learned within the teacher's own classroom through self- or observer-examination and reflection. Professional development is ongoing and embedded in teachers’ practice and daily lives. It should focus on the intersection of activities, subject

matter and how students learn, which results in teacher knowledge and skills, improvements in practice, and increased student achievement.

Technological Pedagogical and Content Knowledge (TPaCK)

Harris et al. (2009) argue that technology integration in classrooms is often ineffective because educators and curriculum developers fail to account for the complex and dynamic relationships between content, context, pedagogy, and technology. To address this problem, the authors propose the Technological, Pedagogical, and Content Knowledge (TPaCK) framework, originated from Shulman (1986) to detail how teachers might effectively integrate technology into teaching practice. The authors emphasize the process of learning more than the tools:

Understanding that introducing new educational technologies into the learning process changes more than the tools used--and that this has deep implications for the nature of content-area learning, as well as the pedagogical approaches among which teachers can select--is an important and often overlooked aspect of many technology integration approaches used to date. (Harris et al., 2009, p. 395)

TPaCK approaches include technology-based educational reform efforts, structured and standardized professional development workshops and courses (such as software-focused initiatives), demonstrations of sample resources, lessons and projects, and technology-focused teacher education courses.

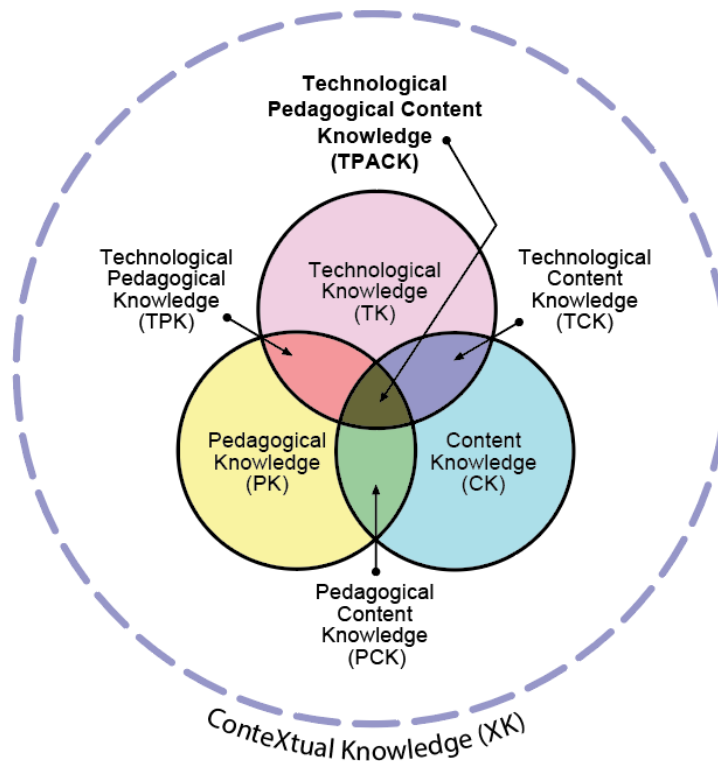


Figure 1. Revised version of the TPaCK framework.
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The TPaCK theoretical framework (Figure 1) recognizes the ways in which technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK) overlap to create unique and synthesized bodies of knowledge about how we use technology to achieve subject-specific learning outcomes. Pedagogical content knowledge (PCK) draws on Shulman’s (1986) concept of knowing how to teach specific content in a discipline. Technological pedagogical knowledge (TPK) is the understanding of how learning changes when using specific technological tools that are developmentally and disciplinarily appropriate. Technological content knowledge (TCK) is the understanding that technologies can influence the representation of knowledge across disciplines. Finally, at the intersection of the three knowledge types, TPaCK involves

understanding how pedagogical techniques that apply technologies can be used to teach content in differentiated ways. In addition, TPaCK also reveals how technology can redress conceptual gaps in students' prior content-related understanding. Contextual knowledge (XK) is the understanding of available technology, knowledge of school, district, state, or national policies (Mishra, 2019). To better understand the levels of contextual knowledge there are micro, meso, and macro factors. Micro factors are factors that involve the classroom environment. Meso factors are factors in the school of the classroom environment. Macro factors are the societal conditions that impact teaching and learning of teachers (Rosenberg & Koehler, 2015). To provide a successful, differentiated, and contextual learning environment, teachers need to develop an open mind to connect the content to technology and pedagogy.

TPaCK has been used as a framework for understanding the successful implementation of technology in schools. Harris and Hofer's (2017) study of seven Canadian schools explored how TPaCK was applied to professional development. For teachers to develop TPaCK, teachers were taught to identify the range learning activity types then learned to match these activity types to digital and non-digital resources. Effective instruction of technology derives from defining the content, process, standards, and goals of a lesson in light of students' preferences and learning needs. One suggestion is to share the range of curriculum-based activities and have teachers select among those activities to plan a new lesson, project, or unit and take account of their own students' learning needs and preferences. Another suggestion is that teachers and researchers

should compare the efficacy of students' learning through content-based activities with and without a technology focus.

Harris and Hofer's (2017) findings indicate that each site's professional culture is important and that providing the time and structure for planning curriculum and professional initiatives with teachers, staff, and administrators is fundamental to fostering the growth of teachers' TPaCK. Another major finding is TPaCK can be used as a framework to connect district professional development initiatives to teacher learning needs, knowledge, and practice. The authors conclude that TPaCK helped with 'meeting teachers where they are' by not focusing on a specific tool but rather framing the focus on the students' personalized learning needs. An additional finding was that the majority of participants in the study agreed that TPaCK should be viewed as applied knowledge rather than a theoretical framework, which means that it can be personalized for each teacher's integration level. While the schools in the study interpreted and applied TPaCK quite differently from each other, the researchers still found that a balance in content, pedagogy, and technology was essential to promoting professional development.

Teachers' strategic use of technology tools defies a one-size-fits-all approach to professional development; instead, technology use should be driven by the specific teaching and learning needs in a given context. In other words, technology use in the classroom should not be sorted, systemized, and packaged into an adoptable program or curriculum (Attard, 2017; Koehler & Mishra, 2009). The integration of technology in learning must be tailored to fit the particular learning needs of students vis-a-vis the demands of the curriculum. In addition, administrators and teachers face the ongoing

challenge of advances in technology that require ongoing adaptations to the curriculum (Wood et al., 2005). The lack of time for planning, implementing, integrating, and updating technology becomes a challenge for teachers' TPaCK development. Having limited time to prepare, learn, and teach technology-integrated content appropriately can hinder TPaCK development and progress.

In addition, technology is not the solution to every problem, and it is reasonable to decide that digital technology is not appropriate to use for all student activities, tasks, or learning processes. Therefore, teachers should not feel compelled to turn to technology for its own sake (Chou, 2011, Gibson, 2001). Teachers must develop TPaCK not to make themselves effective users of educational technology, but rather effective designers of technologically rich learning experiences (Ciampa & Gallagher, 2013).

In that end, the TPaCK framework is just that, only a theoretical framework. While it indeed offers a viable and much-needed philosophy for integrating educational technology successfully, it falls short of explaining what this looks like in action, how to measure its effectiveness, and how to employ it in various contextual learning processes. As Chai, Koh, and Tsai (2013) suggest, "TPaCK still needs to be further understood and developed into an actionable framework that can guide teachers' design of ICT [information and communications technology] interventions" (p. 31). Some studies, however, point to promising directions for promoting the development of TPaCK in teachers. Koehler and colleagues (2011) mention the idea of teachers themselves being designers since most technology is not designed for educational purposes. Teachers can recreate or explore other options for using a specific technology tool, rather than using it

for the one sole purpose for which it was designed. Teachers will need content knowledge, pedagogical approaches, and technology know-how to be able to experiment with new ideas and technology uses (Malik, Rohendi, & Widiaty, 2019). This approach of learning technology with deep play, exploration, and reflection will advance teachers' TPaCK. "Through the design process, learners must consistently work at the nexus of content (what to teach), pedagogy (how to teach it), and technology (using the tools)" (Koehler et al., 2011, p. 151).

Finding Innovative Solutions through Design Thinking

In many ways, design thinking is a perfect context for teachers to combine their knowledge of technology, content and learning to meet the needs of their students. It also embeds many of the features of effective professional development outlined by Desimone (2009). In the qualitative study, *Design thinking: A Creative Approach to Educational Problems of Practice*, the authors examine a graduate teaching course using design thinking to approach their problems of practice (Henriksen et al., 2017) and after working through the five core design thinking skills—empathizing, defining problems, ideating, prototyping, and testing, teachers deepened their understanding and practice. In each stage of design thinking, themes emerged from the process. In the empathy stage, teachers discovered that questioning, recognizing, and challenging their own assumptions led them to help understand their students. During the definition stage, teachers viewed their problem from multiple perspectives, which enriched their understanding. In the ideation phase, teachers recognized ideas from brainstorming and prompted them to think of more than just one idea. In the prototype phase, they focused on building something

real from their ideas and risked failure. In the test phase, teachers found that this phase can be geared to learning and reflection. After failing, they discovered how improvements could be made, and more learning took place.

In *Design Thinking for Education*, Koh, Chai, Wong, and Hong (2016) explore the design thinking cycle as a method for professional development and pedagogical design. The researchers view this as a potential system to foster the design mindset in teachers and pedagogy to promote deeper understanding among students that is integrated with technology. This study focused on Taiwanese preservice middle school teachers utilizing the design thinking method to create math lessons to promote extensive learning. The study concluded that the design thinking model can increase teachers' abilities to learn from their mistakes and grow as educators. The ability to generate new ideas beyond their knowledge base increased, which improved their teaching practices over time.

However, the researchers emphasized that developing and sustaining design thinking concepts among teachers requires continued support from administrators and the development of a professional culture that promotes experimentation and reflection (Baran & Uygun, 2016). Administrators, district personnel, and teachers are responsible for changing their mindsets. As teachers dive into knowledge building with design concepts, so must administrators become learners and collaborators within the process (Wieczorek, 2017). Teachers and administrators that work together can continue to build new knowledge and the values of the school community.

TPaCK and Design Thinking

The act of integrating educational technology by the teacher mirrors the same skill set educators aim to develop in students, prompting the question, “When is it appropriate to use technology and which technological tools will be most effective at enhancing learning?” To create a fundamental change, this type of shift means emphasizing the learning process rather than the results. It foremost implies a focus on creating new adaptations to technological and pedagogical methods and design learning experiences (Starkey, 2011). Developing this mindset and skill-set among educators is where the TPaCK theoretical framework can be extended into a method that develops and promotes learning by a design mindset. Chai et al. (2013) consider learning by design to be a suitable focus for further research because teachers can change their teaching practices and pedagogical beliefs with technology.

This hands-on approach has helped teachers develop a deeper understanding of TPaCK (Harris et al., 2009, Koehler et al., 2007). At the heart of the design thinking method, an emphasis on what Stanford’s design school calls “bias towards action” refers to creating a new mindset of simply doing and learning from the process. Archambault, Wetzel, Foulger, and Williams (2010) examined curriculum projects addressing TPaCK, the impact of redesigned instructional units, instructors’ perceptions, and their roles within professional development workshops and activities. The instructors that participated in the professional development workshops and activities noticed that through various social networking tools, students and instructors were able to provide more feedback. In addition, students were able to reflect on the process of their learning,

therefore shifting their technological pedagogy, or their understanding of how they learn best from technology. This study offers insight into integration processes of student learning; the transformation of the instructor's role from lecturer to facilitator; and the transition from teaching to students to learning with students.

Again, in design thinking, one must first simply do and be able to reflect on the experience to develop contextualized knowledge that serves their pedagogical needs (Wrigley & Straker, 2017). This, of course, can be applied quite neatly in the context of developing teachers' technological knowledge into TPK. Reimagining professional development will be essential to promoting this transition in teacher mindsets. Attempts at formulating an adoptable technology integration model or system, such as TPaCK, still fall short of being actively effective in the classroom when the professional development model itself does not mirror the theoretical construct inherently promoted by the technology model (Foulger, Buss, Wetzel, & Lindsey, 2015; Kimmons & Hall, 2018).

Effective professional development providers understand that teachers need to develop more than just their knowledge of technological tools. To enhance the integration of technology, professional development should foster an experimental culture that prides itself on learning from mistakes and critical self-reflection (Ciampa & Gallagher, 2013). Putting this in perspective requires seeing each community of educators as the prime architects and critical designers of a student-driven learning process (Kirschner, 2015). Experimentation can only thrive in an environment that is driven by student needs. In other words, pedagogy design is not merely pre-written lessons, or a blind application of curriculum adopted by districts or schools, but rather an ever-changing set of practices

developed by experimentation, reflection, and redesign (Koehler et al., 2011; Meyer et al., 2011; Wrigley & Straker 2017). This is the professional environment that must be fostered in our schools. Professional development for educators and learning professionals should model the integration of technology in context within their learning communities individually and in a group (Loveless, 2011; Pea, 1993; Pickering, Daly, & Pacher, 2007; Uerz, Volman, & Kral, 2018).

Harris et al. (2009) suggest that in order for teachers to develop TPaCK, the first step involves creating an awareness of all the possible learning activity types and matching them to both digital and nondigital methods. Effective instruction with technology combines students' preferences and learning needs that derive from defining the content, process, standards, and goals of a lesson, project, or unit. As a result, it is less challenging for teachers to match particular digital and nondigital activities with the content of what the students are learning and what kind of technology is used. The selection process focuses on the students' needs and preferences while taking into account their past experiences and the curriculum. The process should not be definite, and it shouldn't be just an activity to be done. Teachers' effective use and teaching are demonstrated through pedagogy, content, and technological expertise working together.

TPaCK-based professional development needs to provide an environment inclusive of a range of teaching philosophies, styles, and approaches that teachers bring to their work with students (Malik et al., 2019). One approach from Harris et al. (2009) is to share the range of curriculum-based activities and have them select among those activities to plan a new lesson, project, or unit and take into account their own students' learning needs and

preferences. Another suggestion is that teachers and researchers should compare the efficacy of students' learning through content-based activities with and without technology focus. Another recommendation is to create additional models and examine other TPaCK-based professional development models, such as design thinking. Using content as a focus to organize learning, teachers can identify, discuss, select, and apply TPaCK-based activity types within the curriculum (Enderson & Watson, 2019). Teachers become the creators and designers of their instruction (Uerz et al., 2018).

For professional development to be meaningful, fostering technology use should be a two-way street. On one end, the presenter is taking into account the local education culture and providing pedagogical support that relates a broader understanding of the applications and effects of technology influence in the classroom. Professional development for educators should model the integration of technology in context within authentic learning communities (Loveless, 2011; Pea, 1993; Pickering, Daly, & Pacher, 2007). On the other end, however, the educator has to be willing to become researchers themselves. By realizing that effective educational practices are rooted in evidence-based research, and dabbling in a bit of research themselves, they are empowered “to gain [their] own autonomy and respect from governments and researchers of all disciplines [and] become an increasingly important part of the systemic process of change” (Davis, 1999, p. 11).

Furthermore, educators that view themselves as technologically inept will have to become comfortable being the student, as they will need to learn the same language. An inside-out approach to professional development requires educators willing to invest in

research and maintain a student-like approach to experimenting with new practices (Kirschner, 2015; Uerz et al., 2018). Professional development is more effective when teachers bring something to the table. Teacher professionalism, in the context of collaborative learning, means displaying the right values, using craft knowledge to turn big ideas into realistic classroom practice, and engaging in the kind of critical reflection that can get the best out of imperfect technology and adopt innovative ways of working (Austin et al., 2010; Ciampa & Gallagher, 2013). By giving opportunities to the teacher to become aware of their own knowledge, their willingness to learn can shape their own pedagogy, rather than continuing to use the one-size-fits-all approach (Loveless, 2011).

According to Rodgers (2002), in its ideal form, learning should take the form of inquiry, which comprises asking questions, investigating solutions, creating new knowledge as information being gathered, discussing discoveries and experiences, and reflecting on new-found knowledge. Educators are empowered when their pedagogy is student-centered and student-driven; it is immediate feedback and it is in opposition to data-driven analysis and planning. Wiczorek (2017) frames his study on earlier research from Bredeson (2000), who identified multiple domains that would allow teachers to become active decision makers for student learning and school resources. The principal would be required to be a leader by learning along with teachers. For districts and administrators to understand this change, in which educators can experiment and develop technology-enhanced pedagogies with a direct reflection and meaningful connection to student learning, a safe inclusive environment needs to be established. The ever-changing nature of technology requires a different approach to professional development, one that

mirrors the skill-based development among students of the Common Core Standards rather than the content knowledge of past benchmarks (Enderson, & Watson, 2019).

Design thinking offers a model which can bridge the change in teachers' and leaders' mindsets, creating a level playing field in which everyone becomes a collaborator.

Allowing teachers to take the helm will give them confidence and ownership of technology integration:

Less tractable, however, is a tension between institutional concerns with standards and quality of teachers' desire for freedom and creativity - a tension that could impinge on the acceptability of these tools to teachers, if they are introduced in a top-down manner. Thus, for research into design support tools to have a real impact on teachers' practice... (Masterman & Manton, 2011, p. 244)

Effective Professional Development and Design Thinking

Design thinking supports professional development through the creation and design of play. When creating a purpose, the word design connotes that there are variables to take into consideration. Likewise, with respect to execution, to create means to take design into consideration. These two have a place in professional development as teachers should be in a state of designing and creating to meet students' diverse needs.

While some examples of the inside-out model of professional development have been implemented, there is recognition (Darling-Hammond, 2006; Finefter-Rosenbluh, 2016; Polly & Hannafin, 2010) that more profound change is needed. Design thinking, in particular, is blossoming as a system that can be applied to different professional development situations. Originally a model of thinking for product design, the process is getting recognition for showing promise in an education setting (Henriksen et al., 2017; Wrigley & Straker, 2017). Student needs would be placed in the center of the system and

the process would build solutions around these needs based on what teachers are doing in their classrooms (Tondeur, van Braak, et al., 2017)—rather than the top-down, standardized version of professional development, which too many teachers receive now. In this model, teachers would be responsible for the agenda and outcomes of professional development. In a way, administrators would be learning from their teachers instead of merely dictating and facilitating. Cooperation and learning between teachers and administrators will depend on openness, mutual trust, and communication (Vanblaere & Devos, 2016).

Self-reflection is another important component of an inside-out model of professional development. When teachers have a chance to share and reflect, they gain valuable feedback from their peers (Ciampa & Gallagher, 2013; Uerz et al., 2018). Teachers need time and experience in this kind of work to be able to stand back from the detail of managing what their pupils do to undertake the kind of critical reflection that leads to metacognition (Austin et al., 2010). This collaboration is essential to taking stock of what works and what does not work, discovering tweaks and revisions to current methods, then applying them once again to experimentation.

Community of Practice

For educators to draw value from professional development programs, including those in educational technology, collaborative learning and discussion needs to reflect a view from inside the classroom. Phillips (2012) reviews the literature on the CoP as a framework to develop teachers' TPaCK and mentions Wenger's perspective on CoPs. Wenger (2011) defines a CoP as collective learning within a shared domain of interest

where practitioners share experiences and resources. Members' relationships are essential to promoting a community that values new knowledge and solves problems with a collective voice. Knowledge, skills, and attitudes shift through mutual encouragement and learning (Chang, Hsu, & Ciou, 2017). Phillips (2016) examines how TPaCK may be seen through the communal and individual perspective and is determined by identifying the processes of practice and development, which indicates that TPaCK is ideation and a process of knowledge. The identity formation processes and participation practice processes (mutual engagement, shared repertoire, joint enterprise, reification) are factors in teachers' TPaCK representation (An & Reigeluth, 2011; Phillips, 2016).

CoP in education has proven to be an effective context for professional development because it is a set of people who share a concern, a set of problems, or a passion about a topic, who deepen their knowledge and expertise in this area by continuous interaction (Ng & Tan, 2009; Wenger et al., 2002). Educators are actively, collectively, and critically reflecting on educational goals, values, and the issues of equity and social justice while also taking the initiative in their learning (Ng & Tan, 2009). Inexperienced and experienced teachers will gain resources and confidence in their learning and skills by sharing their own experiences of knowledge and research within a school context (Woolway et al., 2019). Collaboration and discussion through collaborative communities allow teachers to analyze and reflect on their teaching practices and students' learning, which then contribute to teachers' professional development (Austin et al., 2010; Ciampa & Gallagher, 2013; Levin & Wadmany, 2005). This fosters a place where teachers can share their practices to sustain instructional improvement and create opportunities for

dialogue. To create a sustainable professional development, collaborative definition, discussion, and solutions will improve teachers' practice while reflection on and participation and confidence in unfamiliar content will develop (Chou, 2011; Woolway et al., 2019).

How TPaCK, CoP, and Design Thinking are Connected

Technology in education is not just a new strategy or tool, but a new paradigm of thinking and interface to promote learning. It is a tall order to think teachers can become comfortable with effectively integrating technology with a professional development that does not address teachers' needs. To meet the challenge, professional development workshops in technology will need strong support from the local professional community, including principals, coaches, and administrators (Kimmons & Hall, 2018; Wieczorek, 2017; Vongkulluksn et al., 2018). In addition, these workshops will need measurability plans that recognize and support these efforts (Fabry & Higgs, 1997; Groff & Mouza, 2008; Wood et al., 2005; Vongkulluksn et al., 2018).

Figure 2 summarizes the conceptual framework driving professional learning in this study. The stages of the design thinking process, TPaCK, and the components of an effective professional development work together to provide meaningful integration of technology with teachers. The CoP is a context in which teachers can support one another in the meaningful integration of technology in teaching. However, to be effective, the CoP must have three mutually supportive elements at play: the design thinking process; having effective professional development; and the teachers' TPaCK.

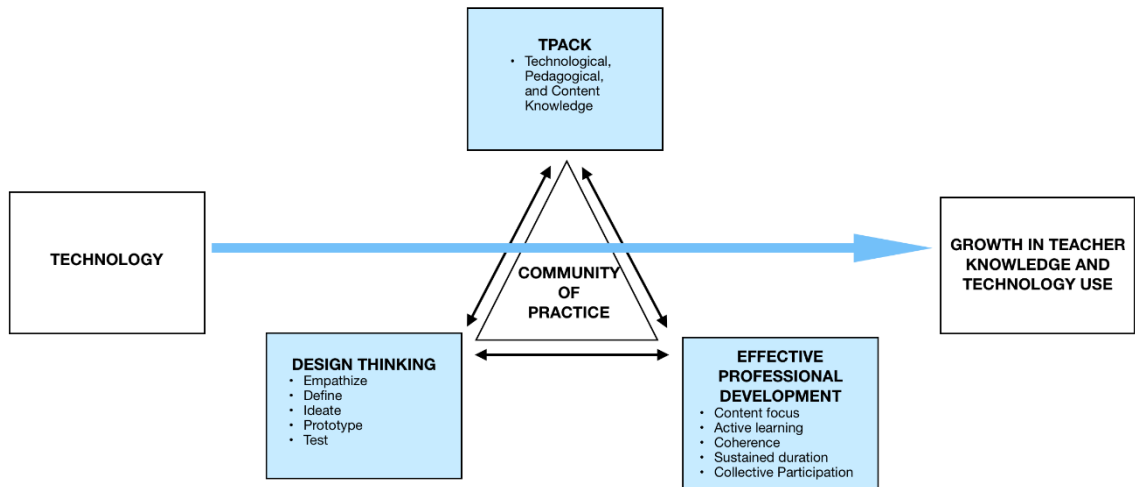


Figure 2. Conceptual framework utilizes literature on effective professional development (Desimone, 2009), TPaCK (Harris et al., 2009), CoP (Wenger, 2011), and design thinking.

