ISBN
9781526415462

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Publication Date
2017

Peer reviewed

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Learning and Teaching with Technology: Technological Pedagogy and Teacher Practice

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In this chapter, we examine technology-enhanced pedagogy in the context of teacher learning and classroom practice. We define and discuss technology-rich environments, which encompass a complex combination of tools, curricula, contexts, and teachers. We will point out that technocentrist approaches (see discussion in Papert, 1990) persist in the classroom and note their counterproductive nature. We then conceptualize technological pedagogy within the framework of technological pedagogical content knowledge (TPACK) (Koehler & Mishra, 2009), which presents a useful way to situate technology and teacher knowledge. Finally, we broaden our view to examine technological contexts across a number of settings and the impact of sociocultural factors on the use of technology and the enactment of technological pedagogy.

In exploring varied teaching contexts, we identify emerging characteristics that support or hinder teacher learning of technological pedagogy and implementation of high quality instruction. In particular, we examine barriers that teachers and schools are likely to confront in developing teacher technological pedagogy and practice. We consider both pre-service teacher education programs and in-service teacher professional development (PD), and their roles in promoting teacher technological pedagogy and improved classroom practice. We look at affordances in existing pre-service and in-service programs, and make recommendations for productive approaches to improve teacher technological pedagogy.

BACKGROUND

Technological Literacy, a Global Priority

Preparing today's global workforce for the information and communication technologies (ICT) used daily in commerce is a national priority for many countries; arguably, developing a competitive ICT workforce is most important for developing countries (Jhurree, 2005). Most national governments look to educational systems to address the need for digital literacy, which places the responsibility for preparing students on schools and teachers (Epstein, Nisbet, & Gillespie, 2011). The approach to meeting this need for an ICT-conversant workforce varies widely by country and region (Ayanso, Cho, & Lertwachara, 2014), as do the barriers, challenges, and limitations to *access*, *skills*, and *usage* of digital technology (ITU, 2009). Nonetheless, the challenge to educate a digitally literate populace is broadly faced globally.

Technocentrist Approaches to Classroom Technology Use

Despite the breadth of literature arguing against them (Jimoyiannis & Komis, 2007; Warschauer, Cotten, & Ames, 2011), *technocentrist* (Papert, 1990) approaches continue to be employed across the globe with poor outcomes (OECD, 2015), often attracting a great deal of publicity (e.g., Sugata Mitra's $1 million TED prize for his school in the cloud). The technocentrist approach views technology access as its own end (Papert, 1990). The technological device itself is viewed as the solution to an instructional challenge.

Moving away from technocentrist approaches requires a significant change in thinking by policy makers and those in leadership positions. Nonetheless, it is an important step to conceptualizing technology-rich environments that are likely to improve teacher practice and student learning. Globally, this shift continues to be a challenge, as decades-old calls to consider pedagogy as an integral part of technology (Watson, 2001) continue to go unheeded. Indeed, publicized failures of large-scale technology projects such as the Los Angeles Unified School District (LAUSD) iPad program (Cuban, 2013) and Turkey's FATIH program (Gamze Isci & Besir Demir, 2015) have helped demonstrate the failure of device-focused approaches that largely ignore teaching practice and pedagogy.

In both the LAUSD and Turkish cases, the lack of technical support and lack of time invested in teacher professional development were identified as central reasons for program failure. In the case of LAUSD, teachers were initially provided with only two or three days of training on the general use of the device (Margolin et al., 2015). The findings from the LAUSD and Turkish technology programs are consistent with our own previous research in Birmingham (Warschauer, Cotten, & Ames, 2011), where a top-down, hardware-driven approach failed to support instructional pedagogy and student learning. We argue that technology can be an integral part of solving challenges in teacher instruction or practice; however, technology use should be predicated on the instructional problem of practice. In the cases mentioned above, there was little consultation with teachers or instructional practice in the deployment of technology. In the context of *access*, *skill*, and *usage*, these cases demonstrate that even when abundant access was available, the absence of *skill* and *usage* on the part of teachers limited students' *skill* and *usage*. Conversely, we note that positive student outcomes have been achieved when teachers are provided with technical support and professional development for the integration of technology in the classroom (Warschauer, 2011; Warschauer, Zheng, Niiya, Cotten, & Farkas, 2014).

