33

Technology Teacher Educators

The Role of Self-Study in Supporting Digital Age Technology Teacher Education

Candace Figg and Kamini Jaipal-Jamani

Contents

Abstract

Technology teacher educators – those teacher educators who teach courses in teacher education programs focused on the pedagogy of how to teach with technology – are a small community, with a teacher education program counting itself privileged if they have one technology teacher educator on faculty offering stand-alone technology pedagogy courses. However, technology teacher educators have knowledge that is essential for shaping the digital landscape and promoting technology-enhanced teaching in both preservice teachers and fellow teacher educators. The purpose of this chapter is to provide a description of how research, specifically self-study research, informs our current understanding of the problems of practice of technology teacher educators. As well, it is within the

C. Figg (✉) · K. Jaipal-Jamani
Brock University, St. Catharines, ON, Canada
e-mail: cfigg@brocku.ca; kjaipal@brocku.ca

J. Kitchen et al. (eds.), *International Handbook of Self-Study of Teaching and Teacher Education Practices*, Springer International Handbooks of Education,
https://doi.org/10.1007/978-981-13-6880-6_33

scope of this chapter to identify any gaps in self-study research that could contribute to our understanding of how technology teacher educators not only promote the knowledge about how to teach with technology but illuminate those problems of practice for technology teacher educators that are distinctly different from the examples in the self-study literature of how teacher educators build their own knowledge about how to teach with technology. Therefore, the chapter will present a review of the literature that describes best practices for building knowledge for teaching with technology appropriate for preservice teaching and illuminates the problems of practice experienced by technology teacher educators, with examples of teacher educators and their experiences. New directions for self-study research to support technology teacher educators so their stories are shared are also discussed.

Keywords

Technology teacher educators · TPACK · Technology integration · Self-study · Digital learning

Introduction

Teaching in the digital learning landscape of today is complicated. With buzz words – like tech-enabled learning, tech-enhanced teaching, online learning environments, blended learning, makerspaces, and flipped classrooms – being touted throughout the current teaching profession, we find that technology often leads to a shift in the way we teach, the resources we use in our teaching practices, and even how we think about teaching and learning (Howell and O'Donnell 2017). A recent review of the digital learning climate in Canada suggested that the goal of education in the twenty-first century around the world was "to prepare all learners to succeed in an ever-changing, technology-driven, and globally connected world by providing the means to develop the skills, competencies, and knowledge they need to succeed today and into the future" (Howell and O'Donnell 2017, p. 7). With such a lofty purpose for those teaching in teacher education programs, it is no wonder that there is a need to prepare future teachers with the same expectations in mind to facilitate their success in preparing these digital learners.

And yet, not every preservice teacher education program includes a stand-alone technology course as part of the program requirement – technology methods courses are relatively new additions to the overall subject area methods courses required in teacher education programs (Niess 2012). The field of educational technology is a young discipline, so the theoretical foundational understandings and scope of general content that should be included in such a course are currently being reframed by research. Additionally, there are no specific curriculum guides to content for these technology courses such as would be found in the "content subject" curriculum courses of science, mathematics, literacy, or social sciences. Compounded by the pervasive and ubiquitous nature of technologies in our daily living environments, the ever-increasing availability of new and different technologies, and the rapid pace with which technologies change, the description of that "technology course content" has been, and will continue to be, difficult to establish and is generally described vaguely as a course that will provide students with an introduction to teaching with technology.

Therefore, the quality of instruction related to digital learning environments and technologically enhanced teaching in programs that do provide technology methods courses is reliant upon the background experiences, technical skill, and pedagogical expertise of the technology teacher educator to design and implement a quality course that promotes growth in knowledge about how to teach with technology. In other words, not just any teacher educator will be able to serve as the technology teacher educator as may have been past practice. Successful technology teacher educators have a knowledge base that, when shared through research methods such as self-study, provides descriptions of how to promote that knowledge base, not just within technology methods classes to preservice teachers but also to their fellow colleagues who are teaching technology in the subject areas.

The purpose of self-study research is to promote improvement in teaching practices from studying specific problems of individual practices (Lassonde et al. 2009). This type of study is rigorous, with a specific focus on how to make individual teaching practice better, and uses qualitative methods such as interviews, questionnaires, reflections, reflective journals, and experiences in communities of practice to inform that teaching practice. Shulman even described research "that renders one's own practice as the problem for investigation" as being "at the heart of what we mean by professing or profession" (Shulman 2000, p. 11). Yet, as teacher educators who are also researchers, when we share the study of these problems of practice, we often describe how the findings will result in an alteration to a course or a program or participant, rather than how the application of these findings will change *us* and our personal teaching practices. This ability to not only reflect upon our teaching practice but also articulate change in our own practices is an important teaching mindset necessary to promote digital pedagogy (such as the pedagogical understandings for promoting the development of future-ready skills within ourselves and our students) and knowledge-building in others (through sharing examples of what worked or models that were effective).

Therefore, the question "How do I build the knowledge preservice teachers need to teach with technology so that they engage students in digital learning?" has been the burning question at the heart of every technology teacher educator for at least the last 25 years when computers and the Internet became more available to schools. A second question becomes "How do technology teacher educators support colleagues and teacher education programs in the current use of technology for pedagogy so that knowledge about teaching with technology is made relevant to the content we are teaching?". Both of these questions indicate that there is specific knowledge, Technological Pedagogical and Content Knowledge (often identified by the acronym, TPACK), that is developed as teachers learn to teach with technologies. Self-study has a role to play in sharing different perspectives on how technology teacher educators promote the knowledge of how to teach with technology and how that teaching changes with new technologies and technology-enabled learning environments.

The purpose of this chapter is to provide a description of how research, specifically self-study research, informs our current understanding of the problems of practice of technology teacher educators. As well, it is within the scope of this chapter to identify any gaps in self-study research that could contribute to our understanding of how technology teacher educators not only promote the knowledge about how to teach with technology but illuminate those problems of practice for technology teacher educators that are distinctly different from the examples in the self-study literature of how teacher educators build their own knowledge about how to teach with technology. Thus, we will introduce you to Technological Pedagogical and Content Knowledge (TPACK), or the knowledge teachers need to teach with technology, in the next section of this chapter, followed by an overview of the current research-based directions that inform technology teacher educators as they design and implement technology courses that support the growth of TPACK knowledge in preservice teachers. Section "Literature Review: Problems of Practice for Promoting Digital Teaching": will describe the literature review, including the methods used to answer the two research questions: (1) What teaching strategies or interventions are currently considered best practices for incorporation into preservice technology methods courses between 2013 and 2018? and (2) What are the problems of practice experienced by technology teacher educators? This section will describe the themes that emerged from the literature review to answer these questions and present examples of self-study research that share narratives of how teacher educators build their knowledge about teaching with technology. Section "Gaps in the Literature" identifies the gaps in the literature, and we conclude the chapter with a discussion about next directions for self-study research to support technology teacher educators.

What Knowledge Do Teachers Need to Teach with Technology?

Between the approximate years of 1985 to 2005, technology teacher educators focused the content of technology courses on building technical skills (see Bull and Bell 2006; Schrum 2005). Preservice teachers were taught how to use sets of tools in their "computer" course so that they would be able to integrate those technologies into their everyday teaching practices and engage students in using those technologies for learning. The educational technology field expected that all teachers would embrace teaching with technology – computers and the Internet would infuse every classroom, or as Koehler and Mishra (2005a) wrote, "It was assumed that teachers who can demonstrate proficiency with software and hardware will be able to incorporate technology successfully into their teaching" (p. 94).

Unfortunately, this did not happen – teachers were not integrating these technologies into their daily teaching practices or instructional activities. Expensive computers sat unused in the back corners of classrooms, while the information readily available "at your fingertips" through the Internet was seldom consulted (Paige et al.

2004; Schrum 2005). In 2005, editors of journals in instructional technology technology field held a national summit to discuss effective uses of technology in teaching and teacher education to make recommendations for research directions that would “accelerate the meaningful impact of digital technologies in education for the 21st century” (Bull and Bell 2006, p. 302). Schrum (2005) explained that the concern of journal editors for research over the past 20 years had focused on the question “Is a technology-based method better than a non-technology-based one?” (p. 219), and the findings about technology-enabled instruction were not advancing the meaningful use of digital technologies for student learning and resulting in “the technological capacity available to schools exceed[ing] our ability to use it effectively to enhance learning” (p. 220).

The fascination of the educational/instructional technology field with how to use the tool appeared to be only one piece of a knowledge base required for teachers to engage in and successfully teach with technology (Koehler and Mishra 2005a; Schrum 2005). Koehler and Mishra (2005a) argued that standards established to provide guidance in building teacher knowledge about how to teach with technology, such as the International Society for Technology in Education (ISTE) national standards or NCATE accreditation standards, explained “*what* teachers need to know,” but not “*how* they are supposed to learn it” (p. 94). They further argued that traditional methods of workshops and courses did not promote the deep understanding that was needed by a teacher to transform their practice. They proposed that teachers engage in learning about technologically enhanced instructional design by *doing* that type of lesson design, which incorporates:

> challenging problems that reflect real-world complexity. The problems should be authentic and ill-structure[d]; that is, they should not have one predetermined, foregone solution but rather be open to multiple interpretations and multiple “right answers.” Students should engage in actively working on solving the problem over an extended period of time in collaborative groups to reflect the social nature of learning. (p. 96)

Mishra and Koehler (2006) proposed a framework describing the knowledge that enabled a teacher to engage in technologically enhanced teaching in technology-enabled learning environments, called Technological Pedagogical and Content Knowledge (TPACK). This framework emphasized the development of “rich connections between technology, the subject matter (content), and the means of teaching it (the pedagogy)” (Koehler and Mishra 2005a, p. 95) in collaborative professional learning contexts and was based on Shulman’s (1986, 1987) theory of teacher knowledge, where teacher knowledge encompasses a number of categories of knowledge specific to the act of teaching (e.g., pedagogical content knowledge, knowledge of learners and their characteristics, and knowledge of educational contexts). The TPACK framework extends Shulman’s model by presenting the following pairs of knowledge intersections in relation to technology: technological content knowledge (TCK); technological pedagogical knowledge (TPK); and the intersection of technology, pedagogy, and content (TPCK), called Technological Pedagogical and Content Knowledge (TPCK or TPACK) (Fig. 1). The knowledge

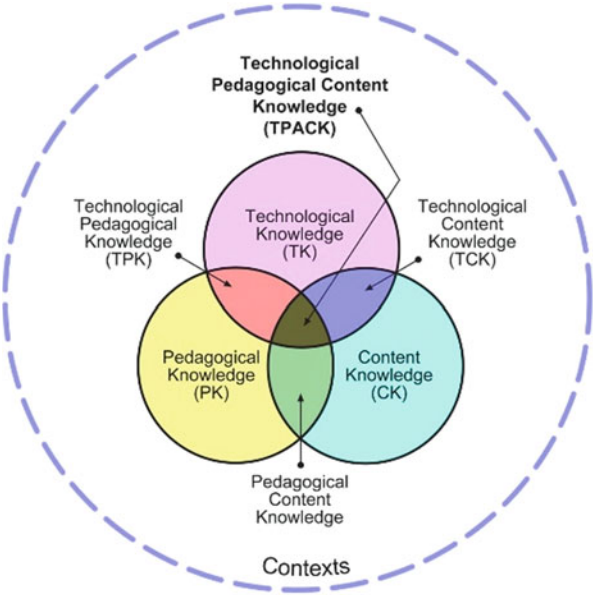

Fig. 1 Technological Pedagogical and Content Knowledge (TPACK). (Reproduced by permission of the publisher, © 2012 by tpack.org)

required for successful technology-enhanced teaching (TPACK) is situated within pedagogical content knowledge (PCK), which relates to "that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding" (Shulman 1987, p. 8).