Effective professional development which incorporates content focus, active learning, coherence, sustained duration, and participation with teachers' TPaCK is important to the growth of teacher knowledge and technology use. To have an effective professional development focused on developing teachers' TPaCK, a process such as the design thinking must be incorporated simultaneously. For example, the empathy and definition stages of design thinking develops the understanding of the problems and challenges with multiple perspectives with the use of technology. The ideation stage helps identify many solutions. The test and prototype stages provide the time to test their ideas and prototype solutions, crucial moments for teachers' learning and the growth of teachers' TPaCK. The CoP provides the space for teacher thinking while providing the support from a community that they trust. Design thinking is the process through which a CoP and effective professional development can occur to foster teacher knowledge and technology use. CoP is the context, design thinking is the process, and the components of an effective

professional development are the structure in which TPaCK is being transformed into growth in teacher knowledge and technology use.

The process can instill positive value beliefs in technology to help overcome teachers' perceptions of their limits to technology integration and make learning relevant to them (Henriksen et al., 2017). The CoP can support and instill teachers' beliefs and applications of classroom technological usage and give the ability to reflect on and develop their professional learning (Polly & Hannafin, 2010; Wieczorek, 2017). In professional learning, reflection, discourse, and teacher differentiation must be considered given teachers' prior experiences and knowledge of technology usage (Ciampa & Gallagher, 2013). Opportunities for effective professional learning in professional development workshops with CoP and the design thinking process will engage reflection, collaboration, and discourse that can contribute to technological teaching and learning experiences in the classroom. When teachers lead the process to create, present, and collaborate in professional development activities, growth in teacher and student learning outcomes can occur (Attard, 2017; Wieczorek, 2017).

The design thinking method to revitalize the facilitation of professional development with the goal of effectively training teachers to appropriately integrate technology in the classroom. Professional development design is still discovering the methods and structures that are most effective in creating confident and willing educators that are prepared to implement technology in meaningful ways. Teachers' beliefs of learning, teaching, and knowledge affect their teaching practices, and these teaching practices affect the use of digital technologies. Through the design thinking process of

empathizing, defining, ideating, prototyping, and testing, teachers' TPaCK did change. Providing a CoP structured around the design thinking method, teachers had an environment that they could explore, discuss, and problem solve technology approaches and tools that connected to student learning.

Chapter 3: Methodology

This study examines whether and how teachers demonstrate TPaCK when they engage in a CoP structured around design thinking. In addition, teachers' perceptions of the process and outcomes of this experience are examined through surveys, exit slips and a focus group. This chapter provides the study's research design and methodology, starting with a review of the research questions, followed by a description of the study site, research participants, survey instrument, exit slip instrument, and focus group questions. A description of the data analysis methods and a discussion of limitations is also provided.

The following research questions guide this investigation:

1. Is there evidence of growth in teachers' TPaCK and technology integration over the course of time? If so, what is the nature of this growth? (RQ1)
2. In what ways do teachers' TPaCK and technology integration emerge as they engage in design thinking in a community of practice? (RQ2)
3. How do teachers evaluate the process and outcomes of this professional development experience? (RQ3)

Research Study

This study focuses on the development and growth of teachers' TPaCK and technology integration after design thinking steps are applied to professional development workshops and post-workshop meetings of participants in a CoP. After a series of design thinking professional development workshops, teachers were invited to participate in a CoP for the purpose of integrating instructional technology in their

classrooms. The CoP, comprised seven teacher participants, met three times from October-January 2020 to focus on the iteration stage of design thinking. During each CoP session, interested teachers discussed TPaCK and technology integration as they engaged in the design thinking process. Participants were surveyed throughout the study and they took part in a focus group after the study to reflect on the process and outcomes of this professional development experience.

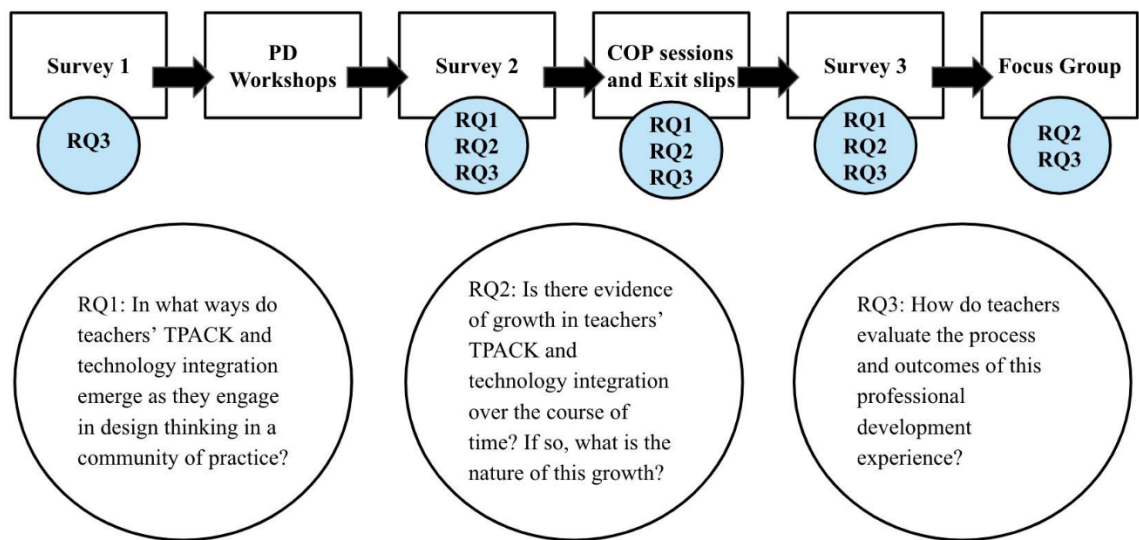


Figure 3. Data collection process.

Research Design and Procedures

This convergent parallel mixed-methods study (Figure 3) examines teachers' thinking about technology integration as it unfolds in a CoP structured around the design thinking framework. An embedded-experiment, mixed-method design is used to examine teachers' TPaCK, their integration of technology in design solutions and their impressions of the professional development experience. During the first phase of the study, teachers engage in a series of professional development workshops that focus on the design thinking process. The professional development workshops focus on the first

two stages of the design-thinking process—Empathize and Define—with the goal of making teachers more adept and comfortable at integrating technology strategically and successfully in the classroom. Teachers choose one unit in the district-adopted Language Arts curriculum and analyze the unit from the student perspective to consider opportunities for active engagement or when students are in the act of doing. Teachers decide which element of the 4C model (communication, collaboration, critical thinking, or creativity) is most emphasized during the unit. Teachers then map the sequence of all 4C activities over the entire unit. Finally, teachers define a problem to address in student learning, as they support ELD students in learning the critical element of the 4C model for that unit. During the next professional development workshop, teachers explore a wide variety of technology tools from virtual reality kits, Ozobots, and software programs such as Flipgrid, Adobe Spark, Thinglink, Synth, Book Creator, and Seesaw. Another professional development workshop focuses on examining the uses of technology tools with their curriculum unit map that includes the 4C activities and ELD support. These first two stages prepared the teachers to start exploring how they might use technology to address this stated problem.

Community of Practice Sessions

The CoP sessions picked up the design thinking process where teachers left off. It provided a context for teachers to iterate through the other three stages of the design thinking process: Ideate, Prototype, and Test. The CoP sessions focused on how teachers can strategically integrate classroom technology to promote student-centered learning. To do this, teachers analyze adopted Language Arts curriculum from a student perspective to

identify strategic opportunities for students to utilize the 4Cs to enhance their access to the curriculum and concepts. In subsequent professional development workshops, teachers matched appropriate technology tools to enhance those 4C activities. Teachers ideated at least three different curriculum sequences for one Language Arts unit to prototype in their own classrooms. Future sessions (beyond the scope of this study) will then see teachers coming back to share and unpack their experiences with the sequences to modify and continue to reiterate the process.

The CoPs also provided a space for teachers to reflect on the process and the facilitation of the CoP sessions. Teachers analyzed and determined if the professional development methods were successful in making them more confident in pedagogically integrating technology. In doing this, the hope was that teachers felt they had more ownership and control over their professional learning as they become part of the process to help design the facilitation of future professional development. These CoP sessions involved a smaller number of teachers.

Survey data was collected before and after these workshops to measure teachers' perceptions about the effectiveness of the workshops and to design activities for the second phase of the study. During the second phase, teachers engaged in a series of CoP sessions structured around three phases of the design thinking process (Ideate, Prototype, Test). Each session began with a review of the previous session. It then proceeded to the current phase of design thinking.

Community of Practice 1: Ideate. In CoP session 1, teachers discussed the challenges that they faced in implementing the literacy curriculum with the focus of

engaging all students. Teachers ideated as many ways to solve those challenges and discuss if some technology tools and resources can engage students and solve their challenges. The teachers analyzed and determined which technology tools will best enhance each 4C-activity within their literacy unit sequence from the professional development workshop.

Guiding questions of CoP 1:

1. How do you view technology's role in the classroom?
2. What are some challenges in the literacy curriculum?
3. What are some challenges in the curriculum or literacy instruction that you would like to see solved by students using technology?
4. What are some initial ideas to resolve those challenges?
5. What do you look forward to seeing in your instruction and student learning by integrating new technology tools in your literacy instruction?
6. What support do you need to be successful in integrating technology into your curriculum?
7. So far, as you have participated in the multi-part technology professional development, what are some aspects of the professional development that have helped reach your professional goal?

Community of Practice 2: Prototype. In CoP session 2, teachers came back from exploring the different prototypes which focused on promoting literacy with the use of technology. Then, teachers prototyped at least three different variations (or prototypes) so that each teacher could test each one in their classrooms and bring back for the next CoP.

Guiding questions of CoP 2:

1. What is your process of researching?
2. If you don't know how to do something with technology, what do you do? What can you do when you don't know something about technology?
3. What are some examples of where technology can be used to promote literacy? With English language development?
4. What are some examples of where technology can be used to promote student learning and the 4 Cs (communication, collaboration, critical thinking, and creativity)?
5. With all these examples listed: what are some questions you have about that idea? What are some changes to the idea you might test to address these questions?
6. What evidence are you going to bring back for our next CoP?

Community of Practice 3: Test. In CoP session 3, teachers brought back their experiences of testing each prototype in their classroom and reflected on what worked and what did not work. From here, teachers reiterated the ideation and prototype phase of the previous sessions to further refine the Language Arts unit and the integration of technology tools.

Guiding questions for CoP 3:

1. What is the lesson you modified and how did you use technology in that lesson?
2. Would you use the technology again? Why or why not?
3. What examples worked and didn't work in the lesson?
4. Would you do this literacy lesson again? Would you modify it?

5. Did this give you other ideas for other lessons? Other content areas?

Each session concluded with an exit slip on which teachers recorded the goals and implementation plan for their next phase. The investigator recorded each session for later transcription and took field notes to identify instances of teachers engaging in TPaCK and technology integration during their CoP session. After the completion of the last CoP session, teachers were invited to take part in a focus group interview regarding their impressions of the process and outcomes of the CoP sessions. The investigator recorded the focus group interview for later transcription.

Primary data, used to answer RQ1 & RQ2, came from surveys 2 and 3, recordings of teachers' CoP meetings, field notes taken by the investigator, exit slips completed after each CoP session, and the focus group interview. These data captured teachers' TPaCK and their plans for integrating instructional technologies into their curriculum. Secondary data, used to support the design of professional development meetings and to answer RQ3, came from a survey of teacher TPaCK (adapted from Schmidt et al., 2009) and a focus group interview. These data comprised teacher feedback regarding the process and outcomes of the professional development activities (see Figure 4 for an overview of the study and data collection).

Participants and School Context

This study involves TK-5 teachers at Laurelwood Elementary (pseudonym), a suburban elementary school in the San Francisco Bay Area of California. Of the total of 18 teachers at Laurelwood, 17 teachers have taught more than four years at the school site. All teachers participated in the literacy and professional development workshops of

the Empathy and Definition stage. At the school site, half of the participating teachers have experience in teaching a grade combination class. Six participating teachers will be represented by their grade level in the CoP. Six of the participating teachers in the CoP are females. Teacher names (pseudonyms) and demographic information are provided in Table 1.

Table 1

Community of Practice Teachers and Their Demographic Information

Name (Pseudonym)	Gender	Grade	Years of Experience
Anna	F	K	12+
Laura	F	K/1	6-8
Tina	F	3	12+
Jessica	F	4	6-8
Evelyn	F	4	12+
Elena	F	5	1-2
Mike	M	5	9-11

The San Francisco Bay Area is home to many innovative high-tech and financial companies. Educational technology initiatives are a prominent feature of this highly populated area. Like most urban centers in the United States, there are both affluent and economically disadvantaged neighborhoods in this region. Future Ready is a network of educators that emphasize vision, culture, strong pedagogy, goal setting, leadership, and the role of people in personalized learning with technology to create a rigorous and engaging student-centered environment. According to the U.S. Department of Education, Future Ready Schools' pledge is a blueprint to move districts forward in career, college, and citizenship (Future Ready Schools, 2015) and is a hub for personalized and digital learning that aligns with instructional practices and technology. In June 2019, Laurelwood Elementary school district received the Digital Learning Readiness report from Future Ready and 2.6% of teachers agreed that professional learning opportunities

provided by the district model effective applications of 21st century skills. The school district in which Laurelwood is located serves over 5,000 students and the TK-8th grade includes roughly 5 middle schools and 10 elementary schools. Laurelwood has an enrollment of approximately 500 students, 30% of whom were eligible for free or reduced-price meals in 2017-2018. Fifty percent of the enrolled students were designated English learners in that same year. The school recently has made some updates to modernize its facilities, including a new flexible instructional space. Other updates include new Apple-TVs, HDMI projectors, document cameras, online resources through Clever portal with access to various learning applications, and updated WIFI for every classroom. The flexible instructional space also houses new technology tools such as flat-screen TVs, projectors, document cameras, and mobile whiteboards. Additionally, the school has a 1:1 ratio of students to Chromebooks along with two carts of 30 iPads that are shared among staff. Since the professional development workshops, sessions, and focus groups will take place in the flexible instructional space, data collection will occur in the flexible instructional space.

Data Collection and Instrumentation

TPaCK survey. The Schmidt et al. (2009) survey was developed by a team of researchers from Iowa University and Michigan State University to measure teachers' confidence in their TPaCK. The modified survey will include 28 Likert-type items ranging from strongly disagree (1) to strongly agree (5). Two additional open-ended questions about participants' professional development experience are also included in the survey. Please refer to Appendix A for the full list of survey items. The survey was

given before the professional development workshops, after the professional development workshops, and after the CoP sessions to capture changes in teachers' confidence in their TPaCK. Teachers' responses to the open-ended items on the survey provided insight into how teachers evaluated the process and outcomes of their professional development experience.

Field notes and recordings of the CoP sessions. After the professional development workshops, the teachers who elected to continue in the study formed a CoP and participated in a series of sessions structured around design thinking. CoP dates were decided by the participating teachers. The CoP met 3 times in November-January of the 2019-2020 school year. The researcher conducted, led, and audio recorded all of the CoP sessions, which was transcribed for data analysis. The researcher also took field notes regarding teachers' use of TPaCK in order to augment and to facilitate the analysis of audio recordings. Together, the transcriptions of audio recordings and field notes were used to explore whether and how teachers engage in TPaCK and technology integration (RQ1) and whether there was evidence of growth over time (RQ2).

Exit slips. After each CoP session, teachers completed an exit slip with four questions:

1. What worked for you today?
2. Why did it work for you?
3. What's one idea that you want to take back with you to apply in your classroom before the next session?

4. What can we prepare for you next time to take you further in your learning? What do you need?

The exit slips were intended to (1) help drive future CoP discussions, (2) provide evidence of teachers' TPaCK and emerging technology integration (RQ1), (3) provide evidence of TPaCK growth and integration of technology (RQ2), and (4) allow for evaluation of the process and outcomes of their experiences (RQ3).

Focus group interview. The focus group interview took place after school, once all three of the CoP sessions and survey had been completed. The following questions guided the focus group:

1. After participating in the CoP, what worked well for you? Give examples.
2. Was there anything you would change to make the process work better for you?
3. Did you find yourself more open or more willing to try new things with technology in your classroom after professional development? Give examples.
4. Do you see yourself integrating technology in other subjects? If so, what would you do?

Refer to Figure 4 for a summary of research questions and instrumentation.

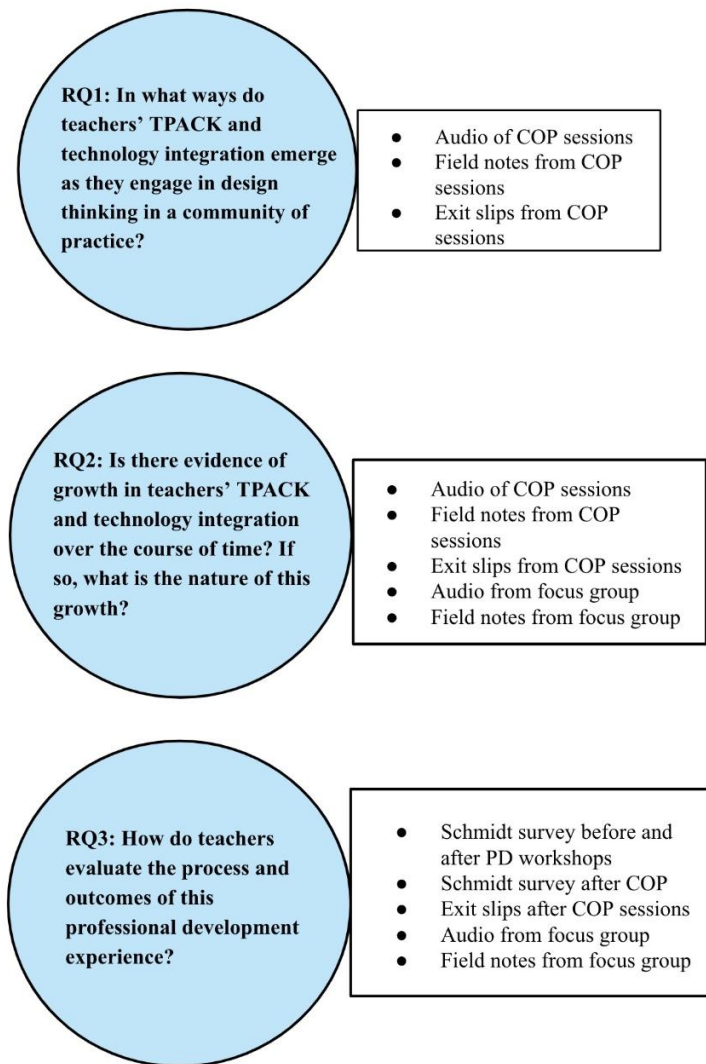


Figure 4. Research questions and instrumentation.

Data Analysis Procedures

As mentioned, TPaCK surveys were given before and after the professional development workshops, as well as after each of the CoP sessions. Surveys were created in Qualtrics, for which San José State University and the participating school district both have licensing agreements. The survey data examined teachers' TPaCK confidence and the process and outcomes of professional development.

Desimone & Garet's (2015) *Best Practices in Teachers' Professional Development in the United States* considered five features in a professional development that will improve teaching practice and student learning. In pursuance of an effective professional development program, the CoP consisted of teachers collectively participating and actively learning with content and goals that were consistent with curriculum and teachers' beliefs during the 2019-2020 school year. The CoP was designed to follow the first three elements of Desimone's (2009) theory of action—to teachers experienced effective professional development, the professional development increased teachers' knowledge and skills and/or change their attitudes and beliefs, and teachers would use their new knowledge and skills, attitudes, and beliefs to improve their instruction and/or pedagogy.

CoPs and the focus group interview were audio recorded and field notes were taken to identify and examine teachers' TPaCK growth and perceptions of the process and outcomes of CoP. The CoP exit slips and conversations were also coded and analyzed for TPaCK core competencies and technology usage. In the Yurdakul et al. (2012) study, the researchers created a TPaCK scale of core competencies with indicators of each core competency. The six TPaCK competency areas were designing instruction, implementing instruction, innovativeness, ethical awareness, problem solving, and field specialization. In this study, I coded the CoP dialogue of each session from the audio recordings for three of the core competency areas. Please refer to Table 2.

Table 2

TPaCK Core Competencies and Indicators

TPaCK Core Competencies	Competencies	Indicators
Designing Instruction	Analyzing the current situation prior to the teaching process	Conducting needs analysis regarding technologies to be used in the teaching process
	Determining appropriate methods, techniques and technologies to be used in the teaching process	Choosing the most appropriate technology to prepare an educational environment to present up-to-date information
	Organizing environments and materials to be used in teaching	Developing interactive teaching materials appropriate to different learning theories
	Developing materials, environments, activities, and measurement tools to be used in the teaching process	Updating the design and content of digital educational material with respect to the learning levels of students
	Planning the teaching conditions	Using search strategies to access online sources in planning the taught content
Innovativeness	Following up-to-date information about content	Using technology in the process of updating knowledge and skills regarding the document
	Following up-to-date information about technology	Updating knowledge about technology used in the process of teaching the content
	Following up-to-date information about the teaching process	Benefitting from new online environments to support the teaching-learning process
	Integrating innovations in real life into the teaching process	Using technology in updating knowledge and skills regarding the process of measurement and evaluation
Problem Solving	Solving problems regarding the teaching process	Solving basic problems with technological tools used in the teaching process
	Solving problems regarding the content information	Using technology for solving problems that are likely to occur in the teaching-learning process
	Solving technology-related problems	Using technology for producing solutions to problems experienced while structuring the content

Note. Adapted from “The development, validity and reliability of TPACK-deep: A technological pedagogical content knowledge scale,” by Yurdakul et al. (2012), *Computers & Education*, 58(3), 964-977.

Each of the indicators of the TPaCK core competencies; designing instruction, innovativeness, and problem solving were given a letter and numerical code. For example, the TPaCK core competency of designing instruction was coded as D1, D2, D3, D4, and D5. For the TPaCK core competency of innovativeness was coded as I1, I2, I3, and I4. For the TPaCK core competency of problem solving was P1, P2, and P3. The CoP transcriptions were also coded for CK, PK, PCK, TK, TPK, TK, TCK, XK, and TPaCK. Refer to Table 3 below.