Technology-Rich Environments

What are technology-rich environments? Though the framework *access*, *skills*, and *usage* has been applied on a macro level to define entire countries as technology-rich (ITU, 2009), it may also serve as a useful framework on a micro level to look at teaching and classrooms. We conceptualize technology-rich environments in the classroom as providing access to digital technology, developing skills with digital technology, and enacting and supporting usage of digital technology. The extent of *access*, *skills*, and *usage* then define the affordances for student learning.

Though access is important, the types and number of devices used in technology-rich classrooms vary widely (Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010). Furthermore, the effective integration of technology may be more dependent on curriculum and instruction than the particular technological tool (Earle, 2002). Thus, we suggest that in the context of *access*, *skills*, and *usage*, technology-rich environments are dependent on the teachers who instruct the student as much as they are dependent on the availability and affordances of the technology itself. We additionally point to the wide range and availability of technological tools and resources in effective classrooms to suggest that there is no single technological saturation point or narrow description of what technology-rich learning environments should look like (Ottenbreit-Leftwich et al., 2010). Technology-rich environments may exist in unexpected places and with limited resources, *if* teachers are able to effectively leverage those resources in ways that support the curriculum and student learning.

Globally, the pursuit of technology-rich classrooms is unfolding at different rates, with different emphases. Developing countries are focusing on greater *access* to digital technology (du Plessis & Webb, 2012) and developed countries are confronting issues of *skill* and *usage* (Haight, Quan-Haase, & Corbett, 2014; van Deursen & van Dijk, 2013). In developed countries where digital technology has proliferated in society and schools, ICT has become a common part of classrooms, as well as teacher preparation and in-service training programs. Nonetheless, the presence of ICT has not resulted in universal improvements in academic performance and learning (OECD, 2015). Indeed, ICT should be viewed as a tool and resource (Dede, 2008) comprising the *access* components of technology-rich environments.

Teaching in Technologically-Rich Environments

Technology-rich environments represent a system that encompasses the technological tools, curriculum, and context, and the teacher who is equipped to leverage the tools in service of teaching the curriculum and promoting student learning. Though teachers are central to this system, other contextual factors also influence teaching, including students' home environments, cultural context, and their individual differences. Technology – when integrated into a program that aligns curriculum, instruction, and assessment in a rigorous and constructivist learning environment – positions teachers to support student learning. Research on integrated and aligned technology programs has shown positive student outcomes on measures both academic and personal (e.g., job and life skills like critical thinking; Incantalupo, Treagust, & Koul, 2014; Warschauer, 2011).

Exemplary teachers do not need to be experts in all – or even many – modes of technology, but they are expert at leveraging relevant, useful technologies that they have sufficient expertise in to engage in student-centered, meaningful learning (Hakverdi-can & Dana, 2012). In fact, many exemplary teachers model life-long learning as they master new digital technologies alongside their students. Additionally, research has found increased levels of technological *skill* and *usage* in the classroom even with limited *access* when teachers have agency in PD and instructional designs (Schrum & Levin, 2013). Teacher *skill* and *usage* of technology is promoted when the school culture and the community support teachers in meaningful integration of technology in their classrooms (Schrum & Levin, 2013; Zhao, Pugh, Sheldon, & Byers, 2002).

TECHNOLOGICAL PEDAGOGY

To better understand teacher *skill* and *usage* of digital technology, we look to the widely used technological pedagogical content knowledge framework (Mishra & Koehler, 2006). We consider how to assess the enactment of TPACK in classrooms and identify the limitations of TPACK as a framework. We then consider the challenges and barriers to teacher technological practice. Finally, we examine the influence of classroom and school contexts on teacher technological pedagogical practices.

Technological Pedagogical Content Knowledge (TPACK)

Nearly thirty years ago, Shulman (1987) set out a specialized view of teacher instructional practice to explain the specific, professional knowledge of teachers.