Mishra and the Deep-Play Research Group (2018) further explained that:

> TPACK suggests that expert teachers have a specialized brand of knowledge, i.e., a blend of technological, pedagogical, and content knowledge. Thus, it is the interaction between knowing a technology, knowing about pedagogy, and understanding a subject matter that makes for effective teaching with technology (Mishra and Koehler 2008). TPACK shatters this myth of technology as being "chrono-centric" and asks only that we focus on "what can your technology do for your content and what is the best way to do it?" The TPACK framework emphasizes the importance of teacher creativity in repurposing technology tools to make them fit pedagogical and disciplinary- learning goals. (p. 12)

Other voices in the field explain this connection with content and preservice teacher preparation:

> Devising a 21st century skills curriculum requires more than paying lip service to content knowledge. Outlining the skills in detail and merely urging that content be taught, too, is a recipe for failure. We must plan to teach skills in the context of particular content knowledge and to treat both as equally important. (Rotherham and Willingham 2009, p. 19)

With such a strong focus on content-centric instruction and learning goals, TPACK has become the theoretical framework that guides how we think about preparing preservice teachers (Figg and Jaipal 2009; Jaipal and Figg 2010b) – specifically teaching that promotes the development of pedagogical knowledge necessary to teach content using technologies (Jaipal-Jamani and Figg 2015; Angeli and Valanides 2009).

More than 1600 publications have been based on the TPACK/TPCK framework over the 15 or so years since the introduction of the idea that teachers with TPACK – this knowledge about how technology can be meaningfully integrated into classroom learning experiences – design and implement successful technology-enhanced learning experiences for digital age students, and they do so by effectively identifying the affordances and constraints of technologies for application to instructional purposes and content (Harris and Phillips 2018). Several reviews of literature of those publications (e.g., Chai et al. 2013; Gur and Karamete 2015; Polly et al. 2010; Rosenberg and Koehler 2015; Tondeur et al. 2012; Voogt et al. 2013; Willermark 2018; Wu 2013) present the general themes held within that body of work, and although the focus and scope of each of these reviews differs, together they present the overall general findings of what we currently understand about TPACK and its impact on "the practice of teachers, professional development providers, administrators, and other stakeholders invested in meaningful educational uses of technology" (Harris and Phillips 2018).

TPACK and Teacher Education

We have selected five specific reviews to share that exemplify key themes from this body of research that are particularly salient for technology teacher educators seeking to answer the question regarding what knowledge best prepares preservice teachers to teach with technology in their initial teaching experiences.

Gur and Karamete (2015) analyzed 115 papers from 2001 to 2015 and concurred with other reviews and critiques of the TPACK framework that the framework is vague and broad and the constructs are ill-defined (Voogt et al. 2013; Cox and Graham 2009; Graham 2011). However, their review suggests that the framework is useful as it does identify areas of teacher knowledge that, if combined with innovation adoption models (such as the concerns-based adoption model suggested by Hall and Hord 2014, or SAMR as described by Hamilton et al. 2016), could provide teacher educators with opportunities to identify gaps in knowledge of preservice teachers, allowing planning for continuous support of TPACK development throughout education programs. Gur and Karamete also shared the important idea from Lee and Tsai (2010) and Lee et al. (2006), that interventions normally produced positive outcomes with a noted increase in self-efficacy and preservice teachers' willingness to use ICT with exposure to technology-enhanced teaching experiences. However, Gur and Karamete further reiterated the caution from Angeli and Valanides (2009) that just increasing the proficiency of each of the seven TPACK knowledge constructs does not automatically result in overall TPACK knowledge. Overall TPACK knowledge grows over time with continued experiences and multiple examples of each construct, but gaining proficiency in one area, such as TK (technical knowledge), does not increase TPACK knowledge alone; therefore, skill instruction alone does not result in TPACK.

Chai et al.'s (2013) examination of 74 papers from 2003 to 2011 highlighted that 54 of these papers reported on the use of technology in various subject domain areas rather than in the technology methods classrooms, with 41% of those studies in the science, mathematics, and engineering classrooms. This finding reinforces the content-centricity of TPACK knowledge. However, to foster TPACK development, the authors suggested that the TPACK framework must also take into account contextual factors, such as the availability of technological solutions, the pedagogical skill of the instructor, or the technological skill of the student. Most importantly, studies showed that most interventions had positive results – exposure to technological instruction often resulted in TPACK growth.

Tondeur et al. (2012) identified 19 qualitative studies published between 2001 and 2009 in which the focus was to prepare preservice teachers to integrate technology into their daily instructional practices. Strategies that were effective for fostering the growth of TPACK were identified, including the practical use of technology within authentic, instructional experiences, with scaffolded technical experiences. Other successful strategies contributed by this review were the use of collaborative learning activities with peers and using reflective discussions and writing activities about appropriate use and role of technology in instruction.

The findings from the analysis and review by Voogt et al. (2013) of 55 journal articles and 1 book chapter published from 2005 to 2011 illuminated the practical use of TPACK in promoting the growth of TPACK knowledge in preservice teachers and expanded the information from the previous reviews. First, their review described the development of the concept in the research and the criticism of TPACK as a theoretical framework similar to the other reviews; however, they noted that, in working with teachers, "TPACK is an intuitive and easy-to-communicate concept" (p. 118) and suggested that this knowledge base should be developed for specific subject area domains. They provided the example of Harris et al. (2009) and Harris et al. (2010a), who developed activity types, those sets of "classroom activities and interactions that have characteristic roles for participants, rules, patterns of behaviour, and unrecognizable materials and discursive practices related to them" (Harris et al. 2009, p. 404). The activity types were developed per subject domain and presented in a taxonomy of content-based activities to help preservice teachers (and in-service teachers new to teaching with technology) to plan lessons enhanced with technology. Preservice teachers used the taxonomy to develop a personal knowledge repertoire of learning activity frameworks that they felt worked well with their instructional styles and combined these activity frameworks to create lessons, units, or learning opportunities (Joyce et al. 2004). For preservice teachers, this is foundational knowledge for successful technology-enhanced lesson planning.

Another specific contribution of Voogt et al.'s (2013) review was to identify additional specific strategies that foster TPACK knowledge growth. Overall, those strategies included modeling of technology-enhanced lesson design or teaching in a technology-rich learning environment; enactment of technology-enhanced lessons, either through microteaching or during field experiences; or designing technologically enhanced lessons. As well, there was an overall understanding about teaching with technology suggested by Niess (2011) that included four central components:

> an overarching concept about the purposes for incorporating technology in teaching a particular subject; knowledge of students' understanding, thinking and learning with technology in that subject; knowledge of curriculum; and curriculum materials in a particular subject that integrated technology in learning and teaching, and knowledge of instructional strategies and representations for teaching and learning that particular topic with technology. (Voogt et al., p. 118)

And finally, Voogt et al.'s analysis highlighted that numerous studies focused on how to evaluate the growth of TPACK in preservice teachers. Of note is that, in this review, the predominant method currently in use were self-report surveys (e.g., Schmidt et al. 2009a), which often reflect increased confidence rather than actual increased knowledge in practice (Lawless and Pellegrino 2007). Other methods also being investigated included performance or design-based tasks evaluated with scales (Angeli and Valanides 2009; Kramarski and Michalsky 2010), rubrics (Harris et al. 2010a), and observational rubrics (Bowers and Stephens 2011).

Willermark (2018) reviewed 107 peer-reviewed journal articles published from 2011 to 2016 to supplement many of the earlier review studies, intent on illuminating the different approaches that have been used to identify teacher TPACK, mostly to "determine the impact of interventions and professional development programs or to descriptively characterize the current state of teacher knowledge (e.g., Herring et al. 2016; Koehler et al. 2014)" (p. 318). Of specific interest to technology teacher educators is Willermark's analysis of the emerging discussion of *TPACK as knowledge* that is "something that the teacher possesses, such as concepts, rules, and procedures" or *TPACK as competence* that is "an inextricable facet of teacher action itself, which must continuously be mastered" (p. 318). Willermark further explained that "knowledge and competence are closely connected, and competent acting requires basic, general, and theoretical knowledge as well as practical experience" (p. 318). Willermark continued that, if a teacher (either preservice or in-service) was evaluated, most research either required the teacher to self-report to complete the evaluation or the performance was marked/observed/evaluated in a teaching activity. As teaching usually comprises actions of planning, implementing, and evaluating, teachers who were self-reporting may have been reporting on their knowledge about planning, implementing, and evaluating teaching with technology without the advantage of the classroom teaching experience. Willermark notes that "gaps have been shown to occur between self-reporting and performance in practice, between displayed knowledge and application of such knowledge, and between performance exercises and typical behavior" (p. 339) and recommended a combination of methods for future research.

In summary, and to put the research in perspective of this review, in the brief 15 plus years that technology teacher educators have researched and explored how to best initiate the process of helping preservice teachers grow their TPACK – this knowledge about how technology can be meaningfully integrated into classroom learning experiences – so that their initial teaching experiences in the digital learning environments of today's classrooms are successful and productive, we have learned the following from the empirical research:

1. The modeling of technology-enhanced learning experiences in the context of subject content areas is influential in promoting technology-enhanced teaching effectiveness (Gur and Karamete 2015; Chai et al. 2013; Tondeur et al. 2012; Voogt et al. 2013).
2. Modeling is important, and the type of modeling matters – modeling just-in-time technical training during a lesson demonstrates how to scaffold technology within a lesson to achieve a learning goal without having the technology distract from that learning experience (Tondeur et al. 2012; Voogt et al. 2013).
3. Engaging in pedagogical reasoning during the technology-enabled learning experience with the instructor promotes growth in understanding how to teach with technologies (Chai et al. 2013).
4. Competency in one of the domains alone will not result in transformation of practice. All domains must be represented. For example, skill competency and acquisition of technical skills alone will not promote teaching with technology (Gur and Karamete 2015).
5. The connections to content subject areas are important and are supported by examples of technology-enhanced activities that can be used effectively in that area (Voogt et al. 2013).
6. Collaborative/peer learning and authentic technology-enhanced learning experiences are effective (Tondeur et al. 2012).
7. Another effective strategy for growing TPACK knowledge is providing opportunities for preservice teachers to design and teach technology-enhanced lessons (Tondeur et al. 2012; Voogt et al. 2013; Willermark 2018).
8. Measurement of TPACK should include opportunities for multiple forms of assessments, both for research (self-report, performance assessments) and for information for preservice teachers' understanding of how their TPACK knowledge and competence is growing (CBAM or SAMR inventories) (Gur and Karamete 2015; Willermark 2018).