Table 3

Data Analysis Codes

Code	TPaCK	Code	Indicators
			<i>Designing instruction</i>
CX	Context	D1	Conducting needs analysis regarding technologies
		D2	Choosing the most appropriate technology
PK	Pedagogical Knowledge	D3	Developing interactive teaching materials
		D4	Updating the design and content of educational material
TK	Technological Knowledge	D5	Using search strategies to access online sources
			<i>Innovativeness</i>
TPK	Technological Pedagogical Knowledge	I1	Using technology in the process of updating knowledge
		I2	Updating knowledge about technology used
		I3	Benefiting from new online environments
CK	Content Knowledge	I4	Using technology in updating knowledge and skills
			<i>Problem Solving</i>
TPaCK	Technological, Pedagogical, and Content Knowledge	P1	Solving basic problems with technology tools (teaching process)
		P2	Using technology for solving problems (teaching-learning process)
		P3	Using technology for producing solutions (structuring content)

Harris, Grandgenett, and Hofer's (2012) study tested an instrument for using structured interviews to assess teachers' TPaCK. The criteria of Harris, Grandgenett, and Hofer's (2012) instrument will be used to measure teachers' TPaCK in the CoPs and

focus group interview. Teachers' TPaCK were coded for fit, technology selections, curriculum goals and technologies, and instructional strategies and technologies. The instrument was cross mapped with the adapted version of Yurdakul, Odabaski, Kilicer, Coklar, Birinci, and Kurt's (2012)'s TPaCK scale. I coded for technology selection with curriculum alignment, if it supported instructional strategies, if it was compatible to both, and if the instructional strategies, content, and the technology fit together.

Validity

To ensure transparency of process and increase study validity, data analysis included (1) expert review, conducted by doctoral committee members, of samples of coded transcript data; (2) an audit trail, noting the time elapsed between data collection and analysis and all decisions made regarding adaptations to instrumentation, procedures, coding and analysis of data; (3) member checks of the survey and focus group data used to answer RQ3. Two raters trained on the coding scheme using approximately one-third of the data. Inter-rater reliability was calculated using another one-third of the data and reached 89.7% exact agreement. Discrepancies in coding were resolved by dialogue.

Addressing Ethical Considerations, Limitations, Positionality

Being a teacher at the school with over fourteen years of experience, I experienced designing and facilitating professional developments with instructional coaches, administrators, and other teacher leaders. The professional development workshops that I'm leading may affect the effectiveness of the professional development workshops since I have facilitated previous professional development workshops. Teachers may see that the professional development as a designated district professional development. I

will address this concern that the professional development workshops are for this study only. As a leader of the study, the professional development workshops will be facilitated by the school technology lead and the administrator during the Fall 2019 school year, while I will observe and take field notes in the professional development workshops. For the CoP sessions, I will be guiding the CoP sessions shortly after the professional development workshops.

The teachers that are participating in the CoP, relational trust is present between the teachers and the researcher. In addition, I do not have an administrative supervisory relationship to any of the teachers and I will guarantee that my evaluation of their work will be not be shared with administration. All data will be stripped of identifying information and only aggregate data of survey responses will be included in the data analysis. Also, to protect the identities of the teachers, the surveys will be collected electronically and completed anonymously by participants.

Chapter 4: Findings

This chapter addresses the findings that emerged from the mixed-method study of whether and how teachers demonstrate TPaCK when they engage in a CoP structured around design thinking. The CoP was designed to create a shared space for teachers to explore ways to integrate technology into their practice. Design thinking was used to provide a structured process for identifying needs, framing solutions, and reflecting on their efficacy. Data on teachers' beliefs and thinking about technology integration and their perceptions of the experience were collected via surveys, transcripts of conversations during the CoP meetings, field notes taken during the CoP meetings, exit slips collected from teachers after each CoP meeting, and teachers' responses to focus-group interview questions. The present chapter begins with the research questions, followed by an analysis of the data used to answer each of these questions.

Research Questions:

5. Is there evidence of growth in teachers' TPaCK and technology integration over the course of time? If so, what is the nature of this growth? (RQ1)
6. In what ways do teachers' TPaCK and technology integration emerge as they engage in design thinking in a community of practice (RQ2)
7. How do teachers evaluate the process and outcomes of this professional development experience? (RQ3)

RQ1: Evidence of Growth in Teachers' TPaCK and Technology Integration

Participants of professional development workshops. Data from the larger group of teachers ($n=16$) came from the professional development workshops. The sample of 16

teachers who participated in the initial professional development workshops includes the subset of 7 teachers who opted to follow-up with participation in the CoP. Items 18-28 of the survey focused on TCK, TPK, and TPaCK. Based on a comparison of pre- and post-professional development surveys, teachers were excited about the new technological tools at the school site. Overall, the 16 teachers reported growth in their TPK, TCK and TPaCK.

At the pretest (Item 21), 9 out of 16 teachers felt that past professional development workshops had not provided opportunities for deep thinking about the use of instructional technology. After the professional development workshops, 15 out of 16 teachers felt that the professional development workshops made them think more deeply about how technology could influence the teaching approaches they use in their classroom. Pre and post survey results show the increase and demonstrate that the professional development workshops made them think more deeply about technology. Refer to Figure 5.

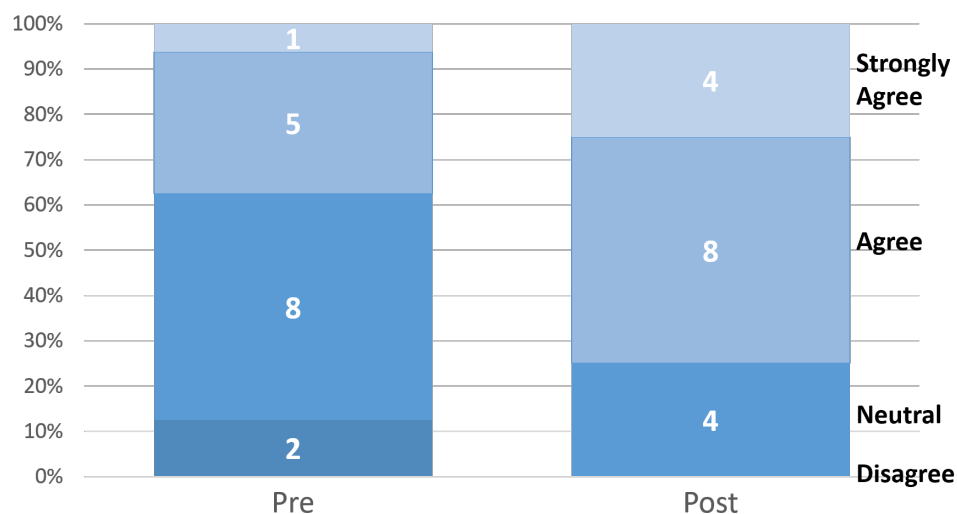


Figure 5. Teachers thinking more deeply about technology influencing the teaching approaches, they use in their classroom.

Pre and post survey results show an increase of critical thinking about how to use technology in the classroom after the professional development workshops. Refer to Figure 6.

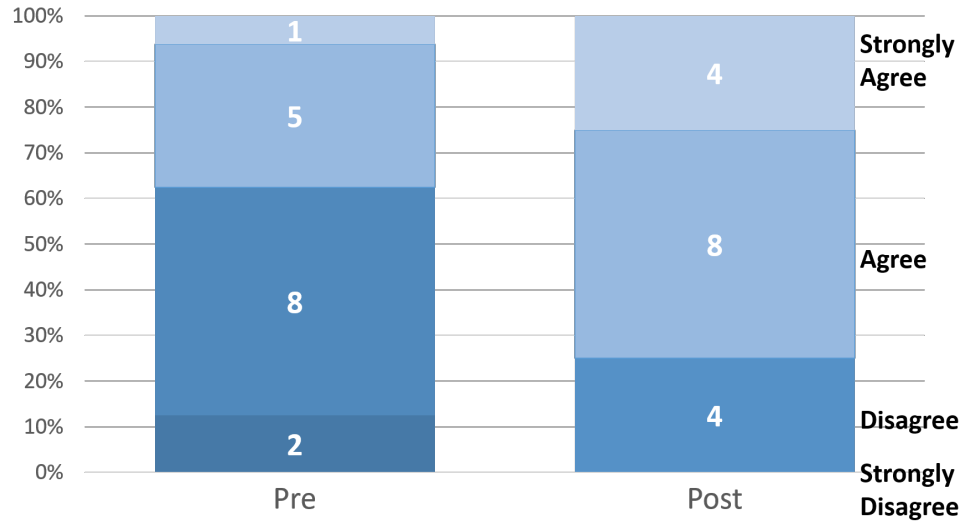


Figure 6. Teachers thinking critically about how to use technology before and after the professional development workshop.

After the professional development workshop, surveys indicate that more teachers felt confident in their ability to adapt technology to different learning activities (Figure 7).

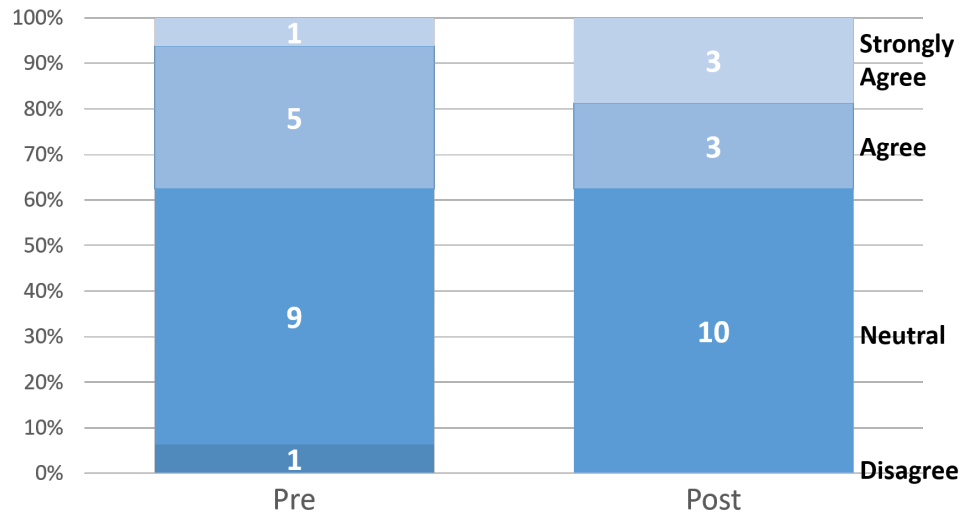


Figure 7. Adapting the use of technology to different learning activities.

In terms of confidence levels, 15 teachers felt they were confident in using strategies that combined content, technologies, and teaching approaches that they learned about in their classroom while there were 10 confident teachers before the professional development workshops (Figure 8).

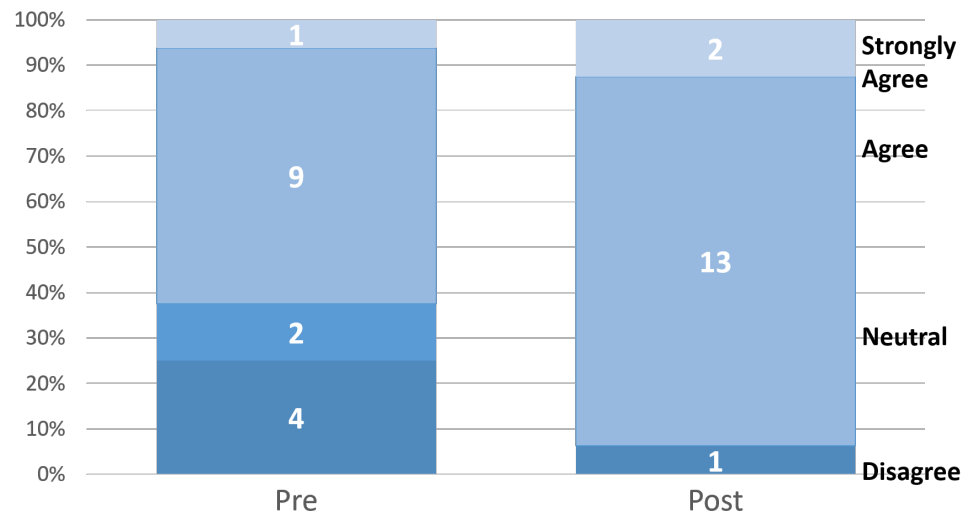


Figure 8. Using strategies that combine approaches of content, technologies, and teaching.

Another positive increase was teacher confidence in selecting technologies to use in their classroom that enhanced what they teach, how they teach, and what students learn. An overall trend toward increased confidence across the Likert categories was found for item 24, [I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn.] Refer to Figure 9 below.

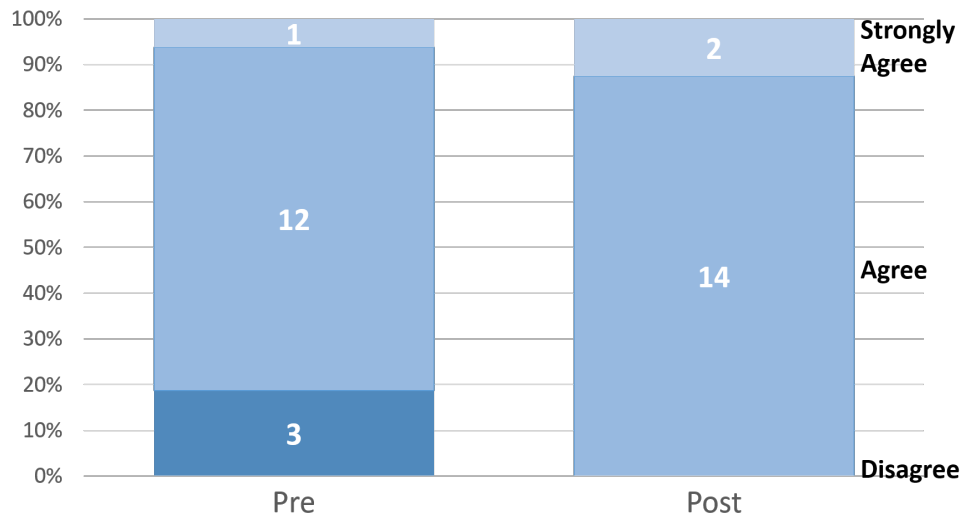


Figure 9. Selecting technologies to use in classroom that enhance teaching.

In item 27 of the TPaCK survey, there was a marginal increase of teachers that reported confidence in choosing technologies that enhanced the content for a lesson. Previously, four teachers were not confident in teaching lessons that appropriately combine literacy, technologies, and teaching approaches. In Item 28, teachers reported that they were more confident in teaching lessons that appropriately combine literacy, technologies, and teaching approaches while four seemed unsure. Refer to Figure 10.

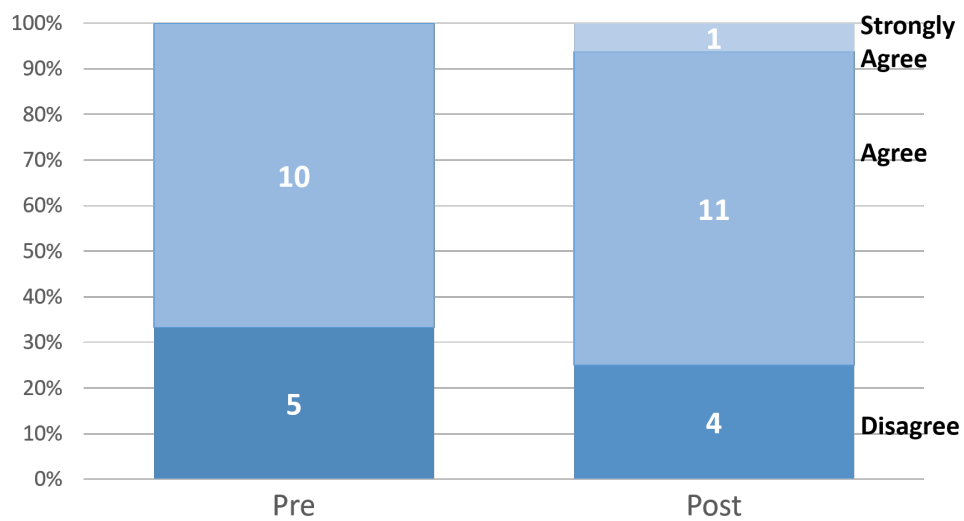


Figure 10. Combining literacy, technologies, and teaching approaches.

From Item 29 in the survey, teachers reported that the professional development workshops with technology provided an opportunity to learn about the new technology tools while giving them the time to reflect on their teaching practice. Some teachers stated (anonymous respondents, 12/12/2019):

I would like to continue to implement and enhance my knowledge of new technologies. Be open and willing to see student perspectives, to be open to try new technologies, and let students' knowledge be a guiding factor as they may know more about technology than I.

A clearer vision where I can fit tech into the pacing of a unit and how different tools can enhance what I'm already doing.

I walked away with different tech tools that I can start thinking about incorporating into my teaching. I am also thinking more about how to use technology to allow students different ways of showing their learning and especially how it can support my English learners.

I experimented with different technology that I could start implementing into my lessons to make learning more engaging and also allows students to show their learning in different ways.

These teachers felt that they walked away with something valuable in their professional development and became more open to technology integration. The professional development workshops with technology provided a space for teachers to think about technology in their practice, while previously other professional development had not. One teacher stated their concern about the misuse and overuse of technology, relating it to screen time:

There are many technology opportunities out there, the question is, how do I use it with younger students who just need the basics. I don't want to use technology for the sake of using technology. (anonymous respondent, 12/12/2019)

This comment alone shows the need for professional development that develops the skill of integrating technology strategically. A teacher who strategically uses technology

doesn't need to worry about screen time, as it would become a tool rather than a time filler.

Participants of both professional development workshops and CoPs. Based on the survey data and the focus group, the seven CoP participants felt that participating in the professional development workshops and the CoP was a positive experience and became open to technology integration. In fact, 5 of 7 teachers reported on item 18 that they knew about technologies that they could use for understanding and teaching literacy while on item 20, 4 of 7 teachers were confident that they could now choose technologies that enhanced the teaching approaches and students' learning for a lesson. All seven teachers felt confident that the professional development workshops and CoPs made them think more deeply about how technology could influence the teaching approaches they use in their classroom. In the focus group, one teacher confirmed this by stating,

I liked how we had that PD in which we're exposed to different tech tools and given examples of how to utilize it in the classroom. And then taking that experience and then now figuring out, "Well, what is just one that I could try and apply in my own classroom?" That definitely helped me because now I'm informed of what resources I could use. And then trying it out and then having our group and then going back there and just feeling informed and aware of ideas and then thinking, what else now? How can I change this and what could I incorporate more of or take away and then meeting again for these collaborative discussions helped me have a better idea of moving forward? (Jessica, personal communication, 1/15/2020)

In the focus group, one teacher stated that their curiosity was what drove them to learn more ways of integrating technology, stating that "It goes back to reflecting on my own teaching, what am I doing and what's working, what's not and how can I make things just more effective for both myself and the students." From the focus group

dialogue, these five teachers started thinking critically about their students (Laura, Anna, Evelyn, Jessica, Mike, personal communication, 1/15/2020).

Laura: I think the thing that's worked for me hearing what other teachers are doing. Even though I teach a different grade level, it still inspires me too because I got excited about hearing about a couple of things that are happening and I'm like "I don't know that my kinders or first graders could do exactly that," but it makes me think, "Well, what could I do that could be similar for their age?"

Anna: Same for me. It makes you reflect on what you do in the classroom that might hinder them later. Our first meeting, you mentioned how your kids don't really do much, they sort of sit there. And because we teach the lower grades and we sort of tell them to wait and tell them too, "Okay we have to do this before you can," because they're so excited. They just want to do.

Evelyn: Yea. That's where the problem solving comes in.

Jessica: Mmm hmmm (*affirmative*).

Mike: Well said.

Laura and Anna confirmed that they started to think more critically of how to use technology in the classroom by hearing from the other CoP participants, while the other three teachers acknowledged what they said. In the focus group, teachers stated that they could see themselves choosing technologies in other subjects as well (participants, personal communication, 1/15/2020).

Laura: I've only used technology in language arts and a little bit in math, but I could see for social studies and science, using the VR kits.

Anna: Yep. I agree.

Evelyn: Okay. Any other subjects?

Mike: Definitely science.

From the CoP, teachers felt confident that they could adapt the use of technologies that they were learning in different learning activities that combined content, technologies, and teaching approaches in the classroom. In CoP 3, these five teachers stated (participants, personal communication, 1/15/2020):

Anna: I think what I would do is use a tour [in the VR kits]. That would fit the theme because I think it would be more valuable for them, but this was a great experience for them to introduce them to it. I would definitely tie it in more with what we're teaching. Maybe introduce a theme. That's what I would change. But I would definitely do it again.

Evelyn: Next time I would use it (Google docs), but maybe use another resource first like ThingLink or Padlet since it's a great place to gather more information.

Mike: I would use it again and I think something I would do different is to create a model, an example.

Elena: I have an idea of using Padlet again. Padlet is very easy for them to put their thoughts out very quickly. It doesn't have to be very well composed. It's just for them to brainstorm so it was very quick. So I was thinking, that might be really nice as a pre-assessment, at the opening of a unit and I can ask them, for example, in science we are going to learn about matter soon. So what is matter, what is not considered matter? I felt like that could be a question I could pose to them and then really quickly have them answer it. From that, I can look and see what are some misconceptions, what are some of their background knowledge and, from that, tailor it to how I'm going to structure the lessons and what to focus on. So that was an idea that I had after using Padlet.

Jessica: I have a similar response to what you said with Flipgrid. I thought maybe I could use it at the end of the unit to assess well what did you learn? It could be any sort of thing. And then, of course, I'd want them to first try and collaborate amongst their table groups so that they can kind of brainstorm, get other people's ideas. Then give them some choices in how they would want to do it whether it's an illustration accompanied by labels and notes if they want to write it or the verbal. But in the video they're essentially sharing whatever they created while still doing their speaking skills. So, it was a way for me for every student to be held accountable for me to check in on what they

learned. That was the first time that I had used Flipgrid and applied it to a whole class for discussion. I noticed that I have a very talkative class and it was nice for them to feed all of that energy into something that was content-based, and they were so engaged. I think they love being able to share their opinion about something. It made me feel like I would love to incorporate more full class discussions while also giving each child the opportunity to share their individual opinion through the Flipgrid video. So, I would definitely want to use it again and also thinking of other ways can I apply it? Even in math. You could do math. Can you give them a lesson, can they apply that particular skill? They can make the problem and now they have to be the teacher and explain how they solved it. So, you're checking in to see if they are applying the skills learned? So, I'm just like, how else can I utilize this now?