This professional knowledge was situated at the intersection of teacher content knowledge (for example, how to add two numbers) and instructional pedagogy (how to teach addition skills to students). The pedagogical content knowledge (PCK) model proposed that teacher instruction be extended beyond content knowledge and general instructional pedagogy and include a more domain-specific knowledge that combined both content and pedagogy (Shulman, 1987). The concept of a PCK model formed the basis of the technological pedagogical content knowledge (TPACK) framework (Mishra & Koehler, 2006). In the TPACK model (see Figure 33.1), technological pedagogy is viewed as part of a web composed of teachers' technological, pedagogical, and content knowledge, situated in particular contexts (Koehler & Mishra, 2009).

Pedagogies within technologically rich environments are linked to teachers' pedagogical knowledge (PK), technological knowledge (TK), and content knowledge (CK) (Chai, Ling Koh, Tsai, & Lee Wee Tan, 2011). In turn, pedagogical knowledge, technological knowledge, and content knowledge are prerequisites for the more complex interactions of pedagogical content knowledge (PCK) and technological pedagogical knowledge (TPK), as well as technological pedagogical content knowledge. To better understand the intersection of knowledge domains within TPACK, we examine the intersection of TK and PK at TPK. TK in the context of TPACK reflects the level of knowledge or skill a

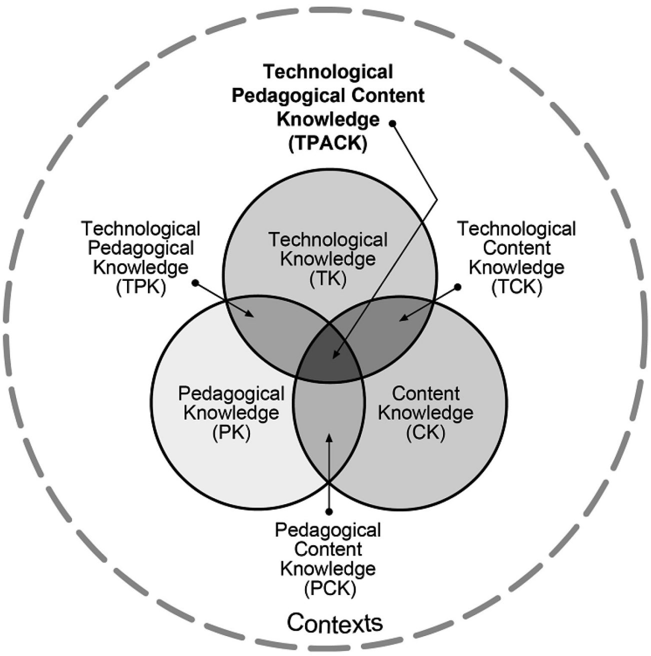

Figure 33.1 Technological pedagogical content knowledge model

Source: Koehler & Mishra (2009). Reproduced by permission of the publisher, © 2012 by tpack.org teacher may have with a given technology – for example, how well a teacher uses a word processing application (e.g., Google Docs). PK represents general classroom pedagogies, such as using peer review to help learn editing skills. TPK, then, would bring these two elements together – for example, a teacher using Google Docs for students to write and comment on each other's papers. Thus, TPK represents a specialized knowledge of integrating technology and pedagogy to promote student learning.

The TPACK framework discourages a *technocentrist* approach. For example, the focus is not on learning to write on Google Docs, but on how the teacher explains and facilitates the use of technology in the peer editing process. Additionally, the example also points to the importance of teacher practice across all TPACK domains. That is, in order for teachers to demonstrate high levels of technological pedagogical knowledge and to engage students in meaningful learning using technology, teachers need to have high levels of technological knowledge *and* pedagogical knowledge. Of course, content-specific knowledge adds an additional layer of complexity. For example, a teacher may know that it is pedagogically helpful for students to understand the broad outline of the progression of the American Civil War before going into details of why the march to Atlanta was crucial. Her knowledge of the content, and the need for an overview, can then be enacted through the use of technology, such as a powerful short video of an animated map illustrating the progress of the battles, the aggregate loss of life, and the shifting control of territory. If teachers are not supported in their pedagogical development, it would seem unreasonable to expect that they would somehow change their instruction simply because technology is introduced into the classroom.