Literature Review: Problems of Practice for Promoting Digital Teaching

From the general reviews of the TPACK literature, we have learned that promoting the growth of TPACK knowledge is a process of authentic, pedagogical, content-centric experiences. Strategies noted as being most effective were (1) having opportunities to design lesson plans; (2) teaching a technology-enhanced activity, either in a microteaching or field experience; and (3) having opportunities to participate in technology-enhanced instruction to see modeling of how to teach in an authentic, problem-based, collaborative learning experience, and

(4) incorporating demonstrations of teaching the technical skills using "just-in-time" methods so that the focus was on the learning goals and not the tool.

As a technology teacher educator (first author) of how to promote TPACK in preservice teaching for nearly 20 years, along with a science teacher educator (second author) who has researched TPACK for the last 20 years, these are strategies that we have long embraced; however, the constraints of a university course embedded within a unique teacher education program – the context within which preservice teachers are engaged in their technological learning experiences – are influencing the extent to which we are able to incorporate some of the best practices into course design and delivery. Technology teacher educators work constantly to infuse new ideas, technologies, and the pedagogies that enhance those technologies into our courses, and we are continuously seeking to learn what interventions have been successful in other programs, albeit with the understanding that we must adapt for our own students, programs, and contexts. Therefore, the research questions that are the basis of the following literature review are:

- What teaching strategies or interventions are currently considered best practices for incorporation into preservice technology methods courses between 2013 and 2018?
- What are the problems of practice experienced by technology teacher educators?

Methods

An extensive query of our library databases, including robust academic databases such as ERIC, Academic Search Complete, Sage Journals Online, and Scholars Portal, plus a query of Google Scholar and specific searches of journals such as *Studying Teacher Education*, *Journal of Teacher Education*, and the *Canadian Journal of Education*, was conducted using the search terms *tpack*, *self-study*, *best practices to develop tpack*, *technology preservice courses*, *preservice teacher education*, and *technology teacher education*. The resulting list of 48 self-studies was reviewed for the discussion of a strategy or intervention and/or redesign of a technology preservice course and how those changes informed teaching practice. Reviews of abstracts and initial readings of articles discussing the experiences of in-service teachers or graduate instructors were removed, as the research question seeks information regarding preservice teaching experiences only. As well, articles describing interventions or strategies applied entirely in alternate settings were also removed from consideration, including courses applied only in field experiences or courses applied in the online environment – unless the self-study clearly articulated how the author's TPACK knowledge had grown through the experience. This resulted in nine articles that highlighted the changes in teaching practices of teacher educators related to growing TPACK knowledge and teaching with technology; however, there were no articles related to technology teacher educators and technology methods courses in a teacher education program. So, to answer the research question about "what are the problems of practice of technology teacher educators" and having extensively searched the sources for self-study, we knew the self-study literature would only be able to describe the problems of practice of teacher educators when those problems of practice involved building TPACK and learning to teach with technology.

The specialized nature of this query – the search for research about technology teacher educators – meant that we required a specialized database; therefore, we restricted the next search to one database. The *LearnTechLib: The Learning and Technology Library* was chosen for the specialized search because this database indexes conference papers and dissertations from the leading technology teacher education conferences and organizations as well as journal articles from the leading international educational technology journals. Aware that in the educational/instructional technology field most of the research is empirical, and searching for ethnography or even narrative stories of lived experiences would show few and far between results, we accepted that the outcome of our next search would be more empirically based.

The process for the search was repeated. One hundred four articles published between the years of 2013 and 2018 emerged using the same search terms: *tpack*, *self-study*, *best practices to develop tpack*, *technology preservice courses*, *preservice teacher education*, and *technology teacher education*. These articles were reviewed for the following: discussion of a strategy or intervention or redesign of a technology preservice course. Once again, articles discussing in-service teachers or graduate teaching were removed. Articles describing interventions or strategies applied entirely in alternate settings were also removed including technology courses applied only in field experiences. However, in this review, articles that examined the use of field experiences as part of a technology methods course were included. Online technology courses were also excluded as most teacher education programs are face-to-face to emulate classroom teaching; however, articles that described blended components and online modules within face-to-face courses were included. Fifty articles remained and were included for the purposes of the final thematic review. Only 2 articles out of the 104 articles described themselves as self-study and are included in our review. 56% (or 28) of the articles described interventions or strategies used in subject area courses, indicating the strong connection between content and TPACK; however, those articles are not reviewed or included here as they were not self-studies and were more focused on researching the content taught or providing research on an intervention.

Of note is that, in addition to the themes of course design and effective strategies or interventions for promoting the growth of TPACK knowledge, 3 other overall themes were evident across these 104 articles: (1) effective evaluation of the growth of preservice teachers' TPACK as the result of an intervention, (2) programmatic influences on preservice teachers' TPACK development, and (3) more illumination of and discussion around the TPACK framework.

First, although assessment of TPACK growth and development is central to how a technology teacher educator might make decisions to foster that growth and development, the lack of clear definition of the constructs of the TPACK framework and often overlapping components have made measurement of such growth a complex and problematic issue (Cox and Graham 2009; Graham 2011). As well, this is a fast-growing and constantly emerging area of research, which makes this stream of research outside of the scope of the research question for this review. As noticed in the earlier reviews of literature described in the previous section, assessment instruments were developed (e.g., the survey instrument developed by Schmidt et al. 2009b and rubrics by Harris et al. 2010a) which have been useful for some purposes to date, and a new focus on measuring preservice teachers' *intention* to implement (as seen in Perkmen et al. 2016) may serve to be a promising method for providing some manner of describing changes and growth in knowledge and attitudes.

Additionally, 11 articles specifically sought to describe ways in which teacher education programs could support preservice teachers throughout their program experiences, such as preparing teacher educators and program leaders who are able to inspire and lead TPACK change (e.g., Carpenter et al. 2016; Herring et al. 2013) or examining how standards and teacher educator competencies are related to and enhance preservice teachers' TPACK (i.e., DeSantis 2016; Foulger et al. 2017). Other articles described how to support the development of preservice teachers' TPACK by organizing the delivery of technology experiences by embedding instructional strategies throughout and across the experiences of the teacher education program (see Brenner and Brill 2013; Mouza et al. 2017a) or making that area of knowledge the responsibility of a single stand-alone technology course, with recommendations that a combination would be the best solution going forward (Elwood and Savenye 2015).

Next, 14 articles tackled the continuing debate about how we define or illuminate the complex TPACK framework. Some sought to flesh out the connections between PCK and TPACK (Phillips et al. 2017), specifically pedagogical reasoning and action (PR + A) and technology (Harris and Phillips 2018); others examined how TPACK could be distributed and dynamic (Di Blas and Paolini 2016), which offers new and intriguing insights on future research. The use of the TPACK framework with other frameworks, such as the Stages of Concern (Marich and Greenhow 2016) and the Universal Design for Learning (Harris et al. 2018), was also investigated with positive results and recommendations for how these different frameworks can work side by side. TPACK and its relationship to critical and computational thinking were discussed, with early recommendations for increased emphasis on problem-based learning (Henderson 2013), and activities that promote thinking "from *consumers* to *creators*" (Mouza et al. 2017b, p. 74) through programming tools were also presented.

Promoting TPACK Growth: Best Practices for Technology Teacher Educators 2013–2018

The remaining 22 articles were relevant to our research question, "What teaching strategies or interventions are currently considered best practices for incorporation into preservice technology methods courses between 2013 and 2018?", and present us with several patterns or themes for the current understandings of what technology teacher educators can view as best practices for fostering preservice teachers' TPACK knowledge growth.

Using Design to Foster TPACK

As demonstrated in earlier reviews, one effective practice to foster TPACK development being used in technology courses today is providing preservice teachers with opportunities to design technology-enhanced lessons, a strategy originally described by Koehler and Mishra (2005a, b) as the *Learning Technology by Design* approach. Prior to the introduction of the TPACK framework, the stand-alone technology course typically consisted of an introduction of several types of teacher productivity tools and computer software that a teacher might encounter in their work (including word processing, gradebooks, presentation tools, spreadsheets, the Internet), with some pedagogical information about their affordances and constraints for use in the classroom (Mouza et al. 2014). However, as many researchers of the time noted (e.g., Kay 2006; Jaipal and Figg 2010a; Niess 2012), there was no transfer between the development of technical skill knowledge and how to use that knowledge in technology-enhanced teaching. The learning-by-design approach (as described by Mishra et al. 2010) uses "rich pedagogical, technological and content problems" (Mouza et al. 2014, p. 208) as the basis for collaborative group work in which preservice teachers find technological solutions to those problems.

In addition to designing lessons and analyzing lesson designs for appropriate use of technology to enhance the lesson, Lloyd (2013) had shown how the TPACK framework could be used as an effective tool for analyzing the knowledge preservice teachers were using to select appropriate learning objects for use in specific teaching contexts and justifying their choices. The language expressed in their reflections demonstrated their solid grasp of the technological pedagogical knowledge (TPK) required for that task. Other researchers, such as Angeli and Valanides (2009) and Graham et al. (2012), provided design-based tasks and sought evidence of TPACK within those tasks through criteria scoring or thematic mapping of constructs.

The more current research studies have investigated expanding and enhancing knowledge gained through creation and analysis of technology-enhanced lesson designs by implementing those designs in microteaching or field experiences and reflecting upon those experiences. For example, Mouza et al. (2014) describe how the preservice teachers in their technology course were also engaged in a 3-week teaching placement during the course and were therefore able to make a strong theory to practice connection through assignments such as a technology resources inventory of resources available to preservice teachers at the teaching site, the design of a technology-enhanced lesson, and ability to teach and reflect upon that lesson. The ability of the associate teacher to model and support the preservice teacher in the modeling of technology-enhanced teaching was also conducive to the development of the preservice teachers' TPACK; however, the "major strength of the integrated approach was the opportunity it provided preservice teachers to design, enact and reflect upon the implementation of a technology-integrated lesson in a real classroom" (p. 219).

As well, the TPACK framework became the basis of the TPACK game – a learning activity developed at the National Technology Leadership Summit's annual gathering in 2007 (Richardson 2010). The TPACK game has been used as a method for introducing the framework and the idea that pedagogy, content, and technology must be considered in the planning of a technology-enhanced activity. Baran et al. (2014) used case study to describe how even an introductory exposure to understanding the TPACK framework supports the design of technology-enhanced activities.