All five teachers mentioned their future teaching approaches with content when using the technology tool again. These CoP participants reported they were more confident of their TPK growth because they discovered new ways to leverage technology to enhance student literacy from peers in the CoP. For example, one teacher stated in the focus group, "I like hearing what other teachers are doing, even though I teach a different grade level. It inspires me too because I got excited about hearing about a couple of the things that are happening, and it makes me think what could I do that could be similar for their [my students] age." Teachers felt more confident in their TPaCK after the professional development process with the support of the semi-structured design thinking CoP. Two teachers confirmed this (Laura, Jessica, personal communication, 1/15/2020) by stating:

Laura: I think the [CoP] meetings worked best for me by hearing what other teachers are doing. Even though I teach a different grade level, it still inspires me too because I got excited about hearing about a couple of the things that are happening and I'm like, "I don't know that my kinders or first grades could do exactly that," but it makes me think, "Well, what could I do that could be similar for their age?" So, I really enjoyed that a lot.

Jessica: I liked how we had that PD in which we were exposed to different tech tools and given examples of how to utilize it in the classroom. And then taking that experience and then now figuring out, "Well, what is just one that I could try and apply in my own classroom?" That definitely helped me because now I'm informed of what resources I could use. And then trying it out and then having our group and then going back there and just feeling more informed and aware of ideas and then thinking, what else now? How can I change this and what could I incorporate more of or take away? And then meeting again. So I feel like this back and forth and having these collaborative discussions, it's helped me have just a better idea of moving forward. What kind of ideas can I use now in my class and just hearing it being used in the other classrooms? I just feel like overall I'm just more and more curious also, which I think is good because then it drives my desire to want to learn more ways. And it goes back to reflecting on my own teaching, what am I doing and what's working, what's not and how can I make things just more effective for both myself and the students?

Laura and Jessica felt more confident of their TPaCK with the support of the CoP because they were able to reflect on their teaching practices. In Item 30 teachers reported on the positive impact of the professional development workshop experience (anonymous respondents, 1/17/2020):

I walked away with a clearer view of how tech can be part of the curriculum without being a mere substitute for tasks that should be done without tech.

I walked away with not only exposure to different tech tools to incorporate into my lessons, but also ideas from my colleagues about different ways to use the tech tools in various lessons and subject areas. Overall, I gained more comfort and confidence in using technology as a teacher to support student learning.

Like the workshop, the CoP structured around design thinking gave teachers the space and time to build their confidence in using technology in their classroom, but it also provided the support and strategies from the other CoP members. The CoP experience also provided a reflection and opportunities for the growth of each teacher's pedagogy in

using technology to support student learning. These themes will be explored in the next section on Research Question 2.

RQ2: Teachers' TPaCK and Technology Integration in Design Thinking CoP

Over the course of three CoP sessions, the participants experienced the stages of design thinking. In the first CoP, the teachers progressed through the empathy and definition stages of Design Thinking. In the second CoP, the teachers discussed and ideated prototypes of technology tools and possible lessons. In the third CoP, the teachers shared a prototype of their tested technology lesson and reflected on the experience. Transcriptions of teachers' conversations from the CoP were examined to answer research question two of how teachers' TPaCK and technology integration emerge in the CoP.

CoP 1: Introduction - Technology challenges. In CoP 1, teachers shared difficulties they were having with the technology itself but revealed that they do integrate technology in their class. Dialogue between three teachers reveal that using technology can be frustrating since sometimes it doesn't work, or they are not confident in their TK to solve the technology problem. Below is an excerpt of their dialogue (Laura, Anna, Mike, personal communication, 11/21/2019).

Laura: Being able to troubleshoot when problems come up because when we're using some of the tools in that PD, there were a couple of things that weren't working and certainly it was probably operator...we were probably doing it wrong, but we just didn't know and we didn't know how to solve the problems. So, I think we would need to know, Oh, that can happen, so how do we fix it? Because with your class when you're trying to do that, if it's going well and all of a sudden it's not working.

Anna: I find that's one of the biggest challenges. I was telling you the other day that my computers weren't working and with Kinder, if you're seeing it takes so long to set up something and if it doesn't work. Now they're disappointed. I'm frustrated. And it just ... it becomes... yeah, it throws everything off.

Mike: Or if the wi-fi goes out for five minutes?

Anna: Yeah, the wi-fi or one of the computers is ... I have to go get another computer and then while I leave to get that computer, then someone else's computer ... so, and I know that technology needs to be replaced and all that but when you teach kindergarten, that can be a big challenge.

Laura: In first too.

These three teachers revealed their challenge of using technology in their lessons especially when it isn't always a user issue. At times, technology doesn't always function or work seamlessly as expected and it becomes frustrating, especially when others depend on it to work and if an individual is uncomfortable with a new tool or process. The discomfort and challenges teachers face is because of their lack of TK and low TPK. Taking a risk of trying a new technology tool with the support of the CoP, these three teachers will grow in their TK and TPK, but also begin to develop TPaCK.

CoP 1: Challenges of students and technology skills. Technology integration and teachers' TPaCK emerged in these areas when examining CoP 1 data transcriptions. In the first CoP, teachers discussed challenges of using technology in the classroom. For example, there was honest dialogue about troubleshooting technology problems, wi-fi not working, and students not knowing what to do with the technology tools. When the CoP spoke of challenges of using technology tools and the literacy curriculum, the teachers' TPK and technology use was revealed. For example, in the quote that follows, two

teachers discuss how students sometimes struggle because they haven't yet learned how to use technology (participants, personal communication, 11/21/2019).

Evelyn: Students don't know how to use that tool or technology. So beforehand you have to know how to use that technology and then teach them how to use that technology's tool appropriately and within the content that you're teaching.

Jessica: I agree. That's what I put down too is that I'm noticing, like whereas with my last year's group, I felt like they seemed more familiar with the technology and how the various tools of the computer were. Whereas with this class it's like little things that I thought that they would have known, they are just really struggling. So it's going back to just learning the basic skills of how do you save this document, how do I manipulate this part? And so I think just the differences in their proficiency in terms of using just the computer itself, but then in addition, exposing them to different applications that they can use and then having them learn that one as well.

The first teacher introduces the problem, while the second teacher empathizes and reframes the problem as a learning opportunity for students. Exchanges like this illustrate how peer interactions in the CoP allow teachers to frame and reframe problems collaboratively. Their common experiences, grounded in the same teaching context, opens up a space for thinking about the articulation of the curriculum. Later in the conversation, another teacher stated:

It's the mindset of the kids because I think to use some of the technology the way we want to use it is, if they're stuck in that teacher led inquiry mindset you're not going to get out of ...you're not going to get from them what you want because you need a little bit more of that creative juice. So, sometimes your integration technology falls flat because they're just still waiting for you to tell them what to do. It's supposed to be more student-led. (Mike, personal communication, 11/21/2019)

In the first CoP, Evelyn and Jessica expressed that they use technology in the classroom but found it sometimes difficult because students do not have the technology

skills yet or the students are waiting to be told what to do. They recognized that their approaches to pedagogy affect the passiveness of students in the next year, taking a long-view on what it means to prepare students in a technological learning environment. Also, teachers recognized that their own familiarity with technology tools and comfort impacts students' passiveness and/or the opposite effect in independence and technology troubleshooting. In the space of this meeting, teachers explored the complexity of this challenge in terms of student prior knowledge, the articulation of the curriculum and their own pedagogical choices. The CoP provided participants a safe environment to share their challenges, empathize with one another, and reframe their challenges in ways that explored their own pedagogy in teaching with technology.

CoP 1: Technology Benefits. Even though integrating technology in their lessons may be stressful, teachers also explored ways in which technology can be beneficial to students. They recognize that technology integration can be beneficial because it engages students and provides students opportunities for developing their voice and creativity. The dialogue exchange between these five teachers reveal their thoughts of technology use (Mike, Tina, Jessica, Anna, personal communication, 11/21/2019):

Mike: I used Synth and the kids had created responses to their NGSS, one of our units. I set it up so I had the parents come in and add to their child's response and then you know, it stitches it all together. So you have this beautiful little podcast where the parents were responding to the students. I also put different avenues to aha moments because I think you can tap into the standards in a lot of different ways and I've had loud students and shy students where I just utilize some video and then all of a sudden I see them blossom. I can assess from that.

Tina: Yeah.

Mike: I just need to see it. And that's another thing that I depend on technology for. It's bringing some of those kids out of their shells.

Tina: That's what I was thinking.

Jessica: I think that technology, although it has its challenges, it's also a great way for students to have more creativity and voice in the classroom and it's clarity. It goes back to being more student centered where they have a more active role and if they do learn how to use the various applications. Then you're giving them different opportunities, different modalities for them to show their learning. You may have a student who maybe is not so vocal in class discussions, but maybe if there's a video that they can create in the privacy of their own time and you give those different scaffolds and supports. Or maybe they're creating a slideshow or using ...What's the Adobe Spark one?

Mike: Adobe Spark?

Jessica: Right, and just different ways for them to show their learning and the tech. Sometimes the kids get stuck on the creative, the art piece, but then knowing that there's different databases to pool that you were showing us, then I think in a way it can help those who sometimes feel like they're stuck when it comes to just a basic, show me your learning with a handout or something. It gives them a different way to show what they know as opposed to what may not have been seen if it were just that one way of doing it.

Anna: I think they're also engaged. Just thinking of my children when they have something they're going to work on and if they're given choices of what to use, it becomes so much more interesting to them versus I have to write this paper.

Jessica: Yeah.

Anna: It gives them choices and so I think technology helps with that. You know, being creative and showing what you've learned in various ways.

In this discussion, teachers share that technology engages and provides choices to show students' learning in multiple ways, which provides another way that teachers can assess student learning. It also becomes a context for drawing families into the learning process. Using a technology tool and resource allows quiet students to shine in the class

and see a student's personality while providing different outlets of creativity and voice. Other technology benefits were that it can provide the scaffolds and supports, as well as choices for students to show their learning. The dialogue of using different types of technology tools, such as Synth or Adobe Spark to promote creativity and voice for all students, furthered the teachers' expression of TPK and TPaCK.

CoP 1: Concerns of Overuse. Although teachers see the value of using technology in the classroom, they also express some concerns of overuse in technology, as well as strategic use of technology. Discussion about online programs, such as Raz Kids, and state testing revealed teachers' PCK and what teachers defined as strategic use of technology or lack of it. Also, the discussion reveals the teachers' TPK (participants, personal communication, 11/21/2019). For example:

- Tina: ...think there's too much of a push for us. Technology, technology, technology. I don't teach a lot with technology. I do like the features and stuff, but a lot of the time I'm like, I don't want you using too much technology...I want you to build your vocabulary. I'm sure we can do that with technology, but the reading part...I feel they're missing when they're on the computer.
- Anna: Right. Yeah, I think it can be done where it's balanced, where it's a small point and it's a very quality time on the computer versus them just sitting there and doing things on the computer where they're not really learning anything or expressing themselves or creating anything. They're just sitting there playing a game.
- Mike: A lot of middle school teachers use adaptive technology. The student has to put in so many hours on it for it to learn them and then they do a lot of their curriculum through that. The students are on there for a long time and then the teacher loads something else up, and it just keeps going. A lot of people are excited about that...I've used tools in the past and I'm like, I'm never using that again. They were on there for too long.

All three teachers see that technology is overused and not with what they believe is best teaching practices, which is reflective of their pedagogy. Even though Anna believes that using technology can be balanced in the classroom, Anna still feels many teachers are having students play a game or a video/lesson is loaded up for students to follow. The amount of time students should have screen time and what they are doing at that time becomes an important topic for educators. Mike explains that certain technology skills need to be learned and practiced because of online assessments, which Mike speaks of in this dialogue (Mike, Tina, personal communication, 11/21/2019).

Mike: The kids have to learn how to type because they have to type their SBAC. I kind of feel forced to teach typing and make sure they practice that. Once we do all the writing on paper and then we have them do it on typing, which is not so bad in itself. I wouldn't do it as much if it wasn't for the SBAC because it is good to type something up and then re-envision it. So, we'll use it on a website, or we'll take it apart and use just parts of it on a slideshow. So that's great. I just feel like having that testing is stressful.

Tina: It is. I found that on the first interim one benchmark, write a paragraph. They were ... we've worked on writing a bit, most of them can write somewhat. One or two sentences, I'm done. It's because they had to type it. But if it was that they had to write it, they'd be writing a lot more.

Mike: Exactly.

Tina: So, there were some zeros in the first interim one.

Teachers continue to try and balance teaching content and using technology. In the example above, the teachers were teaching writing as well as typing their writing. Typing their writing was a skill that all students needed for online assessments. Although there are typing requirements, some teachers used those required skills in another innovative way, as typing being the precursor of a larger project. Teachers recognize the popularity

of screen time use in our 21st century society, but some question the amount of screen time that is needed and beneficial for students' learning. Currently, the overuse of screen time can cause the opposite effect of the 21st century skills: communication, collaboration, creativity, and critical thinking. The skill of teachers' balancing academic skills, content, and technology becomes important in education.

In short, CoP session 1 provided an environment for teachers to feel supported with their teaching and technology use. In addition, the CoP provided a space to exchange and gain new knowledge while also providing the continuous and sustained efforts for teachers' TPK and TPaCK growth. In the first CoP, the teachers acquainted themselves with the empathy and definition stages and discovered each member's own technological challenges and with their students. Technology benefits and concerns of overuse were also defined in the first CoP.

CoP 2: Introduction. Technology and teachers' TPaCK emerged in these areas when CoP 2 data transcriptions were examined. In the second CoP, the participants discussed and shared literacy resources and technology tools that they have used with their students. This is an example of the Prototyping stage of Design Thinking. Themes of technology use and discomfort, curiosity of the technology tools, and technology benefits occurred in the conversations of the CoP. These teachers share their technology use with their students (Laura, Anna, 11/21/2019).

Laura: I do use our language arts curriculum online a lot for literacy, just the books online and the videos for the words and the games. Then BrainPOP Junior and for videos and narration and comprehension and Scholastic for visuals, videos, read a-louds and real-life examples.

Anna: Yeah. I agree, for the lower grades. Some of the ones that we used, or we learned about what I think can be challenging. I think they could be used, but I think they can be challenging. What I use in the classroom are also the online language arts program, like the Heidi songs so they can learn about letters and sounds or the Writing Wizard where they trace letters.

Teachers' technology discussion used in their classroom illustrates limitations in Laura and Anna's PCK, which is revealed in their comments about screen time. Because they use these technology tools for instruction on content and review, not active learning, it is no surprise that they see technology-use as "screen time" that can be replaced by more traditional modes of learning. This being an example of screen time rather than using technology strategically for students' learning. In the dialogue below, the definition of "strategic use" of technology was unclear to some teachers and they revealed that they had low confidence in TPK and TK (Elena, Evelyn, Tina, Jessica, Laura, 11/21/2019).

Elena: I think my hesitations or concerns would be similar to what third grade said is just like how much time is it going to take me to learn it, because that would affect my willingness to want to try it and implemented in my classroom because I have to feel comfortable with it to a certain level before I can introduce it to my students. So just wondering, yeah, how long would that take.

Evelyn: Okay.

Tina: But I also think for both of us, it's the first year doing a new grade.

Jessica: Yeah.

Tina: So, next year, I would feel a little more comfortable in trying this.

Jessica: For sure.

Tina: It's just this year I'm a little more hesitant, like just having the time.

Laura: I feel like in the lower grade with K/1, this doesn't really appeal to me too much. I feel like we're already using more [technology] than I would want to. I do use, you know, nobody's forcing me to use the

things that I'm using because I like that it enhances what I'm already teaching. The Benchmark and BrainPOP in those things, but I don't feel ready or I don't know that it would be valuable for my K/1 students to show their work by way of technology.

Elena needed to feel a certain comfort level before using the technology tool with her students, which revealed her low TPK and TK. Laura explicitly said they felt that they were not ready and felt using technology was not valuable in their teaching practice. These two teachers' discomfort and resistance was mitigated by feedback from their colleagues in the CoP. When Tina said she would be more comfortable next year, Jessica provided reassurance. This reassurance let Laura share her resistance and discomfort of using technology with her students.

Another example showing discomfort with using technology is when this teacher stated, "It depends on your self-efficacy on computers and how challenging you find it. I may be older, but sometimes it's daunting...this computer and all this technology. When I feel overwhelmed, I shut down and then, oh, forget it, I'm not going to do it. So, it has to be really simple for me to be able to really focus on it and get it to my students." The discomfort and the feeling of loss of control is seen in this dialogue since teachers are juggling teaching academic skills, subject matter, and technology skills. Even though teachers may have shown discomfort in using technology, they also see the benefits in using technology in the classroom when they walked through the stages of design thinking throughout the CoP. This point is illustrated in the section that follows.

CoP 2: Student collaboration. A benefit of using technology in the classroom is that it fostered TPACCK growth and provided another avenue for students to collaborate with each other. Other teachers revealed that they used other technology tools such as Flipgrid

with using literacy. Flipgrid is an online tool designed to help students produce one- to five- minute video responses. One teacher stated:

We're transitioning to opinion writing and so I present them with a debate topic. I have this graphic organizer that's essentially their script step by step that they're going to record themselves on Flipgrid. They're sharing their opinion and supporting it with text evidence from the article. I like that it compiles all of their videos into this forum and then they are allowed to view one another's videos. I have these collaborative discussion sentence frames that I want them to use for whether they agree, disagree, or if there's a question or some sort of comment. It's allowing them to hear other people's ideas while utilizing the vocabulary. Then from that with opinion writing, they can then be exposed to counter arguments and then integrate that into their opinion writing for finding a way to address a counter argument. (Jessica, 12/18/2019)

This teacher revealed her TPaCK with the use of Flipgrid in the opinion writing lesson. Instead of teaching opinion writing with outlines and graphic organizers, she integrated Flipgrid before assigning the opinion writing. The teacher's comfort level with technology and the dialogue amongst the CoP members is the reason for higher TPaCK growth compared to other teachers. In the CoP, this teacher revealed that student collaboration occurred while using technology and the students using Flipgrid collaborated by sharing their opinions with each other. Another teacher mentioned another example of student collaboration with the use of Google Docs. The teacher stated:

I've really enjoyed using Google Docs as a place where they can collaborate. So having them on one team of five or six research on one topic and they can all contribute to that same Google doc. Then they can use that research afterwards for their own individual papers. I feel like that's really helped them because some kids will get stuck if they're just doing it on their own. But if they're able to see what the whole team is coming up with together, then they have a better idea of what they're doing, what they're supposed to be looking for, and it just makes them feel more confident when they can pull from that for their own individual work. (Elena, 12/18/2019)

These two teachers have found the balance of teaching academic skills and content while using technology as a tool. The focus of student communication and collaboration with using a technology tool enhanced an academic lesson and provided support for students. Both students and teachers enjoyed using the technology tool in the classroom because they were actively learning from each other. The teachers and students were engaged in the lesson, as well as the process of using the technology tool with what they were learning. Creating and modifying lessons that entails the 4 Cs with technology becomes valuable for teachers' and students' growth and development in their TK, TPK, and TPaCK. Following statements are from two teachers that showed how they incorporated the 4 Cs with technology (Evelyn, Mike, 12/18/2019):

Evelyn: I like ThingLink. You could put an image and you can link it to videos or other information. I think it's also good for teachers because you have all the information in just one spot and that could be shared in Google classroom, or shared with your students, or played in the classroom. Also, students could be doing their own individual research of any topic. So, if you think about ecosystems, research can be done on a topic like wetlands. Then, you could link a video to it and then it'll come up with like a little dot or something. If you click on the dot, it will take you to that link. So, all your information is there in one spot rather than you going to a teacher channel and typing [wetlands] in or YouTubing it.

Mike: Adobe Spark does video too. You're either making an ad or a poster or something to communicate or you can do video and then so in some ways students are communicating, but simultaneously they're also being creative and have to think critically of what information they're going to put in, how they want to present it, things like that.

Evelyn and Mike incorporated student-centered technology lessons that focused on the students' communication, collaboration, critical thinking, and creativity. In these

lessons, Evelyn and Mike use their TK and TPK, and know that they can attach it to any content, therefore providing growth in their TPaCK.

CoP 2: Sparking curiosity. The CoP also provided space for teachers to spark one another's curiosity. Following is a dialogue example between the teachers of the CoP that showed teachers' curiosity of a technology tool, Flipgrid (Jessica, Anna, Mike, Elena, 12/18/19). Flipgrid is a video response that can be shared visually and orally.

Jessica: They're [the students] are going to record themselves and share their opinion and support it with text evidence from the article. What I like about Flipgrid is that it compiles their videos into this forum and then they are allowed to view one another's videos.

Anna: They can be stitched together into like a podcast?

Jessica: Right, yeah. It's really cool.

Mike: Anything that they can share orally or visually can take the pressure off of having to write something out. A safe place to share their thoughts.

Anna: Is it hard for them to present their thoughts in front of the class?

Mike: My ELD students are the ones that tend to be shy....when I used Flipgrid, there is an opportunity to kind of show themselves.

Anna: Yeah. I already have like two students, a couple students that are very quiet...

Mike: And they would do it at home. It's so funny because then all of a sudden you see this whole side of them that you never saw before and Student A wasn't ELD, but Student B was.

Jessica: Last year, it was student A and student B, right?

Anna: Well, you see their goofy side, you see their personality, you know what I mean?

Mike: When they come to school, it's like back to.

Anna: Yeah, quiet. I think when they're little they're not as worried about what others think they are because they're like, we want to go now.

Elena: Yeah.

Flipgrid was one of the shared technological resources in the professional development workshops. The CoP fostered a conversation of how Flipgrid can benefit and support ELD students as well as shy students. In this dialogue, two of the teachers have used Flipgrid before while the other two seemed to be open in hearing of how Flipgrid can engage students.

Another dialogue example below shows another teacher's interest and curiosity in using another technology tool called Padlet that she has not used with her students.

Tina: I've heard a lot about Padlet. I've never used it. Is it good?

Evelyn: I like it because it is a great way for them. It's visually appealing and it's also nicely organized and there's different formats for which they can organize their research information, whether it's vocabulary or something else.

Mike: Yes.

Jessica: Yeah.

Mike: You can choose for them. You can have it in categories already and they can get on and type it into that category. Or you can have more freedom where they're making decisions about where things should go, how they should be connected. So, I've seen examples all the way down to first grade.

Tina: And it's just padlet.com?

Mike: Yeah, Padlet.com. It's a good one. (Tina, Evelyn, Mike, Jessica, Tina, 12/18/2019)

Teachers sharing their experiences of student collaboration with technology impacted each other's curiosity and growth in technology use. Curiosity opens the teacher's minds

of trying other ways to enhance their lesson, using that technology resources, or maybe another resource. The CoP provided the environment to engage the teacher's curiosity of the technology tool.

The dialogue between these three teachers reveals a teacher's inquisitiveness of wanting to try a technology tool named Adobe Spark. The other teachers explain how to use the technology tool and how easy it is to use with the students. In addition, they explain how it encourages students to be creative.