Another successful strategy that further expands the effectiveness of promoting TPACK through the design of technology-enhanced lessons is the use of design teams, adding the collaborative component to the process. For example, Johnson (2014) employed design teams as a strategy in a technology course to examine the effects of the approach on preservice teachers' TPACK compared to the traditional individual approach. Findings from the study demonstrated that, although both instructional strategies promoted TPACK growth in preservice teachers, those preservice teachers who had participated in the collaborative design teams approach showed more improved TPACK as evidenced in written lesson plans. Stansberry (2015) described the redesign of a technology course to include peer teaching teams who not only designed technology-enhanced lessons but taught those lessons as part of a peer teaching team. Findings from this qualitative study revealed that students were able to meet their own learning goals, addressed teaching with technology differently and more professionally at the end of the course than they did at the beginning, and were able to articulate new learning goals for building their knowledge about technology-enhanced teaching at the end of the course.

For those technology teacher educators with programmatic constraints that would never allow access to field work or for those who have their course embedded in a collaboratively designed program where heavy lesson designing in subject area methods coursework make lesson designing within the technology course redundant, studies about effectiveness of activity types and blended learning modules for fostering TPACK growth offer a method for incorporating lesson design strategies in the technology methods course. For example, Harris and Hofer (2016) describe how their taxonomies of TPACK-based learning activity types, categorized by subject areas, are used to select and sequence technology-enhanced activities to create a lesson plan, or project, or series of lessons for combining into a unit. The support provided by the taxonomies promotes deep learning of the planning process and enhances TPACK through the decision-making processes. Hofer and Harris (2016) then offered the learning activity types (LATs) as a set of eight brief, developmental video-based modules in an online format and as open educational resources. The modules guide exploration of the LATs through the selection and analysis processes, with suggestions and considerations. Mourlam and Bleecker (2017) investigated the use of the effectiveness of these LAT short courses in promoting TPACK in preservice teachers by including the completion of these eight modules to the requirements for course assignments. Findings from the study indicated that preservice teacher knowledge about "their ability to combine instructional strategies and technology, select technologies that were compatible with curriculum goals and instructional strategies, as well as fit content, instructional strategies, and technology strongly together within the lesson plan" (p. 2408) were increased, indicating TPACK growth. Both the use of the LAT taxonomies and the online short courses would prove beneficial ways to incorporate lesson designing strategies in technology courses.

Strategies that Work for Fostering TPACK

Although we acknowledge that the learning-by-design approach continues to be a successful form of promoting the growth of TPACK knowledge in preservice teachers, two other strategies also contribute to the knowledge-building process and are noted in the research: modeling and pedagogical reasoning discussions.

The importance of modeling of technology-enhanced teaching for preservice teachers within actual teaching must not be underestimated (Brenner and Brill 2013; Crowe 2004; Mouza et al. 2014), and even though the quality of that modeling might be constrained by resources, skill, or availability, the willingness of faculty teacher educators, the associate teacher overseeing preservice teaching, and even fellow preservice teachers to engage in modeling technology-enhanced teaching provide a learning environment for risk-taking and experimenting (Mouza et al. 2014), thus promoting the growth mindset that is part of teaching in a digital society (Partnership for 21st Century Learning 2007).

As well, current research has suggested that this mentoring and coaching need not merely take place in face-to-face environments. Several articles addressed how this form of distance modeling support might occur such as within field experiences supported by coaching through flipped environments described in Bruciati and Lizano-DiMare (2016). Additionally, Dorner and Kumar (2017) successfully implemented an online collaborative mentoring program that supported learning about how to teach with technology; however, their research had words of caution for developing this type of program in that providing mentoring and coaching in the online environment requires attention to different issues, namely:

> that effective online communications and transparency in the role of the mentor should be an integral part of the instructional design of online collaborative mentoring. Further, the instructional design should be informed by a thorough investigation of participants' technology skills and technology self-efficacy, and a needs analysis of the level and types of guidance expected by mentees based on their previous experiences and existing expertise. A comprehensive picture of mentees' anticipations, prior knowledge, and skills will enable course designers and mentors to design online mentoring experiences that meet expectations and respond to mentees' actual needs. (p. 296)

White and Geer (2013) investigated a video project developed by the Education Services Australia for the Teaching Teachers for the Future (TTF) based on TPACK in which a series of:

> modules were designed for pre-service teachers as professional learning packages that demonstrated the interrelated content, pedagogy and technology knowledge used in Mathematics, Science, History and English. The online modules incorporated videos of teachers

> and their students using ICT in the classroom, lesson plans, useful ideas for incorporating ICT as well as text that described the interaction of the teacher, the students and the technology. (p. 124)

Their qualitative research demonstrated that the preservice teachers valued the modeling of technology-enhanced lessons in a video format where they could learn at their own pace, could access the materials online at their own convenience, and were able to see how “things worked in real classrooms” (p. 131).

A second strategy that also emerged throughout the TPACK literature about technology teacher educators as contributing to building TPACK knowledge is the use of discussion and reflective writing to engage pedagogical reasoning around decision-making. Figg and Jaipal (2013) described a workshop strategy that engaged preservice teachers in a technology-enhanced learning activity followed by a pedagogical dialogue in which the preservice teachers are engaged in a discussion and collaborative reflections in thinking about the activity type, how the activity could be adapted for other content areas, how the activity could be adapted using other technologies, and, most importantly, what preparation would the instructor need to ensure happened prior to the lesson for a smooth implementation. Later in the workshop, how to teach just the skills needed to replicate the learning activity is taught, with a follow-up opportunity for the preservice teachers to design a lesson activity using that technology that they might teach in their own classroom. The final sharing of these activities results in an additional pedagogical dialogue and reflection.

An additional and developing research area is the exploration of preservice teachers’ instructional design processes to highlight their pedagogical reasoning and any relationships or connections between instructional design and pedagogical reasoning. Preservice teachers in three universities in three countries, who are already familiar with TPACK and have experience with technology-enhanced teaching, will be participating in the study by sharing aloud with the researcher their instructional design process, with the goal of highlighting pedagogical reasoning during specific instructional design tasks (Trevisan and De Rossi 2018). As this research is in progress, the research team is hopeful that new insights into pedagogical reasoning that grows out of or is supported by instructional design will emerge.

Using Problem-Based or Authentic Learning to Foster TPACK

Technology courses are grounded in authentic or problem-based learning and have been since the work of Jonassen and Reeves (1996) proposed viewing technology as cognitive tools. Initial investigations of innovative new problem-based structures and learning environments are beginning to make their way into the research literature. Mouza et al. (2014) described how their technology courses not only infused hands-on activities with a variety of technology tools but also required preservice teachers to design and teach a technology-enhanced lesson in their course-embedded field experience creating an authentic and applicable learning experience. Dreon and Shettel (2016) described an authentic learning field experience that was part of their technology course, in which the preservice teachers first served as instructional designers of learning objects for flipped classroom activities and later taught lessons prior to and after the flipped learning object to students in the schools, providing relevant and meaningful learning experiences for preservice teachers. As well, alternative methods for structuring the problems have been investigated. For example, Beaudin (2016) describes the use of structural gamification, or "the application of game-elements to propel a learner through content with no alteration or changes to the content itself. The content does not become gamelike, only the structure around the content" (p. 1132), to set up a problem-based authentic learning experience for preservice teachers, to motivate, and to engage them in content learning. Likewise, Figg and Jaipal-Jamani (2015a, b) describe how structural gamification was implemented to provide background knowledge and flipped learning experiences to support in-class learning activities in a technology methods course. Findings from the qualitative data, surveys, and student-created artifacts were evidence of growth in TPACK knowledge and student engagement. Conference presentations, such as those regarding the use of genius hour (Downes and Figg 2017) and makerspaces (Figg et al. 2018) as inquiry-based projects to structure or support technology courses, are other examples of research investigations emerging as explorations of how these structures can be used to engage creativity as well as problem-based learning in the technology course.

Self-Study in Promoting Teacher Knowledge for Teaching with Technology

Although our review of the self-study literature revealed that technology teacher educators have yet to share their stories of problems of practice to a great degree, there are examples of teacher educators who are openly contributing their problems of practice to our understanding of how TPACK knowledge is developed by teacher educators. It is the narrative quality of self-study, the eliciting of stories of experiences, that are especially useful for teacher educators investigating how teachers learn to teach with technology in online and technology-enabled environments; after all, we have learned from the literature on adoption of innovations that the majority of teachers engage in using innovations, such as digital technologies, through the successful examples of peers – the innovators and early adopters suggested by Rogers (1995) and Harris (1998). Reading stories of the lived experiences of these innovators and early adopters as they sought to design online courses or the understandings gained from adding a new technology to their teaching practice are significant contributions to the literature on the knowledge we need to teach with technology. However, many of these self-study reflective stories end up on a blog post (see Bal 2018), or some other form of social media, and the contribution that could have been made to our overall understandings of how to teach with technology stop there. Hence, the value of self-study research by technology teacher educators is the purposeful sharing of the study of technology-enhanced teaching practices using rigorous data collection and analysis to illuminate these problems of practice.

Bullock and Sator (2018) suggest methods as diverse as "portfolios that track development, journaling one's personal history, action-research through lived experiences, collective self-study, as well as arts-informed and memory-work self-study" (p. 60). These same methods are also the basis of evidence in other forms of research, such as action research, participatory research, or design-based research. Parsons and Hjalmarson (2017) describe the difference between design-based research and self-study as the focus of the research, so that "Design research examines the design, implementation and study of a product or process in an educational setting. Self-study focuses also on the designer of the innovation and the personal learning that influences teaching decisions" (p. 332). Feldman et al. (2004) distinguish action research from self-study as follows: "Traditional action research has a technical orientation toward research that relies on a 'how-to' approach and does not make problematic the nature and context of teachers' work" (pp. 948–949). They go on to state that self-study methodology is distinguished by "the type of practice in which the researcher is engaged – teacher education – and the preferred method of inquiry – narrative" (Feldman et al. 2004, p. 949). Feldman et al. assert that self-study methodology is characterized by three features:

A focus on the self.
The experience of teacher educators acts as a resource for research.
It involves being critical of the self in relation to researcher and teacher educator roles.

LaBoskey (2004) adds that self-study research may also be viewed in terms of five characteristics in which the research is (1) self-initiated and focused, (2) improvement aimed, (3) and interactive; (4) includes multiple, mainly qualitative, methods; and (5) defines validity as a process based on trustworthiness.

The Use of Self-Study to Explore Integrating Technologies into Instruction

Bullock tells of his experiences teaching with blogs and videos (Bullock 2013a, b) in narratives that highlight the "use of self-study as a vehicle for exploring digital technologies" and the professional learning about pedagogy that emerges from those experiences, which are echoed in qualitative research elsewhere (see Jaipal-Jamani and Figg 2015; Jaipal and Figg 2009); yet the narrative component is appealing to teacher educators who are contemplating the same teaching experience. Bullock's (2013a) description of his exploration of blogs to support teacher candidates in the field clearly illustrates how blogs, as a collaborative form of multimodal reflection, may be useful in providing a forum for preservice teachers to discuss and share experiences from their field experiences that have promoted their growth as a professional and, at the same time, provide the instructor with an opportunity to continue and enrich the instructor/student relationship at a distance during pivotal professional experiences. These revelations about how and for what purpose the use of blogs in instruction is successful support the understanding required for teachers wanting to use this technology but unsure of how to approach the integration process.