Mike: Adobe Spark does video too. You can make an ad or a poster or something to communicate or you can do video. In some ways students are communicating, but simultaneously they're also being creative and have to think critically of what information they're going to put in, how they want to present it, things like that. That was one example.

Evelyn: But they could also take pictures. My class is working in social studies of what were some of Spain's influences in California. Students are creating Lego scenes. Then, they're taking pictures because they're going to put it into a stop motion film. After, they will put it into Adobe Spark and then, they'll record their script for their Lego scene.

Mike: Yeah. It's nice because you can put the video in and you mute the video that you loaded in, and then they can speak over it, which is really nice because having them speak in videotape at the same time, it's near impossible.

Tina: Is this easy to learn?

Mike: Adobe Spark is probably the easiest one.

Tina: Self-explanatory, you mean?

Mike: Yeah.

Tina: Do I have time to go into a technology that I'm going to have to research?

Evelyn: No, to be honest, I think it's easier than Creator. Adobe Spark, I feel like it's easier. (Mike, Evelyn, Tina, 11/21/2019)

Once again, a teacher showed interest in using a technology tool, this time being Adobe Spark. The possibility of asking if it was easy to use showed that this teacher was open to learning another technology tool that they might want to use in their teaching. Affirmation from other CoP participants provided a positive feeling that the teacher can use this tool with ease and have the support of their peers in the CoP.

The open conversations, curiosity, and teacher reflections of their own teaching fostered the teachers to step in to ideate and prototype. The teachers ideated some technology tools and resources to engage ELD students as well as touching upon the 4 Cs. Towards the end of the CoP, teachers encouraged and discussed possible technology lessons that they would like to try.

Jessica: Maybe focus on one thing like Adobe Spark. Maybe just one step, you so you're not feeling so overwhelmed where you feel like you have to produce this whole product. Maybe just focusing on one particular step in it and just getting them accustomed to it, as opposed to feeling like I need to create this whole thing. It could just be that simple exposure.

Elena: Or just even logging in and looking at it. I know some of you are not, haven't looked at Adobe spark yet? Just it's not just graphics and just like seeing the features that it has in the video and all that and playing around with it.

Jessica: Well, I know you can type like a keyword and there was like this whole database for different ideas, so maybe if it's even something as simple as what is something of interest to you and type that in and now here's all these things you could do. What is something that you might want to create with all of these ideas that now are at your, your hands? So, I feel like there's different ways to try and familiarize yourself and the students with it, but not having to completely feel like you're, you know, here from here...baby steps.

Mike: It's not, it's always good to introduce a new tech with non-content. Yeah. So you don't want to introduce it and then expect to have them do it and assess them on it, in there. You probably want to introduce it on a Friday when you have time to do something like what is your

favorite thing about Christmas or you know, something that's tied to their life. Then during that, you get them used to where to push the buttons with that or if you messed up, how do you undo it, and you just, you do all that little stuff. And that's where you learn too. But I agree that using tech doesn't mean there has to be some type of final product. When I use tech, 8 out of 10 times, it's not even a final product. It's just something that they do for the process and then those other two times we'll actually use something.

Elena: So, I think that's a good idea of like what they can do for Christmas, that's like using a Flipgrid or that they can audio record themselves and that's it. It's right when you come in from after break, then something easy for you rather than being so stressed out planning your curriculum and everything else when you come back from break.

Mike: I'd definitely structure that one more to where if you're interested in a tool, you already have it set up and then you would have like have them come in groups because it's much easier than running around the classroom or managing, or it won't reload. (Jessica, Elena, Mike, 11/21/2019)

At the end of CoP 2, teachers prototyped a lesson with a technology tool and agreed on testing the technology tool before the next CoP. The conversations between the teachers created the possibility of being able to prototype a lesson of technology with a more open mind since they had the support from the CoP resulting in possible growth in their TK, TPK, or TPaCK.

CoP 3: Introduction. Data transcriptions from the CoP 3 were examined in this section. For the third CoP, teachers agreed that they would plan a lesson that would integrate technology and report out on its effectiveness. This is an example of the Test stage of Design Thinking. Teachers were asked to bring their reflections on how the lesson did or didn't work and why. In the conversations of the CoP, the lessons that they shared were focused on two themes: curriculum and/or student collaboration and engagement. One pattern that emerged in the transcriptions of the CoP is that these

themes, in some ways, reflected teachers' proficiencies and comfort with technology integration.

CoP 3: Curriculum-focused. The teachers that were not as comfortable with technology use in the classroom were focused more on the curriculum content when they tried their lesson with technology. For example, one teacher stated,

We read several stories together as a group with my first graders and then I had them online, go to our curriculum, and find some of those same stories and additional stories within the unit and look for prepositions and pay attention to the different ways that technology is actually being used. It gave them a focus. They weren't just listening to the story online, which I think is okay, but it gave them a focus on listening and rereading but also looking for prepositions. I thought that worked well. (Laura, 1/15/2020)

Another teacher stated, "My students are studying Native American tribes in her and they're using the internet for research. In addition to using books and articles, the internet will provide greater resources. Many of them made notes and answered questions" (Tina, 1/15/2020). Previously, these teachers did not use the technology resources that they had since they were focused on the curriculum. Even though these teachers were still focused on the curriculum, they still ventured into trying something new with technology.

However, there is little evidence of TPaCK in their reflections. For example, there were two teachers who were new in teaching at their grade level and did not have the content knowledge, but also had low TK. Other teachers saw technology as a separate entity from the content. Both of these examples were missed opportunities to connect technology with their pedagogy. That said, the teachers nonetheless ventured into something new because they felt supported by their peers and they were not evaluated on the success of the lesson.

CoP 3: Student collaboration and engagement. Meanwhile, the teachers focused on trying a new technology tool without content since it was their first time using this technology tool in the classroom. Teachers discovered the excitement of using a new technology tool with their class. Below are statements of two teachers that tried a new technology tool. One teacher used Padlet and the other teacher used virtual reality kits.

One teacher stated,

I tried using Padlet with my students and I did it with something that's non content related, but I basically had them come up with goals for 2020 and then I had them each first just list as many goals as they could. Most of them did two or three. Then the next step I had them think about one goal and ways that they can achieve that goal. They linked the goal to 'to do'. So, the arrow should be pointing towards the goal. So, this is what I'm going to do to achieve this goal. I said if your goal is to get better at drawing then maybe you can draw for 30 minutes each day to practice. So, they started thinking about that and I felt like this was very useful to get them to collaborate with each other. One of my students afterwards, "I had them reflect and talk about what they liked about this activity and one of them said, oh I really liked seeing other people's ideas because that helped me come up with ideas. I also liked having that interactive piece of being able to link one part to another part. (Elena, 1/15/2020)

This teacher introduced a new technology tool, Padlet, for the first time without content. This being an example of the teacher's PCK and TPK as the teacher scaffolds students with something familiar, which in this case are their new year goals. The scaffolding increased students' TK and allowed the teacher and students to understand the advantages of using Padlet. With future lessons and projects, students and the teacher could become adept with this tool, resulting in teacher's TPaCK growth.

Another teacher mentioned,

In my class we used VR kits. It was really just having them use the new technology and it was a tour of a museum where they saw fossils. There was some hanging, some on displays and it was interesting to see how excited they were. They got to experience it by group. We had each table go for about five minutes

each table. It was just listening to them talk about what they were seeing and then after they were done, we sat down and they pair-shared and I wrote a sentence frame about what they saw, one thing they saw and then one thing they enjoyed. They had a good time with that. The best thing for me was seeing how excited they were. The first thing they asked was, “when do we get to do it again? (Anna, 1/15/2020)

Both teachers had a positive experience in using the technology tool and noticed students were excited and engaged in their learning because they had the support from their peers. Both teachers’ experienced using a new technology tool without content with their students, which fostered TPK and TK growth. The positive experience of using this new technology tool gives comfort to the students and teachers of using it again in the future with unfamiliar content. For these teachers, their TPaCK begins to develop, which before they were more uncomfortable and less confident of their TK and TPK.

CoP 3: Student collaboration, engagement, and curriculum-focused instruction.

Teachers that were comfortable with using technology were able to combine a curriculum-focused lesson that engaged students and had students collaborate with each other. For example, this teacher created a lesson on opinion writing using Flipgrid as a pre-activity before they began writing their opinion essays. The statement below explains her lesson.

“We are focusing on opinion writing and they were given a debate prompt of should this lion cub be in the zoo? They had to state their position, the source of their evidence, and give a reason why they believe that. They also had to cite text evidence and then come up with one counter argument and how would you reply to it. Then wrap it up with a closing statement, restating your opinion. Then, record themselves with a Flipgrid. After they have completed that task, they are able to view one another's videos and they can comment and respond to them. It could be disagreeing with their opinion. It could be agreeing, but they have to give some sort of feedback to it. Once they had that exposure where they're able to see one another's varying opinions and ideas and are hearing all this text evidence, so forth, then when we had a whole class discussion about it, the students were then able to be more confident in sharing their ideas with one another.”

This teacher goes on and explains why she liked using this technology tool:

I really liked the Flipgrid video because every student has the opportunity to have their voice heard. Especially for my shy, more quiet students, it really allows me to see not just what they're thinking, but their personality really does shine through in those videos. It allows them to reflect upon their own speaking skills. You'll notice that they can redo the video and they'd be like, oh, I didn't really like that part, I should fix that. So, they are learning to analyze how they're speaking and that's just such great practice for them. (Jessica, 1/15/2020)

With the use of this technology tool, this teacher was able to engage students and increase student collaboration and practice the art of communication through speaking and writing. Not only did it allow confidence for students to develop their speaking and writing skills, but it also allowed them to identify and analyze their own skills. The experience of sharing Flipgrid in the CoP increased other members to wonder about how they can use Flipgrid in their classroom since they see the benefits that Flipgrid can be used in a lesson that increases student collaboration and engages all students.

CoP 3: Teacher curiosity of tech tools. Another theme that emerged in CoP 3 is that teachers became curious about the available technology tools that they had and what other things they could do with that tool. For example, this dialogue below shows interest in using the virtual reality kits while another teacher is also starting to brainstorm how they can use another technology tool called Padlet (Evelyn, Mike, Anna, 1/15/2020):

Evelyn: Can we link that to our VR kits? I don't know if there's a feature.

Mike: I don't think they do VR 360 but I know ThingLink has an option for making it a 360. I haven't played around with it yet and I don't know how to get that to our VR kits. I'm going to have to spend some time on that.

Anna: What grade level is that appropriate for? Is it third and up? Seven?

Mike: I know a first-grade teacher using Padlet similar to what the other teacher did where they all came up with ideas about something and then they wrote it on paper first and then just to practice typing. They could all see each other's responses on one wall. They all got on and they just practiced typing their response. Then she would save them. First grade's the lowest. But I can imagine, if you know you can type, you can add anything. It doesn't have to be typing.

Anna: Maybe adding pictures?

Laura: A sentence about that picture.

Mike: They can even just practice searching places, geography lessons and just adding it to a wall. But definitely lower grades would be, like what you did today, calling them by group, working with them in a small group, having it already set up and then they have one or two tasks for them.

In the CoP, teachers share their questions and ideas of using the VR kits, Thinglink, and Padlet. The dialogue exchange of ideas of what they can use the technology tool for and how it can be adapted to the lower grades becomes important since the assumption from one of the teachers saying what grade is this technology tool appropriate for. Also, the CoP provided a space for teachers to become interested in other technology tools that the other CoP members have tried, thus fostering TPaCK growth for the CoP members.

CoP 3: Teacher using technology tools again. All CoP members discussed that they would use the technology tool again in the future and that they can see how it can be incorporated into future lessons. A teacher that had low confidence in TPaCK stated:

Padlet is very easy for them to put their thoughts out very quickly. It doesn't have to be well composed. It's just for them to brainstorm so it was very quick. It might be really nice as a pre-assessment, the opening of a unit and I can ask them, for example, in science we are going to learn about matter soon. What is matter? What is not considered matter? I felt that can be a question I pose for them. From their answers, I can see what are some misconceptions, what are some of their background knowledge, and tailor it to how I'm going to structure the lessons and what to focus on. (Elena, 1/15/2020)

Another teacher that had higher confidence in TPaCK mentioned that she would use Flipgrid again.

I thought maybe I could use it at the end of the unit to assess what they learn. Also, it made me feel like I would love to incorporate more full class discussions while also giving each child the opportunity to share their individual opinion through the Flipgrid video. I would definitely want to use it again, also thinking of other ways I can apply it. You can do math. Can you give them a lesson, can they apply that particular skill? They can make a problem and now they have to be the teacher and explain how they solved it. So, you're checking in to see if they are applying the skills learned? How can I utilize this now? (Jessica, 1/15/2020)

Both teachers grew from walking through the design thinking process with using a technology tool. Both teachers showed TPaCK growth. One teacher was unfamiliar with a technology tool and was hesitant in using any new technology tool in the class. This teacher became familiar with the tool by introducing it without content and then plans to use the tool in the future. The other teacher that had a higher confidence in her TPaCK, also developed her TPaCK as well. This teacher reflected on how Flipgrid can be used in other subject areas.

RQ3: Teachers' Evaluation of the Process and Outcomes of Professional Development Experience

Pre- and post-workshop survey data (items 29 and 30) from all the teachers including the seven CoP participants were used in answering research question three.

Transcriptions from the focus group were also examined to evaluate the process and outcomes of this professional development experience. From the survey items and the focus group, two themes emerged. The two themes that emerged were teachers valued the time of being able to reflect on their teaching practices and they felt supported in their learning.

Reflecting on their teaching practices. After the series of professional development workshops, all teachers at the school site completed the TPaCK survey. Overall, teachers were confident with their knowledge in literacy and familiarity with common student understandings and misconceptions. For example, 15 out of 16 teachers strongly agreed that the professional development workshops made them think more deeply about how technology could influence the teaching approaches they use in their classroom. Here were some of teachers statements (anonymous respondents, 12/12/2019):

Be open and willing to see student perspectives, to be open to try new technologies, and let students' knowledge be a guiding factor as they may know more about technology than I.

A clearer vision where I can fit tech into the pacing of a unit and how different tools can enhance what I am already doing.

I am also thinking more about how to use technology to allow students different ways of showing their learning and especially how it can support my English learners.

I experimented with different technology that I can start implementing into my lessons to make learning more engaging and also allows students to show their learning in different ways.

All four teachers felt that the professional development workshops provided a clearer example of how to use technology to support and engage all students. Despite general positive feelings, some teachers expressed misgivings about technology integration, as one teacher stated, “There are many opportunities out there, the question is, how do I use it with younger students who just need the basics. I don’t want to use technology for the sake of using technology.” Even with these misgivings, teachers showed interest in using technology appropriately and strategically. From TPaCK survey, item 29, three teachers stated (anonymous respondents, 12/12/2019):

I walked away with different tech tools that I can start thinking about incorporating into my teaching. I am also thinking more about how to use technology to allow students different ways of showing their learning and especially how it can support my English learners.

Having the chance to practice and to become more familiar with new technologies and how to implement them into my teaching to help build more powerful environments.

It was beneficial to interact with the tech and see examples of how it can be used in the classroom. It was also beneficial to apply it to a unit and explore ways to integrate it.

These three teachers' statements showed that they were interested in using technology strategically to support students, including English learners with content.

Feeling supported with their learning. Based on focus group transcriptions and TPaCK survey items 29 and 30, all teachers that participated in the professional development workshops and the CoPs felt they were supported with their learning. The teachers felt that the professional development workshops had a focus and goal while providing specific examples of using the technology tool. One teacher stated that they liked having the support while they had time to explore different technology tools with a set goal in mind in the professional development workshops. Another teacher stated:

I enjoyed exploring the different technology tools. It not only allowed me to think about how I can use them in my classroom, but it also helped me determine possible scaffolds to provide for my students to help them be successful in using the tools to learn. I also found it beneficial to map out a unit and decide where in the lessons I could integrate technology tools. (anonymous respondent, 1/17/2020)

This statement points out that for any learning, scaffolds for teachers are important in professional development, but also different scaffolds that teachers need to know with using technology. The guidance provided an arena for teachers to use technology in a

meaningful way that encouraged student engagement and collaboration. All teachers, including the ones that participated in the CoPs, felt that the support that they received from their peers created a meaningful learning experience. In reflecting on the professional development workshops (survey items 29 and 30) two teachers were positive about their experiences:

I loved exploring technology and conversing with my grade level peers about it. (anonymous respondent, 12/12/2019)

I really appreciate the opportunity to test out the different technology and would have benefited from more time doing that and also regrouping with my team to debrief how to incorporate the technology in my classroom. (anonymous respondent, 12/12/2019)

From the TPaCK survey, Item 30, a professional development workshop participant and CoP participant was also positive with their experiences:

I really enjoyed being able to explore different technology tools with my colleagues because it allowed us to troubleshoot together and also experience how our students would feel using the technology tools for the first time. It also allowed me to be more familiar with the tools so I can lead a lesson using them. The CoPs were also helpful because I heard different ideas of how my colleagues are using the technology tools, which inspired me to try them as well. (anonymous respondent, 1/17/2020)

Teachers felt supported by their peers and not judged, even though some may have misgivings about technology or low TK and TPK. Giving the time and safe place for teachers to explore and discuss with their peers about the technology tool that they are interested in using in the classroom while walking through the design thinking process provides a more positive TPaCK growth and development experience.

From the focus group, the CoP teachers addressed that they loved hearing what other teachers were doing with technology across grade levels and felt inspired. Trying a new

technology tool with their students and the support from the CoP, provided more confidence of their technology use and knowledge. Even though the teachers that only participated in the workshops were inspired and knew more about the technology tools that were available to them, the majority of them did not take the first step of trying it with their students. Only after seeing the CoP members using the technology sparked curiosity and desire to try and use it too. The CoP community could have been designated by grade levels or by primary grades (TK-2) and upper grades (3-5). This may have still provided the support and encouragement from their peers when trying a new technology tool. For the professional development workshops, suggestions of exploring technology tools with their grade levels were key in providing the grade-level conversations of application. Furthermore, if there was built in CoP time across grade levels, teachers can also exchange and gain new knowledge from others.

Individual Stories of Teacher Growth

In the section that follows, data from each CoP teacher is presented in narrative fashion in order to paint a more holistic portrait of their experience in the CoP. These individual stories provide additional evidence of the challenges that teachers faced and the growth in TPaCK and technology integration that they reported as they engaged with each other in the CoP structured around design thinking. Because the CoPs provided a safe environment for teachers to share their knowledge and learn from each other, we have a window into teachers' contextual knowledge, TPaCK and their journey of technology integration throughout the process. Here are the individual stories of each

teacher in the CoP. The data from these individual stories are taken from the CoP and focus group transcriptions.

Anna. From the first CoP transcriptions, Anna shared that she used the projector and she had kids circle things on the projector or use the Heidi songs through the literacy curriculum to have students trace letters with the Writing Wizard. She also had students sequence things because her students were excited that others could see their work.

In addition, Anna used Starfall, a website that teaches English reading and writing skills since it starts with letter sounds and letter recognition. She shared that the literacy curriculum did not have enough practice for the students and the curriculum was focused more on sight word practice. The students needed the letter recognition and needed to know the sounds in order to practice reading words. Another program that Anna used in her classroom was RazKids, an online guided reading program with interactive books and reading quizzes.

Some teachers including the kindergarten teacher were overwhelmed with the technology tools after the professional development workshops. There was a list of options that were available, but these teachers were uncertain about which one they should try and whether it would work for their students. In the CoP, Anna tried using a virtual reality kits, one of the technology tools introduced in the professional development workshops. These were virtual reality “glasses” controlled by the teacher’s iPad, which allowed students to experience an online field trip. For her lesson, Anna decided to use the virtual reality kits to explore fossils in a museum. Anna was pleased with the exhibit and students’ enthusiasm, stating:

There were some hanging, some on displays and it was interesting to see how excited they were. They got to experience it by group. We had each table go for about five minutes each table. It was just listening to them talk about what they were seeing and then after they were done, we sat down and they pair-shared. I wrote a sentence frame about what they saw and then one thing they enjoyed. They had a good time with that. The best thing for me was seeing how excited they were. The first thing they asked was, when do we get to do it again? (Anna, 1/15/2020)

In the beginning, Anna was open in seeing how technology can enhance growth and learning in older students but did not see the value of how technology can increase growth in kindergarten students' learning. After using the VR kits, she shared that the students were in the moment discovering fossils, stating:

They're not worried because they're [VR kits] putting them on, they kind of do look silly. They're walking around with them, they're doing things, they're saying things, but they're not even thinking about their experience.

These comments point to Anna's appreciation of the potential for technology to create immersive experiences for her students. Her enthusiasm reflects a newfound understanding for how technology enhances the learning experience, rather than repeating or recapitulating experiences already available to students with non-digital tools. She then goes on in explaining how she held the students' engagement and accountability of their learning by using visual sentence frames and pair shares.

After we did it, we sat down and they pair-shared. I wrote the prompts and so that... Beforehand, I already wrote the sentence frame that's what they were going to share. I told them the ones on which side they were going to go first. Then I told them that they were going to read the sentence frame to their friend and the next partner would do it. That worked. Because there's times where I'm pressed on time and it's like, okay, we've done it so many times that you should know. But it's hard for some of them to remember what they have to say or to use a complete sentence. So, for me, the sentence frames worked. (Anna, 1/15/2020)

It's clear that the reflection afforded by the Design Thinking process during CoP 3 allowed Anna to connect the technological tools with her pedagogical content knowledge. In doing so, she is starting to develop TPaCK around how to best leverage the virtual reality kits as a talking piece that focuses students' learning.

Importantly, the process of reflection leads Anna not only to refine her practice, but also re-evaluate her doubts about technology integration. Anna shares in the focus group with her peers that it "makes you reflect on what you do in the classroom... that might hinder them later." She continues to share her worries of the kindergarteners using the virtual reality kits:

I'm the one that worries. Are they going to break it? Are they going to do this? Am I going to get in trouble because now they've pushed all these buttons? So it's just let them be, let them see. And that's helped me to sort of see. (Anna, 1/15/2020)

Having the space to share her reflections with colleagues and the structure of prototyping and testing technology has allowed Anna to test new ideas and reframe technology integration in ways not afforded in the professional development workshops. With the support of the technology lead and some fifth-grade students, the kindergarten teacher felt comfortable using the virtual reality kits with her students. The students were engaged and excited with learning about fossils as well as using a new technology tool. In the focus group, the kindergarten teacher reflected and stated:

You kind of close yourself to [trying something new with technology]. This sounds like something for upper grades. But when you're actually using it and playing with it and doing it, you're like, "Oh no. I can see, maybe not to the same degree as the upper grades would use them, but I can see my grade level using them. I can see them [students] enjoying them. (Anna, 1/15/2020)

This is this kindergarten teacher's journey of her growth. She became more open in trying a new technology tool with the support of the technology lead and student models. She shared that she would use the virtual reality kits with another content area and another theme as a precursor of the lesson to engage and develop conversation and discussion with her students from what they have seen.