Likewise, Bullock (2013b) describes first experiences using video reflections with preservice teachers. The instructional task in the study required preservice teachers to self-select a technology new to them, which they were to master and create a lesson design in which they use this technology. Reflections were recorded in video clips and shared with the instructor. These reflections revealed that the preservice teachers demonstrated mastery of the tool selected and how to use the tool, but pedagogically, there was little or no transfer to understanding about how to teach with the tool from the activity. Even though preservice teachers did not translate what they were learning about the tool into valuable pedagogical knowledge as expected from the task, the video reflections provided clues about the type of task that might promote a transfer from “learning the tool” to “teaching with the tool.” These findings support the themes from the TPACK literature (as reviewed above) that highlight that the act of simply learning or teaching a tool does not result in technology-enhanced teaching; however, the narrative format of the self-study findings provided contextual evidence about teaching practices that are often difficult to elicit from more empirical forms of research.

Consider the descriptions from Bullock and Sator (2018) of incorporating makerspaces into their courses. They describe their intention to create learning spaces that are authentic, safe, and peaceful spaces, and they identify specific principles of maker pedagogy, “namely: (ethically) hack, adapt, design, and create” (p. 68). These are key concepts about how to use makerspaces for learning. Especially poignant within this article are the descriptions of the dialogues and discussions about how the researchers decided to embody those principles within their own teaching within a makerspace, leading to understanding of better practices for teaching within the makerspace environment. The language provided by the authors around how these principles supported successful integration of makerspaces into meaningful learning experiences conveys practice-based knowledge not often found in more empirical research findings.

The Use of Self-Study to Inform Teaching in Online and Blended Environments

Stories, especially those about teaching online, further provide useful insights into challenges that are often inherent in teaching in these technology-enabled environments that differ from those encountered for face-to-face interactions; these stories also share solutions to those challenges (Parsons and Hjalmarson 2017; Turner 2011). The stories often highlight technical issues, such as how to support learners in using the tools for learning, but, more importantly, share pedagogical issues, such as facilitation, roles of participants and instructor, adaptations of face-to-face interactivity into online environments, and the design process. Stories such as these enable other educators to make connections to their own teaching practice.

Ham and Davey (2005), for instance, describe their experiences working with communication activities in which email and discussion board tools are integrated. Their findings demonstrate how proactive facilitation of communication activities in the online environment often determine the difference between meaningful interactions or an isolated experience that is perceived as less than satisfactory. They also clearly make connections for how that facilitation between student-teacher might occur so that student-student interactions are encouraged, including providing a list of best practices for teaching and communicating in this learning environment. For one who has taught online for over 20 years and supported others in learning to teach online effectively, the simple recommendations described by Ham and Davey as lessons learned are valuable to any novice teacher hoping to successfully navigate teaching in the online environment for the first time. These insights, such as (1) teaching online takes more time than face-to-face situations to moderate and sustain discussion and interaction, (2) establishing interpersonal relationships in the online environment requires a focused effort from the instructor and additional time to ensure connections are made, and (3) building activities into the instruction that explains how to use the online tools as part of the course and never assuming that students will know how to use the tools for learning, are lessons usually learned in less than successful online teaching experiences.

The considerations found in self-study by teacher educators who are sharing stories of what they learned from teaching in an online environment not only include best practices for engaging and communicating with the online student but also highlight the significance of reflective practices for informing and supporting the design and implementation of an online course. For example, Donnelly (2006) shared how she struggled with incorporating an experiential model of learning (providing students with opportunities in each module for a concrete experience, reflective observation, abstraction, and active experimentation) in her online course while effectively providing a model of best practices for students regarding the design, implementation, and use of technologies for learning. The study findings explained how reflection around issues related to the online environment were identified and then resolved, thereby promoting a rigorous online learning experience for students. The examples of how students in this study learned how to select and use a variety of learning technologies to enhance student learning while integrating and evaluating those learning technologies in the context of their own subject areas provided a realistic story of how to incorporate theories of learning as the basis and foundation of design of learning experiences for an online course.

Parsons and Hjalmarson (2017) also highlighted the critical aspect of their role as designer and instructor-designer of an online learning environment and provide useful insights into three key design characteristics of online course development: “focusing on systems of learning and teaching, designing pedagogical tools and products, and using iterative processes” (p. 331). Their study examined how “developing discipline-based knowledge and skills to support literacy/math teaching and learning within a school-based leadership model” led “to foster[ing] communities of practice and student engagement” (p. 338) and led to great personal understanding of how to successfully design synchronous online learning environments as well as how their design of the use of technological tools could both support and engage students in the online environment.

Turner (2011) highlights another inevitable task that online teachers face – adapting a distance course for an alternative technology medium – and realizing that this task required creative thinking about (1) knowledge issues, what knowledge was needed for a successful transition from a synchronous face-to-face environment to an asynchronous distance environment; (2) design issues, what decisions needed to be made about design choices to better fit the distance environment; and (3) change issues, what would the instructor need to learn in order to implement the course as designed. She further identified a step-by-step transition process that could be used to support others in such a task. The transition process utilized thoughtful reflection of the redesign process on four critical areas of transitional knowledge:

- *Student Knowledge*: Knowledge known by students who had taken courses delivered by distance technology.
- *Technical Knowledge*: Knowledge known by technology experts and instructional designers.
- *Experiential Knowledge*: Knowledge known by instructors with experience using virtual multi-user technology.
- *Reflective Knowledge*: Knowledge known by the researcher and reflected upon during the change process (Turner 2011, p. 8).

Although most of the self-studies share stories of teaching in the online environment, and the issues related to those environments, Sanagavarapu (2018) tells of first experiences with learning how to teach in a flipped classroom environment. He then shared six criteria for success that were the result of his self-reflection on his experiences: (1) use a holistic framework for planning, (2) build in intentional scaffolding, (3) ensure equity and access, (4) address and manage the change, (5) seek institutional support, and (6) remember that time is an important resource. Additionally, Sanagavarapu suggests that being realistic and persistent as well as being open to new opportunities and a changing identity allows one to move forward and make changes in teaching practice worth doing. Many of these contributions echo those found in the findings of the self-studies that describe experiences and lessons learned in fully online learning environments.

The Use of Collaborative Self-Study to Promote Teaching with Technology in Subject Area Courses

A unique self-study highlights how the TPACK framework might be used in self-study to enhance understanding of how TPACK emerges and develops through the act of teaching with technologies (Fransson and Holmberg 2012). These researchers "used the conceptual framework of TPACK to visualize and analyze [their] own prerequisites, understanding, and actions when using technology to support learning. In other words, [they] analyzed [their] own PCK [Pedagogical Content Knowledge], TCK, and TPK and how these aspects of TPACK (and thus [their] own TPACK) might evolve during the design and realization of the course" (p. 197). Their findings highlighted the overlap and connectedness of each of the components of TPACK knowledge and how their personal study of building professional knowledge was contributing to their overall ability to teach with technologies.

There are a few studies beginning to emerge in the SSTEP literature that are addressing the important question about how technology specialists, including technology teacher educators, are working with colleagues in faculties to ensure the promotion of TPACK in higher education faculty. For example, Kosnik et al. (2017) describe their collaborative experiences as two literacy teacher educators working with a knowledgeable other during their first experiences of slowly integrating digital technologies, such as wikis, into their teaching practices. Their story eloquently describes their process of risk-taking that is inherent to growth in teaching practice through positive collaborative engagement with colleagues. Likewise, the study by Jaipal-Jamani et al. 2015a describes three literacy teacher educators (the latter three authors) working with two technology mentors to integrate digital technologies into their own teaching practices first and then how that helped them gain confidence to serve as digital mentors for other faculty members. The stories shared by the collaborators highlighted four strategies used by the technology mentors that supported their ability to easily integrate digital technologies into their teaching practices: modeling of the technology in a learning activity, just-in-time technical instruction, pedagogical discussion, and support in designing a learning activity. They then used those same strategies to design and teach technology-enhanced activities to their own students and later taught workshops to faculty colleagues. Together, these two self-studies highlight ways in which the collaborative support from the faculty community enhanced their confidence to change teaching practice.

Although this extensive review of literature only resulted in a total of 11 self-study articles highlighting teacher educators' stories of learning to teach with technology, the SSTEP literature does contain multiple examples of teacher educators and their experiences incorporating specific technologies into their teaching practices, additional descriptions of how teaching with technology led to changes in their personal teaching practice, and even how digital technologies have changed the way teacher educators conduct research – such as the stories we see in *Being Self-Study Researchers in a Digital World* (Garbett and Ovens 2017). By limiting the review to technology courses or technology teacher educators – the focus of the research questions – many of the articles that may have come to light could have been excluded. However, self-study narratives, such as these, illustrate the potential of self-study research findings to inform and promote changes to the teaching practices of teacher educators and are especially effective for informing teaching practices that include technology.

In summary, other themes that emerged from self-studies of teacher educators solving problems of practice that contribute to the growth of TPACK knowledge included the common motivation of remaining relevant to students as an impetus for integrating technology into teaching practice as well as the resulting frustration that teacher educators often experience from the lack of knowledge and expertise when using the new technology in teaching. The narratives often describe the apprehension with the risk-taking that is required to attempt to use a new technology within their teaching practice and the innovative strategies created to overcome these frustrations and challenges. Most, if not all, of these self-studies provide guidance for the reader, such as providing a summary of best practices learned from the journey or next steps in the growth process. We anticipate that most of the chapters in this section on self-study across subject disciplines will highlight the influence of technology upon teacher educators in those disciplines and provide further examples of how teacher educators respond to the pervasive influence of the use of technology across teacher education (Howell and O'Donnell 2017).

Gaps in the Literature

As indicated by this review, the area of self-study of technology teacher educators is a new and emerging area of research. Self-studies by technology teacher educators are rare in the literature, partly due to formative stages of the discipline as a teaching subject domain and partly due to the ever-present change in the field. As well, technology teacher educators – those teacher educators who teach courses in teacher education programs focused on the pedagogy of how to teach with technology – are a small community, with a teacher education program counting itself privileged if they have one technology teacher educator on faculty offering stand-alone technology pedagogy courses.

Understanding how technology teacher educators foster the development of TPACK and the decisions made about "what works" to promote technology-enhanced teaching in preservice teachers to prepare them for their initial teaching experiences can be gleaned from literature reviews of qualitative, design-based, action, and quantitative research literature. However, the stories and narratives of technology teacher educators that describe those decisions, the findings and best practices that result from the rigor of self-studies that describe the trials and errors from the technology classrooms, and the lessons learned, are minimal in the self-study literature. Although this can be attributed to the more focused research on promoting TPACK in preservice teachers in subject matter domains rather than in sharing what they, the experts, are also learning about how to promote TPACK in the technology classroom, the question still remains – what are the problems of practice for technology teacher educators?

How do technology teacher educators make decisions about what should be included in our stand-alone technology courses? Technology teacher educators understand that content for a technology methods course is one of those problems of practice. The field of technology covers such a large knowledge base of technologies, pedagogies, and technical skill requirements that support teaching one content area, much less teaching multiple subject content areas, that selecting appropriate content that grows TPACK within the structure of a short one-term technology methods course is a challenge. Even within the literature reviewed for this chapter, descriptions of what technology teacher educators are doing for content within the technology courses are seldom included. There are descriptions of assignments

(Mouza et al. 2014; Jin et al. 2015) and problem-based activities (Dreon and Shettel 2016), but the perplexing question about content for these courses is infrequently tackled. The narratives and stories from these contexts would provide valuable information and examples for other technology teacher educators struggling with questions such as how to select the types of tools introduced in technology courses, how to determine what background technology knowledge is most important to be shared with preservice teachers, as well as seeking indications of the types of learning activities that promote the attitudes and beliefs that lead to a growth mindset needed for teaching in a digital society. Recommendations for future research directions in self-study for technology teacher educators are simply to get those stories shared. Finger and Finger (2013) called for the urgent need "for research which acknowledges the importance of teacher stories to assist in our understanding of what TPACK looks like in practice" (p. 31), but this is not just the TPACK of the preservice teachers but of the technology teacher educators as well. The expertise that rests buried between the lines of the other research formats is rarely shared, and when they are shared, they are shared most often in the chance meeting of colleagues over coffee or, informally, at conference social events or summits. Yet, the voices of these innovators and early adopters could provide much guidance, not only for other early adopters but for those with little or no experience with technology-enhanced teaching.

A second area that is highlighted by the literature review is the issue related to the difficulty of assessing TPACK – how do we measure the growth of TPACK knowledge in preservice teachers? Do we need to measure the growth or assume that TPACK is always growing? Do we instead research or measure the effectiveness of interventions to promote specific knowledge components of TPACK, or intent to teach with technology, as proposed by Perkmen et al. (2016)? Do we focus on pedagogical reasoning as more important as a measure of TPACK (Chai et al. 2013; Trevisan and De Rossi 2018)? Most of the research in this area is quantitative, and yet, the findings from self-study reflections of the technology teacher educator may be more indicative of what is most effective.

Additionally, the literature review also highlighted how the growth of TPACK knowledge is closely tied to the interaction of content knowledge and technological knowledge. An important area for self-study researchers would be to research how technology teacher educators coordinate what is taught in the technology methods course with the technologically enhanced content that colleagues in the program are teaching in the subject area methods courses so that the preservice teachers are experiencing a well-rounded exposure to how to teach with technology in the content areas. The narrative stories of programs where the faculty are engaging in the process work to make such a coordinated program a reality (such as seen in Lindsey et al. 2016) would be especially informative to other teacher education programs, and the technology teacher educator's understanding of what is contributing to the success of such a program would not only be a pivotal but could present perspectives of actions to promote improvement. We would also recommend that within a self-study of a technology teacher educator, it would be especially important to include what personal knowledge about teaching practice, or teaching with technology, or reflection on teaching preservice teachers, was gained from this experience – in other words, how did the experience result in personal TPACK growth for the technology teacher educator in the self-study?

A separate, but similar, topic for research would include the self-study of how technology teacher educators work with colleagues in the faculty to ensure that they, too, are growing their TPACK knowledge. Descriptions of strategies, successful mentoring techniques, types of administrative support required for success, and motivational aspects of achieving growth are all appropriate findings that could inform other technology teacher educators who are often faced with the same tasks, as are tech-savvy teacher educators. The literature review did highlight two collaborative self-studies (Jaipal-Jamani et al. 2015b; Kosnik et al. 2017) that illustrated how small collaborative groups were successful in promoting TPACK in teacher educators – other stories are needed to enhance our understanding of this powerful method of TPACK knowledge-building.

And finally, and arguably most importantly, what are technology teacher educators learning about teaching with technology that informs their own teaching practices in a digital classroom? Experienced technology teacher educators already possess TPACK – they understand how to use technology and have a highly developed pedagogical knowledge of how to design technologically enabled learning environments. Their practice is not informed by stories from teacher educators who describe how they had to learn how to work with the tool technically, how to figure out a learning activity that was appropriate for that tool, and then how to pedagogically use the tool effectively during instruction (which faculty who teach in subject areas do). Technology teacher educators' practice will be informed by other technology teacher educators sharing how changes made in their technology classrooms influenced their teaching practice. For example, coding in the classroom, makerspaces, genius hour/inquiry-based learning, robotics, and artificial intelligence are all examples of newer technology-enabled learning environments that could be utilized for teaching. In our experiences, it is the technology teacher educators who will be the first ones engaged in overcoming the technical issues of the technologies, ironing out how these environments will work seamlessly in instructional situations, and determining situations in which teachers will be successful in integrating these into teacher education classroom instruction. We would also expect any best practices for working in this new environment or with these new technologies to be shared as well. These are rich and robust areas of self-study research for technology teacher educators.

Next Steps

> Given the rapid rate of change of technology, it is naive to assume that the tools we have today will remain static. Clearly this has implications for how we think about deploying these tools in the classrooms and how we train teachers to use these tools for pedagogical purposes. This is what brings teacher creativity to the forefront, since teachers have to be

> prepared to utilize tools they may have never experienced before in their classrooms. This idea lies at the heart of the TPACK framework as well. (Mishra and Henriksen 2018, p. 2)

As Mousa et al (2014) suggest, the technology does not remain static. We would also suggest that the learning environments that we prefer for technology-enhanced teaching do not remain static. Change is the only constant in the classroom of the technology teacher educator. Self-study research is one of the few forms of research that documents the change process that often occurs quickly in the technology classroom, specifically as it is aligned with personal teaching beliefs and goals. Such research would support and enhance our ability to encourage and promote quality teaching with technology, so the need for the research is real and immediate, and this review illustrates the complete gap in this type of research being done.

There is an opportunity for scholars to engage in robust research agendas to close this gap and encourage the development of a forum for conversations about problems of practice of technology teacher educators that does not currently exist. Therefore, we would like to suggest that our next steps as self-study researchers are twofold. First, we must advocate for this type of self-study research. Our self-study interest groups at the national research conferences are the Self-Study of Teacher Education Practices SIG of the *American Educational Research Association (AERA)* and the Self-Study of Teacher Education Practices (SSTEP) SIG of the *Canadian Association for Teacher Education (CATE)*, a constituent association of the *Canadian Society for the Study of Education (CSSE)*. We recommend attending the SIG meetings and presenting at the conferences and sharing the results of this literature review and inviting young scholars and teacher educators to submit their self-study research to journals such as *Studying Teacher Education* or *Journal of Teacher Education*. We would also invite interested senior scholars to join with us as volunteers to serve as editors or "readers" to pre-read submissions, much as we do for our graduate students, to promote more rigorous publications on these topics.

Secondly, we need to advocate for technology teacher educators to become engaged in self-study research and provide the narratives and much-needed stories of decisions made during their problems of practice. In order to do this, we also need senior self-study scholars to step forward as advocates and volunteers to attend and present at conferences, specifically by attending the special interest groups meetings, such as the special interest group, the Technology as an Agent of Change in Teaching and Learning (TACTL) SIG of the *American Educational Research Association (AERA)*, and the Technology and Teacher Education (TATE) SIG meeting of the *Canadian Association for Teacher Education (CATE)*, a constituent association of the *Canadian Society for the Study of Education (CSSE)*. Then, we also recommend presenting and visiting with the TPACK SIG members at the *Society for Information Technology and Teacher Education (SITE)* which is a unique organization focused on the integration of instructional technologies into teacher education programs. These are the venues where technology teacher educators most often present their research and congregate to learn from the community about best practices, innovations, and advancements in ideas.

Conclusion

The field is wide open. There are opportunities for the development of new special interest groups within our research associations. There are opportunities for new streams of communities of engagement in the self-study research of problems of practice for technology teacher educators; there are opportunities for new advocates and senior scholars alike. We call upon our self-study colleagues to pick up the baton and make this happen. The need for this research is real and imperative.

The capacity for self-study research to contribute to the knowledge base of how to make decisions to improve our technology-enhanced teaching practice cannot be underestimated. Although self-study is informative for other content areas and teaching practices, self-study literature about how technology teacher educators changed their teaching practice with technology and innovative teaching practices and structures has been shown to serve as exemplars of decision-making for future technology educators. Reflecting, reading, and learning from the self-study literature shared by these knowledgeable others, innovators, and early adopters prepare us to enact those decisions we make for our own teaching practices.

References

Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT-TPCK: Advances in technological pedagogical content knowledge (TPCK). *Computers & Education, 52*(1), 154–168.

Bal, I. (2018, April). *Why is it so hard to teach K-12 educators how to personalize learning?* EdSurge. Available at: https://www.edsurge.com/news/2018-04-18-why-is-it-so-hard-to-teach-k-12-educators-how-to-personalize-learning.

Baran, E., Uygun, E., Altan, T., Bahcekapili, T., & Cilsalar, H. (2014). Investigating technological pedagogical content knowledge (TPACK) in action: Workshop design cases. In J. Viteli & M. Leikomaa (Eds.), *Proceedings of EdMedia 2014 – World conference on educational media and technology* (pp. 1536–1541). Tampere: Association for the Advancement of Computing in Education (AACE).

Beaudin, L. (2016). Integrating structural gamification into pre-service teacher education. In *Proceedings of E-Learn: World Conference on E-Learning* (pp. 1132–1136). Washington, DC: Association for the Advancement of Computing in Education (AACE).

Bowers, J. S., & Stephens, B. (2011). Using technology to explore mathematical relationships: A framework for orienting mathematics courses for prospective teachers. *Journal of Mathematics Teacher Education, 14*(4), 285–304.

Brenner, A. M., & Brill, J. M. (2013). Nine substantiated practices in teacher education that promote technology integration in early career teachers: Applying empirical work to professional development. In R. McBride & M. Searson (Eds.), *Proceedings of SITE 2013 – Society for information technology & teacher education international conference* (pp. 2545–2549). New Orleans: Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/48487/.

Bruciati, A., & Lizano-DiMare, M. (2016). Informal technology coaching: Using pre-service teacher field experiences to support K-12 flipped classroom instruction. In *Proceedings of E-learn: World conference on E-learning* (pp. 1307–1312). Washington, DC: Association for the Advancement of Computing in Education (AACE).

Bull, G. L., & Bell, L. (2006). The 2006 National Technology Leadership Summit. *Contemporary Issues in Technology and Teacher Education, 6*(3), 302–305. Waynesville: Society for Information Technology & Teacher Education. Retrieved from https://www.learntechlib.org/p/33140/.

Bullock, S. M. (2013a). Learning to teach and the false apprenticeship: Emotion and identity development during the field experience placement. In M. Newberry, A. Gallant, & P. Riley (Eds.), *Emotion and school: Understanding how the hidden curriculum influences relationships, leadership, teaching, and learning* (pp. 119–140). Bingley: Emerald Group Publishing Ltd.