Laura. In the first CoP, Laura shared that she used the Language Arts curriculum online, videos for the words and the games, BrainPOP Junior for videos and narration and Scholastic for visuals, videos, read a-louds and real-life examples. Laura was hesitant in using more technology in the classroom since she felt the students were using a lot of technology already. She viewed technology use as "screen time" rather than the strategic use of technology for pedagogical purposes, stating, "Whatever unit we're working on there are more books, online books in the literacy curriculum that the students can access and I like that they're getting exposed to that content that I'm teaching." Laura used the online books from the mandated curriculum as a resource for content but did not have the students use other technology tools to communicate, collaborate, critically think, or create, which essentially are the 21st century skills.

In the second CoP, Laura was still a bit hesitant in viewing technology as a tool for her students, stating, "I don't feel ready or I don't know that it would be valuable for my K/1 students to show their work by way of technology." It was through discussion and encouragement from the CoP members that all teachers decided to test a lesson with technology use. Suggestions of lessons such as focusing on one step in that technology tool or using the tool without content also helped ease the CoP teachers' hesitation.

By the third CoP, with hesitation and discomfort, Laura still chose to use the online stories from the literacy curriculum, but instead of K/1 students just reading the story in a reading group, the students identified prepositions individually in the stories. Laura felt it was necessary for the students to practice prepositions in different modes by listening, speaking, and reading it, stating:

It was just to have another mode of listening, reading, seeing, and stretching it for them because we work together as a group and then they worked individually reading the stories online and being able to think. We just talked about prepositions. Am I finding any here? So, I thought that was very valuable (Laura, 1/15/2020).

This activity leveraged the potential of using the online literacy tool as a practical start for students to practice prepositions with different modalities. Also, Laura felt comfortable in modifying a lesson with a literacy tool that she had been using. She loved that it “stretched their thinking” when the students reread the stories. After Laura did this activity with her students, she thought of another way to modify her lesson, stating:

I would have the students write the words and have paper and pencil while they’re listening to the story and just take some notes...write the words that we were looking for because we talked about it after, but they didn't write them down. I think that would've been helpful. (Laura, 1/15/2020)

These comments demonstrate that Laura was focused on the content of the lesson and was more interested in developing strategies for students to learn about prepositions. Using an online resource such as those online readers in a different way provided growth in Laura’s TPK, PK, and PCK and started to develop TPaCK. There was growth in Laura’s PK and TPK because she discovered that students can use the literacy tool to find prepositions and write down the examples, which in the past, she had the students read the online stories by group. The interaction between the students and teachers was

missing. The writing, speaking, listening, and speaking could be shared and discussed with the teacher and other students. Laura's pedagogy with content has been modified and Laura begins to see how she can leverage using this online literacy tool as a way for students to learn about prepositions. For future lessons, Laura would become more receptive in trying another technology tool with content. Before trying a technology tool, the CoP provided the space and support with positive encouragement that Laura needed in order to try a technology tool that she wanted to try with or without content. For example, one member stated,

Maybe if it's even something as simple as what is something of interest to you and type that in and now here's all these things you could do. What is something that you might want to create with all of these ideas that now are at your, your hands? I feel like there's different ways to try and familiarize yourself and the students with it... baby steps. Focus on one thing like for Adobe Spark maybe just like this one step, you know like maybe not feeling so overwhelmed where you feel like you have to produce like this whole product and just focus on one particular step in it and just getting them [students] accustomed to it, as opposed to feeling like I need to create this whole thing. It could just be that simple exposure. (Jessica, 12/18/2019)

This is Laura's journey of her growth. Laura's trial of reflecting on and modifying her lesson with her new TPK and TK, her TPaCK started to develop. After these struggles, Laura heard a plethora of ideas from her peers in the CoP. She started to see the possibility of using new technological tools, such as Flipgrid, in other contexts. When reflecting on this during the focus group she remarked, "What worked best for me is hearing what other teachers are doing. Even though I teach a different grade level, it still inspires me too because I got excited about hearing about a couple of the things that are happening and I'm like, 'I don't know that my kinders or first graders could do exactly that', but it makes me think, 'Well, what could I do that could be similar for their age?'"

So I really enjoyed that a lot.” Laura’s journey of feeling that students had too much “screen time” to her burgeoning TPK and TK were driven in part by her exposure to new ideas and alternative perspectives in her CoP.

Tina. Tina is currently teaching third grade for the first time this year. In the first CoP, she identified a range of challenges, including prioritizing the literacy units, pre-writing skills of students, and lack of professional development training in preparation for grade level change. She felt technology wasn’t important compared to the other learning outcomes, stating, “I don’t teach a lot of technology...I don’t want you using a lot of technology. I want you to build your vocabulary...the reading part that comes into literacy I feel they’re missing when they’re on the computer.” She was uncomfortable with using technology since she was exposed to technology when she was in school or when she started teaching. Her technological problem-solving skills were minimal since she preferred to have someone work with her face-to-face, showing her what to do when she needed assistance. Since she is teaching a new grade level, she also showed concerns of the interim assessments that require the students to type their answers, rather than writing it on paper. She noticed that her students only typed 1-2 sentences and suggested that if they had written it on paper, they would have produced paragraphs.

In the second CoP, the collaborative conversations across grade level from others stirred up Tina’s curiosity in some of the technology tools being used. Tina asked pointed questions about the accessibility of the tool, how easy it is to learn and whether it was user friendly. Even though Tina was curious, and the CoP members supported her learning, she showed some discomfort by stating, “When I feel overwhelmed, I shut

down and then, oh, forget it, I'm not going to do it. So, it has to be really simple for me to be able to really focus on it and get it to my students.” Tina had low confidence in TK and TPK because she wasn't comfortable with using technology, but also felt that technology was somehow that had to be learned apart from other content. This also being her first year teaching third grade, Tina was not familiar with the curriculum yet.

In the third CoP, she was not present, but shared her thoughts in writing with the CoP. She stated that her students were working on research projects using online search tools. This was the first time the students have used the Chromebooks that were not related to the online literacy curriculum or an online assessment. In the future, she hopes that she would use the VR kits, Padlet, and Adobe Spark with her students with the support from the CoP.

This is this third grade teacher's journey of her TPK and TK growth. She became more open in trying a new technology tool with her students. She shared that she would like to use other technology tools in the future. Tina was hesitant at first, but became positive about the professional development experience because there was time for her to plan and “play” with the technology tools and the CoP provided the support and collaboration that she needed without judgement.

Jessica. Jessica discovered that this year's fourth grade class didn't seem to have the TK to maneuver the various tools on the Chromebook as compared to last year's class. She had to go back and teach the basic skills of saving a document and other computer proficiencies, in addition to exposing those same students with different applications that they can use and then having them learn that as well. The fourth-grade teacher was

familiar with Google suite tools. The fourth-grade teacher explored another technology tool, Flipgrid. She used Flipgrid to foster open-ended discussion through video responses before students engaged in opinion- writing. She was able to give support for the shy students and students that didn't know what to write.

This year, Jessica chose to use Flipgrid with a literacy lesson about expressing opinions. Flipgrid is a web-based video response program. Short 1 minute, 3 minute, or 5 minute videos can be recorded, permitting students to produce brief testimonials. Before using Flipgrid, the fourth-grade students had to brainstorm and complete a graphic organizer with sentence frames of their reasons and textual evidence. Once the students have written their script, they then record themselves reading it. For those that have finished recording, they are able to view another student's video and comment and respond. Students will comment by disagreeing or agreeing with their opinion. Jessica noticed a difference in students' confidence in class discussions, mentioning:

The students were then able to be more confident in sharing their ideas with one another and not only... If you agreed with someone else and you were like, oh, why we both have that, but oh, I didn't think of that reason too. Now they're being more open to ideas, but they're also hearing counter arguments. All of these activities then feed into the ultimate piece, which is when they have to do their essay. Through that, not only were they able to gain different ideas, you're giving the text evidence, you're doing yours orally, and you're listening to one another. Now they've heard a wealth of ideas that they can now apply in their opinion essay. (Jessica, 12/18/2019)

Using Flipgrid increased student engagement and provided a context for students to organize the support for their opinions, but also gave them practice with public speaking. Before the professional development workshops, the fourth-grade teacher felt confident with her TK and TPaCK but had never used Flipgrid in a lesson. The CoP structured

around the design thinking gave Jessica the opportunity to prototype and test this writing lesson with Flipgrid. This process allowed the fourth-grade teacher's TPaCK to grow.

Knowing that technology has its challenges, she felt that it was a great way for students to have more creativity and voice in the classroom, stating (Jessica, 12/18/2019):

I think that it allows them to be more student centered where they have a more active role and if they do learn how to use the various applications, then you're giving them different opportunities, different modalities for them to show their learning. So, you may have a student who maybe is not so vocal in class discussions, but maybe if there's a video that they can create in the privacy of their own time and you give those different scaffolds and supports.

Rather than using a handout or worksheet, another way to engage students was by having a different way to show students' learning with technology. The fourth-grade teacher used the Flipgrid video-response program with her students for the opinion topic, leading to her TPK growth. The students shared their opinion with supporting evidence and then, the teacher compiled the videos in a forum and allowed the students to view the videos. Collaborative discussion sentence frames of agreeing, disagreeing, and comments were used. The students heard and utilized the vocabulary and other people's ideas to strengthen their argument, and integrated counter arguments before writing their opinion essay. In the third CoP, Jessica loved how every student had the opportunity to have their voice heard:

It really allows me to see not just what they're thinking, but their personality really does shine through in those videos. It allows them to reflect upon their own speaking skills. You'll notice that they can redo the video and they'd be like, oh, I didn't really like that part. I should fix that. So, they are learning to analyze how they're speaking and that's just such a great practice for them. Ultimately, I just really like these Flipgrid videos because you're having to practice it. You're then preparing for the oral discussion, which then we put it all together and it helps you with articulating your ideas in writing. (Jessica, 1/15/2020)

Jessica reflected and shared that having the students articulate their ideas in video before writing, created a richer class discussion and writing. In the focus group, she brainstormed which content area could she use Flipgrid, other than literacy. Jessica stated:

I would definitely want to use it [Flipgrid] again and also thinking of other ways can I apply it? Even in math. You could do math. Can you give them a lesson, can they apply that particular skill? They can make the problem and now they have to be the teacher and explain how they solved it. So, you're checking in to see if they are applying the skills learned? How else can I utilize this now? (Jessica, 1/15/2020)

In the CoP structured around design thinking, Jessica continued to reiterate how she could have modified the lesson and how Flipgrid can be used for another content area. The CoP provided a space for her to share her thoughts of using Flipgrid, but also provided a platform for Jessica to illustrate more of her self-confidence in TPK, TCK, and TPaCK growth. She discovered that she would be able to use Flipgrid at the end of the unit to assess what did the students learned, and students can possibly share their ideas through illustration and notes before collaborative group work, so the students can practice their speaking skills. This was a possible strategy that Jessica learned from a CoP member that has used Flipgrid. This is Jessica's journey of her TPaCK confidence and growth with the support from the CoP.

Evelyn. In the first CoP, Evelyn shared contextual knowledge of what occurred with her students. She explained that her students typically waited for her to solve the problem instead of trying to solve the problem themselves. Evelyn agreed with the other teachers that despite the fact that it spiraled, the curriculum left gaps in students' knowledge of technology across grade levels. This teacher had taught fourth grade several years and

was well aware of the challenges of teaching different tools from typing into Google doc or using the other apps that Google Suite offered.

In the second CoP, Evelyn shares her experience using Padlet for research projects, book clubs, and projects based on their individual interests with student choice. She likes using Padlet because videos, audio clips, and information could be added and curated into an organized online bulletin board. She also shared using slides, not only for presentations, but using them to create a book with a first-grade class. Another tool that she also enjoyed using was ThingLink because students were able to create a wall that connected information by an icon, stating:

You can put an image and you can link it to videos or other information. All the information is in one spot and it can be shared in google classroom or shared with the students. If a student clicks on a dot, the dot will take them to the info. Or video. You could create it by themes or topics. Students can also be creating their own ThingLink and doing their own individual research. (Evelyn, 12/18/2019)

Evelyn shared that ThingLink was useful for students to curate information on a wall. Sharing her excitement about her experience in using these technology tools increased the curiosity of some of the other CoP members who were less familiar with educational technology. Other teachers that used the tools such as Padlet and ThingLink chimed in, stirring up curiosity for others. For example:

Tina: I heard a lot about Padlet. I've never used it.

Evelyn: It's visually appealing and it's also nicely organized. There's different formats for which they can organize their research.

Mike: Yea.

Jessica: Yea.

Mike: You can choose for them. You can just have it in categories. They're making decisions about where things should go, how they should be connected. (Tina, Evelyn, Jessica, Mike, 12/18/2019)

This dialogue occurred because Evelyn had used Padlet and Tina had heard of others using Padlet too. In the third CoP, Evelyn shared that her class was working on taking pictures of their Social Studies Lego creations. The students were working on creating a stop motion film, then using Adobe Spark to insert narration over the pictures. This was her first time using Adobe Spark with her students. Evelyn and her students were excited about engaging in this "work in progress." In addition, she shared another technology lesson where the students were working on a group newsletter in Google Docs about natural disasters. Instead of curating information on Google docs, she shared in the third CoP, a better and more efficient tool would have been Padlet or ThingLink. Another CoP member mentioned that Padlet also had new features like creating a timeline and a Padlet can be used to host other students' Padlets and group work. The CoP provided the space for Evelyn to share her technology experiences and get excited about other technology tools that she had never tried. Evelyn started brainstorming ways of integrating a new technology tool with the lesson content, stating:

I was thinking about the VR kits after you used them, and I was like I could have used that for the gold rush or California missions. We could walk through it and go through that experience and then work on a project. (Evelyn, 1/15/2020)

In short, Evelyn was comfortable in using and trying a new technology tool with her students from the outset. However, the CoP provided the environment for her to share her ideas as well as learn about the features of other technology that could enhance her teaching practice.

Elena. This is the first year Elena is teaching fifth grade from kindergarten. Elena is still learning about the fifth-grade curriculum, while also learning the academic skills of her students. She had some technological knowledge but felt discomfort in using technology since her experience was mostly in Google Docs. She states:

I've had the most experience in using google doc, like being new to fifth grade and just starting to use more technology with my students. But I've really enjoyed using Google Docs as a place where they can collaborate. So, having them like one team of like five or six research on a topic and they can all contribute to that same google doc and then they can use that research afterwards for their own individual papers. I feel like that's really helped them because some kids will get stuck if they[re just doing it on their own. But if they're able to see what the whole team is coming up with together, then they have a better idea of what they're doing, what they're supposed to be looking for, and then it makes them more confident when they can pull for that for their own individual work. (Elena, 12/18/2020)

Elena used Google Docs as a way for students to collaborate as a team. In the second CoP and third CoP, she tried a technological tool that she was curious about, but also knew that she would be able to use Padlet because of the ease in using the application. To introduce the technology tool to her students, she did a non-content related lesson of students' 2020 goals. Then, the students brainstormed ways to reach that goal. After brainstorming, they connected their strategies to their goals and she liked that students were interacting with each other's ideas, stating,

One of my students afterwards, I kind of had them reflect and talk about what they liked [about] this activity and one of them said, oh I really liked seeing other people's ideas because that helped me come up with ideas. I also liked having that interactive piece of being able to link one part to another part. (Elena, 1/15/2020)

In the focus group, Elena shared that she would use Padlet again and she could use it as a pre-assessment at the opening of a unit to gain insight of what students know, stating,

I can look and see what are the misconceptions, what are some of their background knowledge and, from that, tailor it to how I'm going to structure the lessons and what to focus on. So, that was an idea that I had after using Padlet. (Elena, 1/15/2020)

In short, Elena started with little confidence in her TK and TPK since it was her first year teaching fifth grade. Also, before the CoP, she was only comfortable with using Google Docs. She learned that using a technology tool and learning something new does not always have an end product, it's the process that the teacher and students are experiencing. Elena stepped out of her comfort zone with the support of the CoP members. The CoP provided a safe place for her to take a risk in trying a technology tool without content since she knew that everyone was also taking a risk. With these CoP experiences, Elena began to become more confident with her TK and TPK and creating a start of her TPaCK.

Mike. Mike has been teaching fifth grade for several years and shares his pedagogical content beliefs about the literacy curriculum. He commented that the literacy lesson in the curriculum begins with analyzing Robert Frost poems in the second month of being in school. He felt that the students' minds were not ready to understand and analyze poetry on that deeper level in the second month.

Mike grew up with exposure to educational technology tools from his parents, who were also educators and interested in technology, so he knew more about the educational technology resources that are available. He reported in the TPaCK survey that he has high confidence in his TK, TPK, and TPaCK. Currently, he is also the technology lead at the school site. Before providing the professional development workshops, the researcher

and he discussed which technology tools would be presented at the professional development workshops.

In the second and third CoP, Mike shared more of his TPK and what he noticed with his students using technology. He explained that writing drafts before typing was important and felt that the typing is required since the students are going to be asked to type out their writing for testing. Later, he told the CoP participants that the typed work is used in their online portfolios, websites or taken apart to be used in a slideshow. Even though the typing was required, he also believes that all students could show their learning and teachers could provide different avenues for their students. By providing different avenues of learning, Mike said he can better assess their learning, stating,

I put different avenues to aha moments because I think you can tap into the standards in a lot of different ways and I've had loud students and shy students where I just utilize some video and then all of a sudden I see them blossom and I can assess from that. (Mike, 11/21/2019)

Mike also noticed that providing the different platforms for learning allows him to see the student as a whole and that certain technological tools worked better with certain students. One technology tool that he has been enjoying and using with his class was Adobe Spark since it can create an ad, poster, or video, anything that can be used for communication. He believes that this gives the students time to be creative and to think critically of what information they are going to put in and how they want to present it. Another tool that Mike enjoys is Flipgrid because students will be shy in the classroom but shine in video responses. For example, "In Flipgrid or anything where they can share orally or visually can take the pressure of having to write something out. A safe place to

share their thoughts.” Insights like these suggest that Mike has deep TPaCK about when, why and with whom technology might support learning.

Just like their students, teachers need a safe place to share their thinking and learning. Because Mike had confidence in his TPK and TK, he was sometimes seen as someone that knew everything about technology. However, in the CoP, he admits that sometimes he did not have the time to test a technology tool fully to know all the features of that tool. Even though he had high confidence in TPaCK, the teachers in the CoP pushed him to think of other strategies or consider whether there were other features with pedagogical benefits in a technological tool. They also broadened his awareness of how the technological tools can be beneficial to other grade levels. He also shared that he is still learning with his students in figuring out how to use a technological tool and always tries to put himself in their position, student-centered learning.

Chapter 5: Discussion

To meet the demands of teaching in the twenty-first century, teachers must learn to use technology strategically to create a student-centered learning environment. Educators encounter a profession that was once traditional and teacher-centered and having to shift their mindset to be futuristic and student-centered is a tall task to ask for, especially without the training and professional development. To develop teachers' TPaCK, teachers' pedagogy with technology needs to be taken into account. Teachers' attitudes and perceptions of technology use needs to be addressed in professional development. Districts need to provide meaningful professional development that encourages dialogue and support with technology tools without judgement. To encourage dialogue exchange and support with technology use, components of effective professional development of content focus, active learning, coherence, sustained duration, and collective participation should be followed. A CoP structured around design thinking was used to develop teachers' TPaCK. This study was to examine teachers' experiences of TPaCK development and growth through professional development and in a CoP structured around design thinking. This chapter explains the summary for each of the three research questions and presents pertinent conclusions and recommendations.

First, to see whether teachers felt that they grew in competence and TPaCK as a result of the study, (RQ # 1), data was collected to follow 16 teachers as they participated in three professional development workshops on technology tools, followed by a series of three meetings among 7 of those 16 teachers in a CoP structured around design thinking. The 16 teachers took a TPaCK survey before and after the technology workshops (see

Appendix A) to gauge the perceived effects of the workshops along. Focus group transcriptions from the CoP teachers were also examined and coded for teachers' input on their growth in TPaCK competencies as a result of that phase of the study (Table 2).

Second, to answer the question, how teachers' TPaCK and technology integration emerge as they engage in design thinking in the CoP (RQ #2), transcriptions from the CoP were examined. The CoP transcriptions capture the dialogue of the seven participants as they engaged in the design thinking process and introduced new technology tools into their instruction. In each CoP, the teachers walked through a different stage of design thinking. In the first CoP, teachers experienced the empathy and definition stages. By the second CoP, the teachers experienced the ideation stage and discussed the technology tools each had used in the past. They finished by selecting a technology tool to integrate in their teaching within the following month. In the third CoP, the participants reflected on prototyping and testing their technology tools in a lesson. The dialogue was coded, and themes were identified for further analysis.

Third, to examine how teachers evaluate the process and outcomes of this experience (RQ #3), transcriptions from the focus group and items 29 and 30 from the TPaCK survey were examined. Items 29 and 30 were open-ended questions that allowed participants to explain what they took away from the professional development experience and what activities and structures supported their learning. Qualitative descriptions were coded, and themes were identified for further analysis.

Summary of Findings

The data indicate that teachers felt more knowledgeable and skilled in TPaCK as a result of the professional development activities. Teachers were excited about the availability of technology resources that they could use in the classroom. After the workshops, the teachers believed that they were more knowledgeable about the technology tools made available to them and felt comfortable that they could use these tools in their instruction. In addition, the knowledge and skills that teachers acquired fueled a sense of efficacy in selecting and applying technology to classroom instruction over the course of the three CoP meetings.

The next set of findings addressed opportunities for teacher engagement in TPaCK during the CoP sessions. In the CoP, participants discussed TK and TPK and their comfort with using technology with their students. Concern about “using technology for the sake of technology” and increasing children’s “screen time” among the more resistant teachers dissipated over time as they learned more about the ways in which their peers integrated technology with instruction. They also explored the idea of balancing technology with content and basic skills with their peers. In the second CoP, teachers prototyped lessons that they were thinking of doing before the next CoP meeting. Teachers more experienced with educational technology discussed ways to use technology strategically to increase student engagement and collaboration. The conversation prompted other participants to become curious of how a technology tool can cause a shift in student participation. The CoP provided an opportunity for teachers to support and encourage each other to experiment with educational technology. In the third

CoP, teachers shared their experiences of integrating a technology tool with their class. Some teachers introduced a new tool without content. The ones that introduced a tool without content, they discovered that the tool was easy to use, and they would use the technology tool again because it increased student engagement, collaboration, and reflection. The teachers that tried a technology tool with content, they would use the technology tool another time with other content areas. All participants noticed a shift in student engagement and collaboration when a technology tool was used.