Bullock, S. M. (2013b). Using digital technologies to support self-directed learning for preservice teacher education. *The Curriculum Journal, 24*(1), 103–120.

Bullock, S. M., & Sator, A. (2018). Developing a pedagogy of "making" through collaborative self-study. *Studying Teacher Education, 14*(1), 56–70.

Carpenter, J., Graziano, K., Borthwick, A., DeBacker, T., & Finsness, E. (2016). A diagnostic tool to help leaders develop TPACK ready teacher preparation programs. In G. Chamblee & L. Langub (Eds.), *Proceedings of society for information technology & teacher education international conference* (pp. 2802–2805). Savannah: Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/172090/.

Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2013). A review of technological pedagogical content knowledge. *Educational Technology & Society, 16*(2), 31–51.

Cox, S., & Graham, C. R. (2009). Diagramming TPACK in practice: Using an elaborated model of the TPACK framework to analyze and depict teacher knowledge. *TechTrends, 53*, 60–69.

Crowe, A. R. (2004). Teaching by example: Integrating technology into social studies education courses. *Journal of Computing in Teacher Education, 20*(4), 159–165.

DeSantis, J. (2016). Investigating the relationship between TPACK and the ISTE standards for teachers. *Issues and Trends in Educational Technology, 4*(1), 16–30. University of Arizona Libraries. Retrieved from https://www.learntechlib.org/p/180275/.

Di Blas, N., & Paolini, P. (2016). Distributed and Ddnamic TPACK: Evidences from a (large) case study. In G. Chamblee & L. Langub (Eds.), *Proceedings of Society for Information Technology & teacher education international conference* (pp. 2815–2821). Savannah: Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/172093/.

Donnelly, R. (2006). Integrating learning technologies with experiential learning in a postgraduate teacher education course. *Studying Teacher Education, 2*(1), 91–104.

Dorner, H., & Kumar, S. (2017). Pre- and inservice teacher satisfaction with online collaborative mentoring for technology integration: Applying the Kano quality attributes. *Online Learning Journal, 21*(4). The Online Learning Consortium.

Downes, T., & Figg, C. (2017). *Addressing the use of Genius Hour in the teacher education program at Brock University*. Paper presented at the 2017 Canadian Society for the Study of education. Toronto: Ryerson University.

Dreon, O., & Shettel, J. (2016). The impact of authentic: How field experiences and authentic projects influence TPACK development. In G. Chamblee & L. Langub (Eds.), *Proceedings of society for information technology & teacher education international conference* (pp. 2827–2833). Savannah: Association for the Advancement of Computing in Education (AACE).

Elwood, K., & Savenye, W. (2015). Current tensions: A review of technology integration models utilized by pre-service teacher educator programs. In D. Rutledge & D. Slykhuis (Eds.), *Proceedings of SITE 2015 – Society for information technology & teacher education international conference* (pp. 2295–2300). Las Vegas: Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/150320/.

Feldman, A., Paugh, P., & Mills, G. (2004). Self-study through action research. In *International handbook of self-study of teaching and teacher education practices* (pp. 943–977). Dordrecht: Springer.

Figg, C., & Jaipal, K. (2009, March). Unpacking TPACK: TPK characteristics supporting successful implementation. In Society for Information Technology & Teacher Education International

Conference (pp. 4069–4073). Association for the Advancement of Computing in Education (AACE).

Figg, C., & Jaipal, K. (2013). Using TPACK-in-practice workshops to enable teacher candidates to create professional development workshops that develop tech-enhanced teaching. In R. McBride & M. Searson (Eds.), *Society for Information Technology & teacher education international conference annual 2013* (pp. 5040–5047). Chesapeake: AACE.

Figg, C., & Jaipal-Jamani, K. (2015a). Investigating the development of TPACK knowledge through gamification. In D. Rutledge & D. Slykhuis (Eds.), *Proceedings of SITE 2015 – Society for information technology & teacher education international conference* (pp. 3148–3156). Las Vegas: Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/150440/.

Figg, C., & Jaipal-Jamani, K. (2015b). Using gamification strategies to engage teacher candidates as they develop TPACK knowledge. In M. Niess & H. Willows-Giles (Eds.), *Handbook of research on teacher education in the digital age* (pp. 663–690). Hershey: IGI Global Publications.

Figg, C., Rowsell, J., Welbourn, S., & Pelchat, K. (2018). Using informal learning of Makerspaces to enhance technological pedagogical and content knowledge (TPACK). In E. Langran & J. Borup (Eds.), *Proceedings of society for information technology & teacher education international conference* (pp. 2037–2040). Washington, DC: Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/182808/.

Finger, G. & Finger, P. (2013). *Understanding TPACK in practice: Praxis through technological pedagogical reasoning*. Presented at international conference on educational technologies (ICEduTech) 2013.

Foulger, T. S., Graziano, K. J., Schmidt-Crawford, D., & Slykhuis, D. A. (2017). Teacher educator technology competencies. *Journal of Technology and Teacher Education, 25*(4), 413–448. Waynesville: Society for Information Technology & Teacher Education. Retrieved from https://www.learntechlib.org/primary/p/181966/.

Fransson, G., & Holmberg, J. (2012). Understanding the theoretical framework of technological pedagogical content knowledge: A collaborative self-study to understand teaching practice and aspects of knowledge. *Studying Teacher Education, 8*(2), 193–204.

Garbett, D., & Ovens, A. (Eds.). (2017). *Being self-study researchers in a digital world*. Cham: Springer.

Graham, C. R. (2011). Theoretical considerations for understanding technological pedagogical content knowledge (TPACK). *Computers & Education, 57*(3), 1953–1960.

Graham, C. R., Gorup, J., & Smith, N. B. (2012). Using TPACK as a framework to understand teacher candidates' technology integration decisions. *Journal of Computer Assisted Learning, 28*(6), 530–546.

Gur, H., & Karamete, A. (2015). A short review of TPACK for teacher education. *Educational Research and Reviews, 10*(7), 777–789.

Hall, G. E., & Hord, S. M. (2014). *Implementing change: Patterns, principles, and potholes* (4th ed.). Raleigh: Pearson.

Ham, V., & Davey, R. (2005). Is virtual teaching, real teaching? Learnings from two self-studies. In C. M. Kosnik, C. Beck, A. R. Freese, & A. P. Samaras (Eds.), *Making a difference in teacher education through self-study* (pp. 101–116). Dordrecht: Springer.

Hamilton, E. R., Rosenberg, J. M., & Akcaoglu, M. (2016). The substitution augmentation modification redefinition (SAMR) model: A critical review and suggestions for its use. *TechTrends, 60*(5), 433–441.

Harris, J. (1998). *Design tools for the internet-supported classroom*. Alexandria: Association for Supervision and Curriculum Development (AACE).

Harris, J., & Hofer, M. (2009). Instructional planning activity types as vehicles for curriculum-based TPACK development. In I. Gibson et al. (Eds.), *Proceedings of society for information technology & teacher education international conference 2009* (pp. 4087–4095). Chesapeake: AACE.

Harris, J., & Hofer, M. (2016). Planning for deep learning using TPACK-based learning activity types. In G. Chamblee & L. Langub (Eds.), *Proceedings of society for information technology & teacher education international conference* (pp. 2864–2871). Savannah: Association for the Advancement of Computing in Education (AACE).

Harris, J., & Phillips, M. (2018). If There's TPACK, is there technological pedagogical reasoning and action? In E. Langran & J. Borup (Eds.), *Proceedings of society for information technology & teacher education international conference* (pp. 2051–2061). Washington, DC: Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/182811/.

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*, 393–416.

Harris, J., Grandgenett, N., & Hofer, M. (2010a). Testing a TPACK-based technology integration assessment rubric. In D. Gibson & B. Dodge (Eds.), *Proceedings of SITE 2010 – Society for information technology & teacher education international conference* (pp. 3833–3840). San Diego: Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/33978/.

Harris, J. B., Hofer, H. J., Schmidt, D. A., Blanchard, M. R., Young, C. Y., Grandgenett, N. F., & Van Olphen, M. (2010b). "Grounded" technology integration: Instructional planning using curriculum-based activity type taxonomies. *Journal of Technology and Teacher Education, 18*(4), 573–605.

Harris, L., Yearta, L., & Chapman, H. (2018). The intersection of the UDL and TPACK frameworks: An investigation into teacher candidates' use of technology during internship. In E. Langran & J. Borup (Eds.), *Proceedings of society for information technology & teacher education international conference* (pp. 2175–2180). Washington, DC: Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/182973/.

Henderson, J. (2013). Linking critical pedagogy and educational technology. In R. McBride & M. Searson (Eds.), *Proceedings of SITE 2013 – Society for information technology & teacher education international conference* (pp. 1873–1876). New Orleans: Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/48374/.

Herring, M., Redmond, P., Thomas, T., Combs, B., Smaldino, S., & Williams, A. (2013). Leadership needs to develop TPACK ready teacher candidates. In R. McBride & M. Searson (Eds.), *Proceedings of SITE 2013 – Society for information technology & teacher education international conference* (pp. 3599–3604). New Orleans: Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/48663/.

Herring, M. C., Koehler, M. J., & Mishra, P. (Eds.). (2016). Handbook of technological pedagogical content knowledge (TPACK) for educators. Routledge.

Hofer, M., & Harris, J. (2016). Open educational resources (OERs) for TPACK development. In G. Chamblee & L. Langub (Eds.), *Proceedings of society for information technology & teacher education international conference 2016* (pp. 2872–2877). Chesapeake: Association for the Advancement of Computing in Education (AACE).

Howell, S., & O'Donnell, B. (2017). *Digital trends and initiatives in education*. Toronto: Association of Canadian Publishers.

Jaipal, K., & Figg, C. (2010a). Expanding the practice-based taxonomy of characteristics of TPACK. In D. Gibson & B. Dodge (Eds.), *Society for Information Technology & teacher education 21st international conference* (pp. 3868–3875). Chesapeake: Association for Advancement of Computing in Education.

Jaipal, K., & Figg, C. (2010b). Unpacking the "Total PACKage": Emergent TPACK characteristics from a study of preservice teachers teaching with technology. *Journal of Technology and Teacher Education, 18*(3), 415–441. Chesapeake: AACE.

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

Jaipal-Jamani, K., Figg, C., Collier, D., Gallagher, T., Winters, K. L., & Ciampa, K. (2015a). Transitioning into the role of technology leaders: Building faculty capacity for technology-enhanced teaching. In D. Rutledge & D. Slykhuis (Eds.), *Proceedings of SITE 2015 society for information technology & teacher education international conference* (pp. 3264–3271). Las Vegas: Association for the Advancement of Computing in Education (AACE).

Jaipal-Jamani, K., Figg, C., Gallagher, T., Scott, R. M., & Ciampa, K. (2015b). Collaborative professional development in higher education: Developing knowledge of technology enhanced teaching. *Journal of Effective Teaching, 15*(2), 30–44.

Jin, Y., Jenner, A., Karakaya, O., Kramer, E., & Schmidt-Crawford, D. (2015). Dive into content areas: Instructional review and redesign of a blended technology integration course for PK-6 pre-service teachers. In D. Rutledge & D. Slykhuis (Eds.), *Proceedings of SITE 2015 – Society for information technology & teacher education international conference* (pp. 3276–3281). Las Vegas: Association for the Advancement of Computing in Education (AACE).

Johnson, L. (2014). Impact of design teams on preservice teachers' TPACK, attitudes, & skills. In M. Searson & M. Ochoa (Eds.), *Proceedings of SITE 2014 – Society for information technology & teacher education international conference* (pp. 2544–2551). Jacksonville: Association for the Advancement of Computing in Education (AACE).

Jonassen, D. H., & Reeves, T. C. (1996). Learning with technology: Using computers as cognitive tools. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (1st ed.). New York: Macmillan. Retrieved from http://www.aect.org/edtech/ed1/.

Joyce, B., Weil, M., & Calhoun, E. (2004). *Models of teaching* (7th ed.). Boston: Allyn and Bacon.

Kay, R. (2006). Evaluating strategies used to incorporate technology into preservice education: A review of the literature. *Journal of Research on Technology in Education, 38*(4), 383–408.

Koehler, M. J., & Mishra, P. (2005a). Teachers learning technology by design. *Journal of Computing in Teacher Education, 21*(3), 94–101.

Koehler, M. J., & Mishra, P. (2005b). What happens when teachers design educational technology? The development of technological pedagogical content knowledge. *Journal of Educational Computing Research, 32*(2), 131–152.

Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. (2014). The technological pedagogical content knowledge framework. In J. M. Spector (Ed.), *Handbook of research on educational communications and technology* (pp. 101–111). New York: Springer.

Kosnik, C., Menna, L., & Bullock, S. M. (2017). Changing our practice and identity go hand-in-hand: A self-study of our efforts to infuse digital technology into our literacy courses. In D. Garbett & A. Ovens (Eds.), *Being self-study researchers in a digital world* (pp. 47–60). Cham: Springer.

Kramarski, B., & Michalsky, T. (2010). Preparing preservice teachers for self-regulated learning in the context of technological pedagogical content knowledge. *Learning and Instruction, 20*(5), 434–447.

LaBoskey, V. K. (2004). The methodology of self-study and its theoretical underpinnings. In J. John Loughran et al. (Eds.), *International handbook of self-study of teaching and teacher education practices* (pp. 817–869). Dordrecht: Springer.

Lassonde, C. A., Galman, S., & Kosnik, C. (2009). *Self-study research methodologies for teacher educators*. Rotterdam: Sense Publishers.

Lawless, K. A., & Pellegrino, J. W. (2007). Professional development in integrating technology into teaching and learning: Knowns, unknowns, and ways to pursue better questions and answers. *Review of Educational Research, 77*(4), 575–614.

Lee, M. H., & Tsai, C. C. (2010). Exploring teachers' perceived self efficacy and technological pedagogical content knowledge with respect to educational use of the world wide web. *Instructional Science, 38*(1), 1–21.

Lee, K., Suharwoto, G., Niess, M., & Sadri, P. (2006). Guiding inservice mathematics teachers in developing TPCK (technology pedagogical content knowledge). In C. Crawford, R. Carlsen, K. McFerrin, J. Price, R. Weber, & D. Willis (Eds.), *Proceedings of SITE 2006 – Society for information technology & teacher education international conference* (pp. 3750–3765). Orlando: Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/22684/.

Lindsey, L., Buss, R., Foulger, T., Wetzel, K., & Pasquel, S. (2016). The technology infusion iTeach experience: Preparing student teachers to integrate technology. In G. Chamblee & L. Langub (Eds.), *Proceedings of society for information technology & teacher education international conference* (pp. 2923–2930). Savannah: Association for the Advancement of Computing in Education (AACE).

Lloyd, M. (2013). Something's coming, something good: Identifying TPACK competence in pre-service teachers' analyses of learning objects. *Australian Educational Computing, 28*(1), 71–82.

Marich, H., & Greenhow, C. (2016). Technology integration and teacher stages of concern categorized by TPACK knowledge types. In G. Chamblee & L. Langub (Eds.), *Proceedings of society for information technology & teacher education international conference* (pp. 2941–2948). Savannah: Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/172113/.

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

Mishra, P., & Koehler, M.J. (2008). *Introducing technological pedagogical content knowledge.* Paper presented the annual meeting of the American Educational Research Association, New York, March 24–28. (Conference Presentation).

Mishra, P., & The Deep-Play Research Group. (2018). Crayons are the future. In P. Mishra & D. Henriksen (Eds.), *Creativity, technology & education: Exploring their convergence* (pp. 9–16). Cham: Springer Briefs in Educational Communications and Technology.

Mishra, P., Koehler, M. J., Shin, T. S., Wolf, L. G., & DeSchryver, M. (2010). Developing TPACK by design. In J. Voogt (Ed.), *Developing TPACK. Symposium conducted at the annual meeting of the Society for Information Technology and Teacher Education (SITE)*. San Diego.

Mourlam, D., & Bleecker, H. (2017). Early career teacher candidate TPACK development: Implementation of a learning activity types short course. In P. Resta & S. Smith (Eds.), *Proceedings of society for information technology & teacher education international conference* (pp. 2404–2409). Austin: Association for the Advancement of Computing in Education (AACE).

Mouza, C., Karchmer-Klein, R., Nandakumar, R., Ozden, S. Y., & Hu, L. (2014). Investigating the impact of an integrated approach to the development of preservice teachers' technological pedagogical content knowledge (TPACK). *Computers & Education, 71*, 206–221.

Mouza, C., Nandakumar, R., Yilmaz Ozden, S., & Karchmer-Klein, R. (2017a). A longitudinal examination of preservice teachers' technological pedagogical content knowledge in the context of undergraduate teacher education. *Action in Teacher Education, 39*(2), 153–171.

Mouza, C., Yang, H., Pan, Y.-C., Yilmaz Ozden, S., & Pollock, L. (2017b). Resetting educational technology coursework for pre-service teachers: A computational thinking approach to the development of technological pedagogical content knowledge (TPACK). *Australasian Journal of Educational Technology, 33*(3), 61–76.

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education, 21*(5), 509–523.

Niess, M. L. (2011). Investigating TPACK: Knowledge growth in teaching with technology. *Journal of Educational Computing Research, 44*(3), 299–317.

Niess, M. L. (2012). Rethinking pre-service mathematics teachers' preparation: Technological, pedagogical and content knowledge (TPACK). In D. Polly, C. Mims, & K. Persichitte (Eds.), *Developing technology-rich, teacher education programs: Key issues* (pp. 316–336). Hershey: IGI Global.

Paige, R., Hickok, E., & Patrik, S. (2004). *Toward a new golden age in American education*. Washington, DC: Office of Educational Technology, US Department of Education.
Parsons, A. W., & Hjalmarson, M. A. (2017). Study of self: The self as designer in online teacher education. *Studying Teacher Education, 13*(3), 331–349.
Partnership for 21st Century Learning. (2007). *Framework for 21st century learning*. Retrieved from http://www.p21.org/our-work/p21-framework.
Perkmen, S., Antonenko, P., & Caracuel, A. (2016). Validating a measure of teacher intentions to integrate technology in education in Turkey, Spain and the USA. *Journal of Technology and Teacher Education, 24*(2), 215–241.
Phillips, M., Koehler, M., Rosenberg, J., & Zunica, B. (2017). Unpacking TPACK: Reconsidering knowledge and context in teacher practice. In P. Resta & S. Smith (Eds.), *Proceedings of society for information technology & teacher education international conference* (pp. 2422–2429). Austin: Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/177538/.
Polly, D., Mims, C., Shepherd, C. E., & Inan, F. (2010). Evidence of impact: Transforming teacher education with preparing tomorrow's teachers to teach with technology (PT3) grants. *Teaching and Teacher Education, 26*(4), 863–870.
Richardson, K. W. (2010). TPACK game on. *Learning & Leading with Technology, 37*(8), 34–35.
Rogers, E. M. (1995). *Diffusion of innovations*. New York: The Free Press.
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.
Rotherham, A. J., & Willingham, D. (2009). 21st century. *Educational Leadership, 67*(1), 16–21.
Sanagavarapu, P. (2018). From pedagogue to Technogogue: A journey into flipped classrooms in higher education. *International Journal on E-Learning, 17*(3), 377–399. Retrieved from https://www.learntechlib.org/primary/p/173324/.
Schmidt, D., Baran, E., Thompson, A., Koehler, M., Punya, M., & Shin, T. (2009a). Examining preservice teachers' development of technological pedagogical content knowledge in an introductory instructional technology course. In I. Gibson, R. Weber, K. McFerrin, R. Carlsen, & D. Willis (Eds.), *Proceedings of SITE 2009 Society for Information Technology & teacher education international conference* (pp. 4145–4151). Charleston: Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/31308/.
Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009b). 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.
Schrum, L. (2005). A proactive approach to a research agenda for educational technology. *Journal of Research on Technology in Education, 37*(3), 217–220.
Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.
Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1–23.
Shulman, L. (2000). Inventing the future. In P. Hutchings (Ed.), *Opening lines: Approaches to the scholarship of teaching and learning* (pp. 95–105). Menlo Park: Carnegie Foundation for the Advancement of Teaching.
Stansberry, S. (2015). Transformative practice in teaching with technology for preservice teachers. In D. Rutledge & D. Slykhuis (Eds.), *Proceedings of SITE 2015 – Society for information technology & teacher education international conference* (pp. 2596–2604). Las Vegas: Association for the Advancement of Computing in Education (AACE).
Tondeur, J., van Braak, J., Sang, G., Voogt, J., Fisser, P., & Ottenbreit-Leftwich, A. (2012). Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence. *Computers & Education, 59*(1), 134–144.

Trevisan, O., & De Rossi, M. (2018). TPCK and Initial teacher education: Insights on the development of pedagogical reasoning in TPCK-based instructional design (ID) practices. In E. Langran & J. Borup (Eds.), *Proceedings of society for information technology & teacher education international conference* (pp. 2128–2132). Washington, DC: United States: Association for the Advancement of Computing in Education (AACE).

Turner, S. A. (2011). A self-study of technological transition: Instructional impacts of shifting a distance course delivery system. *Journal of Educators Online, 8*(2), 1–24.

Voogt, J., Fisser, P., Pareja Roblin, N., Tondeur, J., & van Braak, J. (2013). Technological pedagogical content knowledge–a review of the literature. *Journal of Computer Assisted Learning, 29*(2), 109–121.

White, B., & Geer, R. (2013). Preservice teachers experience with online modules about TPACK. *Australian Educational Computing, 27*(3), 124–132.

Willermark, S. (2018). Technological pedagogical and content knowledge: A review of empirical studies published from 2011 to 2016. *Journal of Educational Computing Research, 56*(3), 315–343.

Wu, Y. T. (2013). Research trends in technological pedagogical content knowledge (TPACK) research: A review of empirical studies published in selected journals from 2002 to 2011. *British Journal of Educational Technology, 44*(3), E73–E76.