The rich dialogue from the CoP created access for teachers TPK and TPaCK to be revealed. The CoP participants discovered other uses of technology tools that were shared from other participants, which also gave the teachers the time to reflect about how they could apply it to their practice. With appropriate guidelines of incorporating the components of effective professional development with an environment, such as a CoP, teachers empathized and defined their technology challenges with each other resulting them to be more comfortable with each other since they realize that the challenges they are facing, others in the CoP are facing too. In the other CoP sessions, teachers ideated, prototyped, and tested their technology lessons. The exchange of ideas and knowledge created an onset of other members being more receptive of student technology use. The design thinking process provided a roadmap for teachers to step through the process of developing their TPaCK while integrating technology use in the classroom. The CoP provided the community support for teachers to develop their TPK and TPaCK.

The study's findings support the view that providing the workshops and CoP were important in teachers' learning. The teachers that participated in the workshops felt that

the experiences were positive because they were given more than just a list of available technology tools. Teachers were excited to “play” with the technology tools, plan a literacy unit with a focus of reaching all students with their grade-level peers, including ELD students with the 4 Cs and technology tools. And they felt that the technology tools and the workshops addressed their TK and TPK. Teachers felt that they were able to walk away with a variety of technology tools that they could incorporate in the classroom.

The teachers that participated both in the workshops and the CoP felt very supported through the meetings. They were excited by the conversations across grade levels of and started to see how technologies might be applied at their own grade level. The safe and familiar social context of the CoP encouraged teachers to speak honestly about both the challenges and possible solutions to introducing technology as a meaningful tool for learning. Even though the technology tools that they tried were different, teachers that were hesitant in using technology became more open to using technology in the classroom. The findings also revealed patterns in teachers’ problem-solving that reflected differences in their levels of TPaCK development. The ones that were less advanced in TPaCK benefited from new ideas and encouragement from the more advanced TPaCK members. The more advanced TPaCK members benefited from the CoP because other members helped them to clarify and solidify their own TPaCK practices. The shared lessons that teachers provided gave others’ “aha” moments for them that they can still use that technology tool but at their grade level. The shift of this thinking was the catapult to development and growth of these CoP teachers’ TPaCK and technology integration in their practice.

Discussion of the Results Related to Literature and Field

Previous literature recommended that additional TPaCK-based professional development models should be created and examined since the contextual conditions can also contribute to teachers' TPaCK (Rosenberg & Koehler, 2015). Contextual conditions such as the school site can also contribute to teachers TPaCK since teachers are considered to be the designers of students' learning. Literature suggests (Agostinho, Lockyer, & Bennett, 2018, Asensio-Pérez et al., 2017, Michos & Hernández-Leo 2020, Voogt et al., 2015) that teachers' CoPs are unexplored through design thinking. This study contributes to teachers' learning that is focused on the design-thinking process as a structure for the professional development workshops and the CoP. Design thinking was used to focus dialogue on identifying authentic instructional needs, leveraging specific benefits to technology and problem-solving practical problems in implementation. By providing the structure of design thinking, resistant teachers became more open to the idea of technology use. Honest discussion about the benefits and challenges of technology helped open them up to critical reflection on their own beliefs about technology. Focused discussion on addressing these perceived challenges helped them overcome their initial resistance and learn more about the successes of their peers.

Even after brainstorming ideas and technology tools that can be used in lessons for the ideation and prototyping stages, teachers with less advanced TPaCK became a bit uncomfortable because they were trying something new. After testing the technology tool with their class, these same teachers shared that they were surprised by their own and students' actions. The CoP participants shared their positive experiences of using the

technology tool with their students. Teachers saw an increase in student engagement and student collaboration, resulting in changing their beliefs of seeing technology as a tool for student learning. These data support the claim that professional development that focuses on developing teachers' TPaCK can create a higher confidence in effectively using technology tools (Zhang, 2019).

Previous research (Bene & McNeilly, 2020) suggested that further studies should examine design thinking to nurture collaboration. This study addresses that valuing ideas and solutions was a key element of a CoP and design thinking, thus providing teachers' gain in their TPK and TPaCK. Design thinking being one of those methods and structures of professional development design created novice teachers and teachers that had low TPK, TCK, and TPaCK to be confident with their preparations to implement technology in meaningful ways. Across grade level participants involved themselves with the design thinking process. The empathy and definition stage set the precedent for ones that were stressed about something extra to do or that they were being judged or graded on. Those stages created an empathy and understanding of each other's technology perceptions and challenges. After hearing each other's challenges, other members' stress levels subsided. In the ideation and prototype stages, teachers shared their thoughts of technology benefits and what available technology tools would be used for a technology lesson that they were going to test.

Furthermore, using content such as literacy as a focus to organize learning, teachers were able to identify, discuss, select, and apply TPaCK-based activity types within the curriculum and future ways should be examined to support teachers' TPaCK (Enderson

& Watson, 2019). The CoP members were able to discuss, select, and apply TPaCK-based activity types within the curriculum. That said, 2 of 7 members chose to experiment with a technology tool with their students without content since it was a new tool. Starting in this way helped students learn to use the technology in a familiar context, while helping the two teachers see how the tools facilitate student learning. After using the tool for the first time in this context, the 2 teachers saw how they could then use this technology tool for teaching content. In other words, the experience of successfully implementing technology in a context devoid of content, had a positive effect on these teachers' TPK and TPaCK. Once these teachers saw the potential of technology for content instruction, their PK and PCK then affected their technology use (Uerz et al., 2018). Finally, once teachers experienced using the technology tool with their students, teachers' reflection of their own teaching changed their belief of technology use. Through the design thinking process of empathizing, defining, ideating, prototyping, and testing, teachers' TPaCK did change.

TPaCK-based professional development models structured around design thinking were used in this study and followed the elements of effective professional development. Desimone's (2009) core components of an effective professional development was applied in the professional development workshops and/or in the CoP. The first feature of an effective professional development is content focus. Content focus referred to activities that focus on subject matter content, which in this study was literacy. Another element of an effective professional development is active learning. Active learning referred to opportunities for teachers to observe others, receive feedback, and analyze

student work. Active learning occurred in the CoP. The third feature of an effective professional development is coherence. Coherence involves content, goals, and activities that are consistent with teacher beliefs, student needs, school curriculum, and school, district, and state goals. In this study, the coherence was using a technology tool that engaged all learners, including ELD learners. Coherence was also the school focusing on reaching the ELD students and increasing literacy for all students. The belief when students have a higher capacity to read and write, students would be able engage and participate more in other content areas. The fourth component of effective professional development is sustained duration. Sustained duration referred to continuous professional development. In this study, the CoP provided teachers time to engage in sustained professional development beyond the initial PD workshops over the course of 3 monthly meetings and structured around the design thinking process. The fifth component of an effective professional development is collective participation. Collective participation involves groups of teachers from the same grade, subject, and school to build an interactive learning community, in this study was the CoP.

Contributions to the Literature on Professional Learning

In the present study, a CoP following the design thinking process was implemented to enhance Desimone's (2009) components of effective professional learning. In particular three key insights emerged from the data that might inform those interested in preparing teachers to implement educational technology through professional learning experiences.

First, by providing a CoP structured around the design thinking method, teachers had an environment in which to explore, discuss, and problem-solve the use of technology to

support student learning. Findings were consistent with previous literature (Ciampa & Gallagher, 2013; Uerz et al., 2018) that by providing the time for teachers to share in the CoP, teachers had a chance to reflect and gain valuable resources and increased confidence in technology skills within a school context (Woolway et al., 2019). The CoP provided a space for teachers' curiosity of shared technology tools from other members. Novice teachers began asking questions of new technology tools that more advanced teachers with a higher TPaCK about the simplicity of learning how to use the technology tool. These conversations would not have occurred without the CoP members because of their own previous beliefs of technology use. The findings of the present study suggest that the CoP is another way to support novice teachers in developing their TPK and TPaCK as well as advancing and clarifying veteran teachers' TPK and TPaCK. This collaboration allowed teachers to exchange insights into what worked and what did not and gave them the support to experiment with the technology tool again.

Second, findings supported from previous literature (Austin et al., 2010; Ciampa & Gallagher, 2013; Levin & Wadmany, 2005) suggest that all CoP participants contributed to their own professional learning. The professional development workshops and the CoP provided the environment for the teachers to dive deeper with technology integration, particularly by shifting their technology beliefs and their own assumptions of students' technology usage. This study finding is consistent with Loveless's (2011) literature that teachers' felt that they were inclined to learn when given the opportunities that can shape their own pedagogy. Novice technology users focused their technology lessons with their students without content during the study since it was their first time using the tool.

Before trying the technology tools, these teachers focused on teaching the curriculum and content. This study provided the teachers to develop their TK, TPK, and TPaCK. After trying the technology tools, the novice technology users shared in the CoP that they would use the technology tool again and this opened other conversations of other technology tools being used in other classrooms. Therefore, the CoP provided opportunities for teachers in developing and growing their pedagogy in other areas, such as technology.

Third, our findings suggest that providing a CoP structured around the design thinking process, there was an increase in teacher technology engagement because of the success and excitement of using the technology tool with their students. With the collaboration and support from the CoP members, the camaraderie not only increased the engagement, it also provided the support for the CoP members that were hesitant and did not see the value in using technology in their class. Just gaining TK was not enough to create strategic technology integration in the classroom. To ask educators to use technology strategically in the classroom and integrate technology with content, educators will need to practice using a technology tool in the classroom and be the critical designers of student learning. In order to encourage teachers to persist in these efforts, a supportive community needs to be established without the evaluation from the administrator. Therefore, continuous pedagogy design is an ever-changing set of practices developed by experimentation, reflection, and redesign (Koehler et al., 2011; Meyer et al., 2011; Wrigley & Straker 2017).

Recommendations

For teacher knowledge growth and technology to occur, several key elements, suggested by this study, may need to be included. These are:

- Professional development, including CoPs, need to have Desimone's (2009) components: (content focus, active learning, coherence, sustained duration, and collective participation).
- A safe space, like a CoP for a deeper dialogue exchange amongst a trusted community needs to be established for teachers to share challenges and solutions
- A CoP needs to have some structure, like the Design thinking process to create an iterative process and promote teacher knowledge gains and technology integration
- Having a CoP across grade levels sparks curiosity and creates an understanding of what other grades are doing
- In the CoP, novice TPaCK teachers benefited from advanced TPaCK teachers. Advanced TPaCK teachers clarified their own TPaCK.

This study was consistent with another study that indicated the design thinking method can imprint positive beliefs in technology to help overcome teachers' perceptions of their limits to technology integration and make learning relevant to them (Henriksen et al., 2017). All teachers that participated in the professional development workshops and in the CoP opened up their perceptions of technology use in the classroom. As stated in previous studies, teachers indicated that they felt supported in their learning and enjoyed discussing the variety of technology tools used in other classrooms with the CoP. The

rich dialogue produced in the CoP gave teachers the ability to reflect and develop their growth in their professional learning (Polly & Hannafin, 2010; Wieczorek, 2017).

Technology tools were introduced in the professional development workshops with the focus on engaging all students with 21st century skills and literacy. To reduce anxiety, teachers needed the time to “play” with technology to familiarize themselves with the technology tool and the time for reflection, discourse, and teacher differentiation (Ciampa & Gallagher, 2013). In the professional development workshops, this time was provided, but the duration and amount of time needed for deeper reflection did not yield the same results as the CoP participants. This study findings are consistent with previous studies (Crippen & Archambault, 2012; Russell et al., 2003; Wood et al., 2005) that providing a safe environment to work with the technology tools causes teaching and learning benefits. The CoP participants indicated that they felt supported by their community and excited to hear other teachers’ lessons of technology across grade levels in the school. By providing the CoP for teachers to work with the technology tools, teachers’ TPK, TK, and TPaCK began to develop and grew. Teachers’ became open to the possibilities of using different technology tools in the classroom and strategically integrating technology.

Study Limitations

This study explored how elementary teachers’ TPaCK emerged through the design thinking process and in the CoP in a Northern California school. The study draws on rich qualitative data to explore teachers’ perceptions, their design thinking and their reflections of the process. Nonetheless, there were some limitations worth noting. One

limitation was the data collection was a convenience sampling. The data collection occurred in one school in Northern California. Another limitation was this study was not a controlled study. No comparison can be drawn since this study was focused on teachers' professional development experiences with technology at one site. Another limitation was the length of time in the data collection. Pre-surveys were given in May 2019 and the post surveys were given in November 2020 due to the school calendar. Dates of previous professional development were given precedent before these professional development workshops. Also, only after the professional development workshops were completed, the CoP meetings began.

The CoP met from November 2019 - January 2020 for three times. Even though the CoP meetings were scheduled in advance, one participant could not make it to the last CoP. Guiding questions from the researcher was given to the CoP participant, so that participant's thoughts were shared with the group. This participant's absence from the third CoP could have created a possible different CoP experience. In addition, the participants in the CoP included the participant researcher. Even though the participant researcher participated in the CoP, the dialogue between the CoP members indicated teachers' growth and development in their learning. To ensure the validity of data analysis from the CoP transcriptions, two raters were trained on the coding schemes and the inter-rater reliability was 89.7% exact agreement. Nonetheless, this study offers teachers' professional development experiences with technology integration in their professional learning through the professional development workshops and the CoP structured around design thinking.

Conclusion

While this study provided insight of teachers' professional development experiences of technology integration structured around the design thinking process and a CoP was provided at one site, a controlled study could provide a comparison between two similar sites. Another recommendation for future research is providing more time for the study that allowed the teachers to complete another TPaCK survey at the end of the school year to indicate reported teachers' confidence and growth from the school site in that year. Further research is needed to understand the interplay between the design thinking method, the CoP experience, and TPaCK. The balance of three of these indicates strategic technology use and integration in the classroom. What are those components that increase maximum TPaCK development and growth? Are there other structures that have more TPaCK development and growth?

Overall, all teachers gained more comfort and confidence in using technology as a teacher to support student learning. The exposure and exploration of the technology tools with the support from their peers across grade levels and/or CoPs, teachers' collaboration and joint knowledge of their PK, CK, and TK have resulted in growth of their TK, TPK, TCK, and/or TPaCK, some more than others. Embedding the design thinking method within the professional development workshops and in the CoPs created the focus and structure with teachers' learning. Teachers need to design learning experiences with a focus that are tailored to students' needs and competence and school organization policies, which professional development should address this type of learning (Augustsson, 2018). By providing the semi-design thinking method that started their

focus on literacy and technology use with English language learners and 21st century learning skills in the empathy and definition stages gave the focus and goal for all teachers. This being one of the things that teachers mentioned why they felt that professional development workshops were effective. All teachers were able to ideate strategies that they could use the technology tools to enhance their literacy unit. The teachers in the CoP had in-depth support from the technology lead and the facilitator to prototype and test their solutions. The test and prototype stages provided the time to test their ideas and prototype solutions, in which crucial moments for teachers' learning and growth of teachers' TPaCK.

References

- Adams, P. (2011). ICT and pedagogy: Opportunities missed? *Education 3–13*, 39(1), 21-33.
- Agostinho, S., Lockyer, L., & Bennett, S. (2018). Identifying the characteristics of support Australian university teachers use in their design work: Implications for the learning design field. *Australasian Journal of Educational Technology*, 34(2).
- Augustsson, D. (2018). Collaborative media in educational settings: Teaching as a design profession. *The International Journal of Design Education*, 13(2), 1-19.
- Alenezi, A. (2017). Obstacles for teachers to integrate technology with instruction. *Education and Information Technologies*, 22(4), 1797-1816.
- An, Y. J., & Reigeluth, C. (2011). Creating technology-enhanced, learner-centered classrooms: K–12 teachers' beliefs, perceptions, barriers, and support needs. *Journal of Digital Learning in Teacher Education*, 28(2), 54-62.
- Archambault, L., Wetzel, K., Foulger, T. S., & Kim Williams, M. (2010). Professional development 2.0: Transforming teacher education pedagogy with 21st century tools. *Journal of Digital Learning in Teacher Education*, 27(1), 4-11.
- Asensio-Pérez, J. I., Dimitriadis, Y., Pozzi, F., Hernández-Leo, D., Prieto, L. P., Persico, D., & Villagrà-Sobrino, S. L. (2017). Towards teaching as design: Exploring the interplay between full-lifecycle learning design tooling and teacher professional development. *Computers & Education*, 114, 92-116.
- Attard, K. (2017). Personally driven professional development: Reflective self-study as a way for teachers to take control of their own professional development. *Teacher Development*, 21(1), 40-56.
- Austin, R., Smyth, J., Rickard, A., Quirk-Bolt, N. & Metcalf, N. (2010). Collaborative digital learning in schools: Teacher perceptions of purpose and effectiveness, *Technology, Pedagogy, and Education*, 19:3, 327-343.
- Baran, E., & Uygun, E. (2016). Putting technological, pedagogical, and content knowledge (TPACK) in action: An integrated TPACK-design-based learning (DBL) approach. *Australasian Journal of Educational Technology*, 32(2).
- Bene, R., & McNeilly, E. (2020). Getting Radical: Using design thinking to tackle collaboration issues. *Papers on Postsecondary Learning and Teaching*, 4, 50-57.

- Blank, R. K., de las Alas, N., & Smith, C. (2007). *Analysis of the quality of professional development programs for mathematics and science teachers: Findings from a cross-state study*. Washington, DC: Council of Chief State School Officers.
- Blank, R. K., & de las Alas, N. (2009). *The effects of teacher professional development on gains in student achievement: How meta analysis provides scientific evidence useful to education leaders*. Washington, DC: Council of Chief State School Officers.
- Boshuizen, H. P., & Wopereis, I. G. (2003). Pedagogic benchmarks for information and communications technology in teacher education. *Technology, Pedagogy and Education, 12*(1), 149-159.
- Bredeson, P. V. (2000). The school principal's role in teacher professional development. *Journal of In-Service Education, 26*(2), 385-40
- Bryk, A. S. (2009). Support a science of performance improvement. *Phi Delta Kappan, 90*(8), 597-600.
- Bushweller, Kevin C., Ed. (2017). Classroom technology: Where schools stand. technology counts. *Education Week, 36*(35).
- California Department of Education. (2012). *Greatness by design: Supporting outstanding teaching to sustain a golden state*. Retrieved from <https://www.cde.ca.gov/eo/in/documents/greatnessfinal.pdf>
- Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2013). A review of technological pedagogical content knowledge. *Journal of Educational Technology & Society, 16*(2), 31-51.
- Chang, Y., Hsu, C., & Ciou, P. S. (2017). Examining the use of learning communities to improve pre-service teachers' technological pedagogical content knowledge. *International Journal of Learning and Teaching, 3*(2), 136-43.
- Cheng, S. L., & Xie, K. (2018). The relations among teacher value beliefs, personal characteristics, and TPACK in intervention and non-intervention settings. *Teaching and Teacher Education, 74*, 98-113.
- Chou, C. H. (2011). Teachers' Professional Development: Investigating Teachers' Learning to Do Action Research in a Professional Learning Community. *Asia-Pacific Education Researcher (De La Salle University, Manila), 20*(3).
- Ciampa, K., & Gallagher, T. L. (2013). Professional learning to support elementary teachers' use of the iPod Touch in the classroom. *Professional Development in Education, 39*(2), 201-221.

- Crippen, K. J., & Archambault, L. (2012). Scaffolded inquiry-based instruction with technology: A signature pedagogy for STEM education. *Computers in the Schools*, 29(1-2), 157-173.
- Darling-Hammond, L. (2006). Constructing 21st-century teacher education. *Journal of Teacher Education*, 57(3), 300-314.
- Davis, N. (1999). Teacher education and information technology: Challenges for teacher education. *Journal of Information Technology for Teacher Education*, 8(1), 3-13.
- Desimone, L.M. (2009). Improving impact studies of teacher's professional development: toward better conceptualizations and measures. *Educational Researcher*, 38(3), 181-189.
- Desimone, L.M., & Garet, M. S. (2015). Best practices in teachers' professional development in the United States. *Psychology, Society and Education*, 7(3), 252-263.
- Desimone, L. M., Porter, A. C., Garet, M. S., Yoon, K. S., & Birman, B. F. (2002). Effects of professional development on teachers' instruction: Results from a three-year longitudinal study. *Educational evaluation and policy analysis*, 24(2), 81-112.
- Dillon, P., & Åhlberg, M. (2006). Integrativism as a theoretical and organisational framework for e-learning and practitioner research. *Technology, Pedagogy and Education*, 15(1), 7-30.
- Enderson, M. C., & Watson, G. S. (2019). A case study of a STEM teacher's development of TPACK in a teacher preparation program. In *Society for Information Technology & Teacher Education International Conference of the Association for the Advancement of Computing in Education (AACE)*, 2169-2176.
- Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education*, 59(2), 423-435.
- Fabry, D. L., & Higgs, J. R. (1997). Barriers to the effective use of technology in education: Current status. *Journal of Educational Computing Research*, 17(4), 385-395.
- Figg, C., & Jaipal, K. (2012, March). TPACK-in-Practice: Developing 21st century teacher knowledge. In *Society for Information Technology & Teacher Education International Conference of the Association for the Advancement of Computing in Education (AACE)*, 4683-4689.

- Finefter-Rosenbluh, I. (2016). Behind the scenes of reflective practice in professional development: A glance into the ethical predicaments of secondary school teachers. *Teaching and Teacher Education*, 60, 1-11.
- Foulger, T. S., Buss, R. R., Wetzel, K., & Lindsey, L. (2015). Instructors' growth in TPACK: Teaching technology-infused methods courses to preservice teachers. *Journal of Digital Learning in Teacher Education*, 31(4), 134-147.
- Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, 38(4), 915-945.
- Gibson, I. W. (2001). At the intersection of technology and pedagogy: Considering styles of learning and teaching. *Journal of Information Technology for Teacher Education*, 10(1-2), 37-61.
- Groff, J., & Mouza, C. (2008). A framework for addressing challenges to classroom technology use. *AACE Journal*, 16(1), 21-46.
- Hardy, I., Rönnerman, K., Moksnes Furu, E., Salo, P., & Forsman, L. (2010). Professional development policy and politics across international contexts: From mutuality to measurability. *Pedagogy, Culture & Society*, 18(1), 81-92.
- Harris, J., Mishra, P., & Koehler, M. (2009). Teachers' technological pedagogical content knowledge and learning activity types: Curriculum-based technology integration reframed. *Journal of Research on Technology in Education*, 41(4), 393-416.
- Harris, J., Grandgenett, N., & Hofer, M. (2012). Using structured interviews to assess experienced teachers' TPACK. In *Society for information technology & teacher education international Conference e of the Association for the Advancement of Computing in Education (AACE)*, 4696-4703.
- Harris, J. B., & Hofer, M. J. (2017). "TPACK Stories": Schools and School Districts Repurposing a Theoretical Construct for Technology-Related Professional Development. *Journal of Research on Technology in Education*, 49(1-2), 1-15.
- Henriksen, D., Richardson, C., & Mehta, R. (2017). Design thinking: A creative approach to educational problems of practice. *Thinking Skills and Creativity*, 26, 140-153.
- Howard, S. K. (2013). Risk-aversion: Understanding teachers' resistance to technology integration. *Technology, Pedagogy and Education*, 22(3), 357-372.
- Kimmons, R., & Hall, C. (2018). How Useful are our Models? Pre-Service and Practicing Teacher Evaluations of Technology Integration Models. *TechTrends*, 62(1), 29-36.

- Kirschner, P. A. (2015). Do we need teachers as designers of technology enhanced learning?. *Instructional Science*, 43(2), 309-322.
- Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)?. *Contemporary issues in technology and teacher education*, 9(1), 60-70.
- Koehler, M. J., Mishra, P., & Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology. *Computers & Education*, 49(3), 740-762.
- Koehler, M. J., Mishra, P., Bouck, E. C., DeSchryver, M., Kereluik, K., Shin, T. S., & Wolf, L. G. (2011). Deep-play: Developing TPACK for 21st century teachers. *International Journal of Learning Technology*, 6(2), 146-163.
- Koh, J. H. L., Chai, C. S., Wong, B., & Hong, H. Y. (2015). Design Thinking and Education. In *Design Thinking for Education* (pp. 1-15). Springer, Singapore.
- Koh, J. H. L., Chai, C. S., Wong, B.; & Hong, H. Y. (2016). *Design thinking for education: conceptions and applications in teaching and learning*. S.l.: Springer.
- Kooij, D., de Lange, A., Jansen, P., Kanfer, R., & Dijkers, J. (2011). Age and work-related motives: Results of a meta-analysis. *Journal of Organizational Behavior*, 32(2), 197-225. doi:10.1002/job.665
- Levin, T., & Wadmany, R. (2005). Changes in educational beliefs and classroom practices of teachers and students in rich technology-based classrooms [1]. *Technology, Pedagogy and Education*, Vol. 14, No. 3, 2005, 14(3), 281-307.
- Loveless, A. (2011). Technology, Pedagogy and education: Reflections on the Accomplishment of what teachers know, do and believe in a digital age, *Technology, Pedagogy, and Education*, 20:3, 301-316.
- Luckin, R. (2008). The learner centric ecology of resources: A framework for using technology to scaffold learning. *Computers & Education*, 50(2), 449-462.
- Malik, S., Rohendi, D., & Widiaty, I. (2019, February). Technological Pedagogical Content Knowledge (TPACK) with Information and Communication Technology (ICT) Integration: A Literature Review. In *5th UPI International Conference on Technical and Vocational Education and Training (ICTVET 2018)*. Atlantis Press.
- Masterman, E., & Manton, M. (2011). Teachers' perspectives on digital tools for pedagogic planning and design. *Technology, Pedagogy and Education*, 20(2), 227-246.

- Merga, M. K., & Williams, R. (2016). The role of health educators in mitigating health risk from increasing screen time in schools and at home. *Asia-Pacific Journal of Health, Sport and Physical Education*, 7(2), 157-172.
- Meyer, E. J., Abrami, P. C., Wade, A., & Scherzer, R. (2011). Electronic portfolios in the classroom: Factors impacting teachers' integration of new technologies and new pedagogies. *Technology, Pedagogy and Education*, 20(2), 191-207.
- Michos, K., & Hernández-Leo, D. (2020). CIDA: A collective inquiry framework to study and support teachers as designers in technological environments. *Computers & Education*, 143, 103679.
- Mishra, P., (2018). Revised version of TPACK image. Retrieved from <https://punyamishra.com/2018/09/10/the-tpack-diagram-gets-an-upgrade/>
- Mishra, P. (2019). Considering Contextual Knowledge: The TPACK Diagram Gets an Upgrade.
- Mosely, G., Wright, N., & Wrigley, C. (2018). Facilitating design thinking: A comparison of design expertise. *Thinking Skills and Creativity*, 27, 177-189.
- Murray, C. (2017, December 13). Survey: 74 Percent of Educators Support the Use of Technology in Schools. Retrieved from <https://edtechmagazine.com/k12/article/2013/02/survey-74-percent-educators-support-use-technology-schools>
- Ng, P. T. & Tan, C. (2009) Community of practice for teachers: sensemaking or critical reflective learning?, *Reflective Practice*, 10(1), 37-44, doi: 10.1080/14623940802652730
- Niess, M. L. (2011). Investigating TPACK: Knowledge growth in teaching with technology. *Journal of Educational Computing Research*, 44(3), 299-317.
- Partnership for 21st Century Skills. (Last Reviewed: Monday, May 13, 2019.). Retrieved from <https://www.cde.ca.gov/eo/in/cr/p21cskls.asp>
- Pea, R. D. (1993). Practices of distributed intelligence and designs for education. *Distributed cognitions: Psychological and educational considerations*, 11, 47-87.
- Phillips, M. (2012). The role of community in teachers' knowledge development. In ACEC2012: Its Time Conference (October 2012). Vol. 2, 452-463.
- Phillips, M. (2016). Re-contextualising TPACK: Exploring teachers'(non-) use of digital technologies. *Technology, Pedagogy and Education*, 25(5), 555-571.

- Polly, D., & Hannafin, M. J. (2010). Reexamining technology's role in learner-centered professional development. *Educational Technology Research and Development*, 58(5), 557-571.
- Price, L., & Kirkwood, A. (2014). Informed design of educational technology for teaching and learning? Towards an evidence-informed model of good practice. *Technology, Pedagogy and Education*, 23(3), 325-347.
- Rodgers, C. (2002). Defining reflection: Another look at John Dewey and reflective thinking. *Teachers College Record*, 104(4), 842-866.
- Rosenberg, J. M., & Koehler, M. J. (2015). Context and technological pedagogical content knowledge (TPACK): A systematic review. *Journal of Research on Technology in Education*, 47(3), 186-210.
- Russell, M., Bebell, D., O'Dwyer, L., & O'Connor, K. (2003). Examining teacher technology use: Implications for preservice and inservice teacher preparation. *Journal of teacher Education*, 54(4), 297-310.
- Sanders, M., & Hembrick-Roberts, J. (2013). Leadership for more equitable schools through service integration. In Tillman, L. C., & Scheurich, J. J. (Eds.), *Handbook of research on educational leadership for equity and diversity*. 476-493. New York, NY: Routledge.
- Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). 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.
- Scoggin, D., & Vander Ark, T. (2018). Should We Limit "Screen Time" in School?. *Education Next*, 18(1), 54-63.
- Selwyn, N. (2008) From state-of-the-art to state-of-the-actual? Introduction to a special issue. *Technology, Pedagogy and Education*, 17(2), 83-87, doi: 10.1080/14759390802098573
- Sipilä, K. (2014). Educational use of information and communications technology: Teachers' perspective. *Technology, Pedagogy and Education*, 23(2), 225-241.
- Starkey, L. (2011). Evaluating learning in the 21st century: a digital age learning matrix. *Technology, pedagogy and education*, 20(1), 19-39.

- Tondeur, J., Pareja Roblin, N., van Braak, J., Voogt, J., & Prestridge, S. (2017). Preparing beginning teachers for technology integration in education: ready for take-off? *Technology, Pedagogy and Education*, 26(2), 157-177.
- Tondeur, J., van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2017). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: a systematic review of qualitative evidence. *Educational Technology Research and Development*, 65(3), 555-575.
- Turner, K., Simon, S., Pickering, J., Daly, C., & Pachler, N. (2007). Portfolios for learning: Teachers' professional development through M-level portfolios. In Pickering, J. and Daly, C. and Pachler, N., (eds.) *New Designs for Teachers' Professional Learning*. Institute of Education, University of London: London. (2007)). 89-115.
- Underwood, J., & Dillon, G. (2011). Chasing dreams and recognising realities: Teachers' responses to ICT. *Technology, Pedagogy and Education*, 20(3), 317-330.
- Uerz, D., Volman, M., & Kral, M. (2018). Teacher educators' competences in fostering student teachers' proficiency in teaching and learning with technology: An overview of relevant research literature. *Teaching and Teacher Education*, 70, 12-23.
- Vanblaere B., & Devos, G. (2016). Relating school leadership to perceived professional learning community characteristics: A multilevel analysis. *Teaching and Teacher Education*, 57, 26-38.
- Van Raaij, E. M., & Schepers, J. J. (2008). The acceptance and use of a virtual learning environment in China. *Computers & Education*, 50(3), 838-852.
- Van der Heijden, B., Van Vuuren, T., Kooij, D., & de Lange, A. (2015). Tailoring professional development for teachers in primary education. *Journal of Managerial Psychology*, 30(1), 22-37. doi: 10.1108/JMP-07-2014-0211.
- Vongkulluksn, V. W., Xie, K., & Bowman, M. A. (2018). The role of value on teachers' internalization of external barriers and externalization of personal beliefs for classroom technology integration. *Computers & Education*, 118, 70-81.
- Voogt, J., Laferriere, T., Breuleux, A., Itow, R., Hickey, D., & McKenney, S. (2015). Collaborative design as a form of professional development. *Instructional science*, 43(2), 259-282.
- Wenger, E., McDermott, R., & Snyder, W. M. (2002). It takes a community. (excerpt from *Cultivating Communities of Practice: A Guide to Managing Knowledge*), *CIO*, 15(15).

- Wenger, E. (2011). *Communities of practice: A brief introduction*. Presented at STEP Leadership Workshop, University of Oregon.
- Wieczorek, D. (2017). Principals' perceptions of public schools' professional development changes during NCLB. *Education Policy Analysis Archives/Archivos Analíticos de Políticas Educativas*, (25), 1-49.
- Wood, E., Mueller, J., Willoughby, T., Specht, J., & Deyoung, T. (2005). Teachers' perceptions: Barriers and supports to using technology in the classroom. *Education, Communication & Information*, 5(2), 183-206.
- Woolway, J., Msimanga, A., & Lelliott, A. (2019). Continuous Collaborative Reflection Sessions in a Professional Learning Community: The Development of Grade 8 Natural Sciences Teachers' Reflective Practice. *African Journal of Research in Mathematics, Science and Technology Education*, 1-13.
- Wrigley, C., & Straker, K. (2017). Design thinking pedagogy: The educational design ladder. *Innovations in Education and Teaching International*, 54(4), 374-385.
- Yurdakul, I. K., Odabasi, H. F., Kilicer, K., Coklar, A. N., Birinci, G., & Kurt, A. A. (2012). The development, validity and reliability of TPACK-deep: A technological pedagogical content knowledge scale. *Computers & Education*, 58(3), 964-977.
- Zhang, Q. (2019). *Technology enhanced instruction and English teacher's TPACK*. Paper presented at the 2019 International Symposium on Education and Humanities Sciences (ISEHS 2019). doi: 10.12783/dtssehs/isehs2019/31601

Appendices

Appendix A: Survey Questions for All Teachers

Demographics

Years of teaching:

- 1-2 3-5 6-8 9-12 13 and more

Grade Level Taught:

- | | |
|--|---|
| <input type="checkbox"/> Transitional Kindergarten | <input type="checkbox"/> Third Grade |
| <input type="checkbox"/> Kindergarten | <input type="checkbox"/> Fourth Grade |
| <input type="checkbox"/> First Grade | <input type="checkbox"/> Fifth Grade |
| <input type="checkbox"/> Second Grade | <input type="checkbox"/> Other: Special Education |

Which of the following do you have? Check all that apply.

- | | |
|---|---|
| <input type="checkbox"/> Master's Degree | <input type="checkbox"/> Technology classes (University, KCI, online, Intel Teach, etc.) |
| <input type="checkbox"/> Other Master's Degree | <input type="checkbox"/> Other Credentials in Technology (Apple Teacher, Google Educator, etc.) |
| <input type="checkbox"/> Reading/Literacy Credential/ Certificate | |
| <input type="checkbox"/> Certificate in Technology | |

Likert Scale:

Strongly Agree (SA), Agree (A), Somewhat Agree (SA), Neither (N), Somewhat Disagree (SD), Disagree (D), Strongly Disagree (SD)

TK (Technology Knowledge)

1. I know how to solve my own technical problems.
2. I can learn technology easily.
3. I keep up with important new technologies.
4. I frequently play around the technology.
5. I know about a lot of different technologies.
6. I have the technical skills I need to use technology.

CK (Content Knowledge)

7. I have sufficient knowledge about literacy.
8. I can use a literary way of thinking.
9. I have various ways and strategies of developing my understanding of literacy.

PK (Pedagogical Knowledge)

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

11. I can adapt my teaching based-upon what students currently understand or do not understand.
12. I can adapt my teaching style to different learners.
13. I can assess student learning in multiple ways.
14. I can use a wide range of teaching approaches in a classroom setting.
15. I am familiar with common student understandings and misconceptions.
16. I know how to organize and maintain classroom management.

PCK (Pedagogical Content Knowledge)

17. I can select effective teaching approaches to guide student thinking and learning in literacy.

TCK (Technological Content Knowledge)

18. I know about technologies that I can use for understanding and doing literacy.

TPK (Technological Pedagogical Knowledge)

19. I can choose technologies that enhance the teaching approaches for a lesson.
20. I can choose technologies that enhance students' learning for a lesson.
21. My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom.
22. I am thinking critically about how to use technology in my classroom.
23. I can adapt the use of the technologies that I am learning about to different teaching activities.
24. I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn.
25. I can use strategies that combine content, technologies and teaching approaches that I learned about in my coursework in my classroom.
26. I can provide leadership in helping others to coordinate the use of content, technologies and teaching approaches at my school and/or district.
27. I can choose technologies that enhance the content for a lesson.

TPACK (Technology Pedagogy and Content Knowledge)

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

Professional Development

29. This professional development will focus on literacy and technology. What would you want to walk away with this professional development?
30. Think of a professional development experience that you found useful. What are some structures, activities, or strategies that you found most useful to your learning?

Appendix B: Consent Form for Survey

REQUEST FOR YOUR PARTICIPATION IN RESEARCH

TITLE OF THE STUDY: Developing teachers' technological, pedagogical, and content knowledge with design thinking and community of practice

NAME OF THE RESEARCHERS

Name: Lara Kassab, Faculty Member

Email: Lara.Kassab@sjsu.edu

Phone Number: 408-924-4091

Department Name: Teacher Education

Name: Jennifer G.H. Wang, Ed.D Student

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Phone Number: 408-923-1910

PURPOSE

The purpose of this study is to examine whether and how teachers demonstrate technological pedagogical content knowledge (TPACK) in the integration of instructional technologies when they engage in a community of practice (COP) structured around design thinking.

PROCEDURES

I will email the survey to participants. It should not take more than 15 minutes to complete. After the professional development workshops, participants will be asked to complete another survey. Second survey link will be emailed again to complete.

POTENTIAL RISKS

There are no known risks in this study.

POTENTIAL BENEFITS

The survey may help with reflection of their practice.

COMPENSATION

There is no compensation for participation.

CONFIDENTIALITY

Pseudonyms will be used for any identifiable data. Data will be de-identified, should any identifying information be provided on the open-ended items, prior to analysis.

PARTICIPANT RIGHTS

Participation in this study is completely voluntary. You can refuse to participate in the entire study or any part of the study without any negative effect on your relations with

San Jose State University. You also have the right to skip any question you do not wish to answer. This consent form is not a contract. It is a written explanation of what will happen during the study if you decide to participate. You will not waive any rights if you choose not to participate, and there is no penalty for stopping your participation in the study.

QUESTIONS OR PROBLEMS

For further information about the study, please contact Jennifer G.H. Wang, jennifergeehuei.wang@sjsu.edu. Complaints about the research may be presented to Dr. Lara Kassab, lara.kassab@sjsu.edu.

For questions about participants' rights or if you feel you have been harmed in any way by your participation in this study, please contact Dr. Pamela Stacks, Associate Vice President of the Office of Research, San Jose State University, at 408-924-2479.

SIGNATURES

Clicking 'yes' to the informed consent on this survey indicates that you voluntarily agree to be part of the study, that the details of the study have been explained to you, that you have been given time to read this document, and that your questions have been answered. You will receive a copy of this consent form for your records.

Appendix C: Consent Form for CoPs, Exit Slips, and Focus Group

REQUEST FOR YOUR PARTICIPATION IN RESEARCH

TITLE OF THE STUDY: Developing teachers' technological, pedagogical, and content knowledge with design thinking and community of practice

NAME OF THE RESEARCHERS

Name: Mark Felton, Faculty Member

Email: mark.felton@sjsu.edu

Phone Number: 408-924-3745

Department Name: Teacher Education

Name: Jennifer G.H. Wang, Doctoral Student

Email: jennifergeehuei.wang@sjsu.edu

Phone Number: 408-923-1910

PURPOSE

The purpose of this study is to examine whether and how teachers demonstrate technological pedagogical content knowledge (TPACK) in the integration of instructional technologies when they engage in a community of practice (COP) structured around design thinking.

PROCEDURES

Participate in 3 community of practice sessions.

Complete exit slips after each community of practice session.

Complete survey after the third community of practice session.

Participate in focus group after the third community of practice session.

Community sessions and focus group will be audio-taped.

POTENTIAL RISKS

There are no known risks in this study.

POTENTIAL BENEFITS

The survey may help with reflection of their practice.

COMPENSATION

There is no compensation for participation.

CONFIDENTIALITY

Audio-tapes will be transcribed by a third party service. Pseudonyms will be used for any identifiable data. Data will be de-identified, should any identifying information be provided on the open-ended items, prior to analysis.

PARTICIPANT RIGHTS

Participation in this study is completely voluntary. You can refuse to participate in the entire study or any part of the study without any negative effect on your relations with San Jose State University. You also have the right to skip any question you do not wish to answer. This consent form is not a contract. It is a written explanation of what will happen during the study if you decide to participate. You will not waive any rights if you choose not to participate, and there is no penalty for stopping your participation in the study.

QUESTIONS OR PROBLEMS

For further information about the study, please contact Jennifer Wang, jennifergeehuei.wang@sjsu.edu. Complaints about the research may be presented to Dr. Mark Felton, mark.felton@sjsu.edu

For questions about participants' rights or if you feel you have been harmed in any way by your participation in this study, please contact Dr. Pamela Stacks, Associate Vice President of the Office of Research, San Jose State University, at 408-924-2479.

SIGNATURES

Clicking 'yes' to the informed consent on this survey indicates that you voluntarily agree to be part of the study, that the details of the study have been explained to you, that you have been given time to read this document, and that your questions have been answered. You will receive a copy of this consent form for your records.

Appendix D: Letter of Consent from School Site Administrator

[REDACTED] ELEMENTARY SCHOOL
[REDACTED] SAN JOSE, CA [REDACTED]

June 3, 2019

[REDACTED] Principal
[REDACTED]
San Jose, CA [REDACTED]

Dear Human Subjects Committee:

It is my understanding that Jennifer G.H. Wang will be conducting a research study at [REDACTED] Elementary School on "Developing Teachers' Technological, Pedagogical, and Content Knowledge with Design Thinking and Community of Practice." Ms. Wang has informed me of the design of the study as well as the targeted population.

I support this effort and will provide any assistance necessary for the successful implementation of this study. If you have any questions, please do not hesitate to call. I can be reached at [REDACTED]

Sincerely,
[REDACTED]
Principal

Appendix E: Institutional Review Board Approval (Survey)



Office of Research
Division of
Academic Affairs

San José State University
One Washington Square
San José, CA 95192-0025

TEL: 408-924-2272
officeofresearch@sjsu.edu
sjsu.edu/research

SAN JOSE STATE UNIVERSITY HUMAN SUBJECTS INSTITUTIONAL REVIEW BOARD

IRB Notice of Approval

Date of Approval: 6/7/2019

Study Title: Developing Teachers' Technological, Pedagogical, and Content Knowledge with Design Thinking and Community of Practice

Primary Investigator(s): Dr. Mark Felton

Student(s): Jennifer Gee-Huei Wang

Other Team Members:

Funding Source: None

IRB Protocol Tracking Number: S19100

Type of Review

- Exempt Registration: Category of approval §46.104(d)(1)
- Expedited Review: Category of approval §46.110(a)()
- Full Review
- Modifications
- Continuing Review

Special Conditions

- Waiver of signed consent approved
- Waiver of some or all elements of informed consent approved
- Risk determination for device:
- Other:

Continuing Review

- Is not required. Principal Investigator must file a [status report](#) with the Office of Research one year from the approval date on this notice to communicate whether the research activity is ongoing. Failure to file a status report will result in closure of the protocol and destruction of the protocol file after three years.

Is required. An annual [continuing review renewal application](#) must be submitted to the Office of Research one year from the approval date on this notice. No human subjects research can occur after this date without continuing review and approval.

Approved by Dr. Pamela C. Stacks
Associate Vice President
Institutional Official
Office of Research
San Jose State University

IRB Contact
Alena Filip
Human Protections Analyst
408-924-2479
Alena.Filip@sjsu.edu

Primary Investigator Responsibilities

- Any significant changes to the research must be submitted for review and approval prior to the implementation of the changes.
- Reports of unanticipated problems, injuries, or adverse events involving risks to participants must be submitted to the IRB within seven calendar days of the primary investigator's knowledge of the event.
- If the continuing review section of this notice indicates that continuing review is required, a request for continuing review must be submitted prior to the date the provided.

Appendix F: Institutional Review Board Approval (Community of Practice)



Office of Research
Division of
Academic Affairs

San José State University
One Washington Square
San José, CA 95192-0025

TEL: 408-924-2272
officeofresearch@sjsu.edu
sjsu.edu/research

SAN JOSE STATE UNIVERSITY HUMAN SUBJECTS INSTITUTIONAL REVIEW BOARD

IRB Notice of Approval

Date of Approval: 6/7/2019

Study Title: Developing Teachers' Technological, Pedagogical, and Content Knowledge with Design Thinking and Community of Practice

Primary Investigator(s): Dr. Mark Felton

Student(s): Jennifer Gee-Huei Wang

Other Team Members:

Funding Source: None

IRB Protocol Tracking Number: S19100

Type of Review

- Exempt Registration: Category of approval §46.104(d)(1)
- Expedited Review: Category of approval §46.110(a)()
- Full Review
- Modifications
- Continuing Review

Special Conditions

- Waiver of signed consent approved
- Waiver of some or all elements of informed consent approved
- Risk determination for device:
- Other:

Continuing Review

- Is not required. Principal Investigator must file a [status report](#) with the Office of Research one year from the approval date on this notice to communicate whether the research activity is ongoing. Failure to file a status report will result in closure of the protocol and destruction of the protocol file after three years.

Is required. An annual [continuing review renewal application](#) must be submitted to the Office of Research one year from the approval date on this notice. No human subjects research can occur after this date without continuing review and approval.

Approved by Dr. Pamela C. Stacks
Associate Vice President
Institutional Official
Office of Research
San Jose State University

IRB Contact
Alena Filip
Human Protections Analyst
408-924-2479
Alena.Filip@sjsu.edu

Primary Investigator Responsibilities

- Any significant changes to the research must be submitted for review and approval prior to the implementation of the changes.
- Reports of unanticipated problems, injuries, or adverse events involving risks to participants must be submitted to the IRB within seven calendar days of the primary investigator's knowledge of the event.
- If the continuing review section of this notice indicates that continuing review is required, a request for continuing review must be submitted prior to the date the provided.