An additional challenge of technological knowledge in the digital realm is the complex and ever-evolving nature of technology itself. Whereas analog technologies such as paper and pencil afforded *specificity*, *stability*, and *transparency*, digital technologies are *protean*, *unstable*, and *opaque* (Koehler & Mishra, 2009). That is, the rapidly changing nature of digital tools and modalities makes them usable in different ways that are continually changing. This means that unlike content and pedagogy that may be largely stable over extended periods of time, technology is continually changing and evolving, creating a shifting landscape that is challenging for teachers to master (Koehler & Mishra, 2009). Indeed, the amorphous nature of technology led Koehler and Mishra to conclude that there is no single best way to design PD for technological integration, but rather that design should consider subject and classroom contexts.

Assessing Technological Pedagogy with Technological Pedagogical Content Knowledge

A number of assessments have been used to measure teacher understanding of pedagogies and to assess their growth and learning through the lens of TPACK;

however, the changing nature of technology makes assessing teacher TPACK and practice more challenging than assessing knowledge of more stable domains such as content (Koehler, Shin, & Mishra, 2012). For example, a question about using DVD or CD burners may have been relevant a few years ago, but today those technologies are outdated and would be less useful in assessing classroom technology use. Assessments of technological pedagogy need regular examination due to the continual changes in technology and differential adoption of technology across schools and countries. Additionally, though there are numerous assessment tools for TPACK, few have been validated (Koehler et al., 2012); thus, choosing an appropriate assessment becomes paramount.

Most TPACK assessments are quantitative and survey based. Although some qualitative approaches have been guided by TPACK (Groth, Spickler, Bergner, & Bardzell, 2009), they are less often used (Koehler et al., 2012). Two TPACK assessment types may be particularly useful in PD settings: self-report surveys and lesson assessment rubrics. Self-report surveys, when validated, have been useful in tracking teacher TPACK growth during pre-service (Chai et al., 2011) and in-service (Shin et al., 2009) education. The use of rubrics (Harris, Grandgenett, & Hofer, 2010) can help teachers better understand their classroom planning and how they enact lessons integrating technology. Multiple varied measures, such as self-report surveys and classroom observations or teacher interviews, may also be useful in providing greater detail on the extent of teacher knowledge.

Limitations of Technological Pedagogical Content Knowledge

We acknowledge that the TPACK model has a number of limitations and constraints. Most notably, teachers bring their own histories and beliefs to the classroom, and classroom contexts vary from class to class and school to school (Angeli & Valanides, 2009). It is difficult to measure TPACK domains due to the interconnected nature of each of the knowledge domains (Archambault & Barnett, 2010). Some have argued that the relationships and intersection between these specialized forms of knowledge do not work evenly and that TK and PK are more closely connected to each other and TPACK than with CK, for example (Chai et al., 2011).

Indeed, the intent of TPACK is to provide a framework to discuss the facets of teacher knowledge, not to propose a course for teacher instruction (Harris, Mishra, & Koehler, 2009). Nonetheless, TPACK can be a good starting point to conceptualize *skill* and *usage* of technology in the classroom. TPACK survey results can provide researchers and practitioners with basic information about teacher *skills* and *usage* of technology in the classroom, their pedagogical practices, and their technological pedagogical practices. Understanding teacher skills may then also help identify technological opportunities for students in the classroom. Furthermore, contextualized survey questions can provide more detailed and relevant information about teacher TPACK depending on the setting or specific research goal (Chai et al., 2011).

Barriers and Challenges to Implementing Technological Pedagogy

What challenges do teachers face as they develop and implement classroom practices with the use of technology? We identify two broad types of barriers that hinder and challenge teachers' efforts in successfully integrating technological pedagogy in the classroom. We classify them as first-order, or extrinsic, and second-order, or intrinsic, barriers (Ertmer, 1999).

First-order barriers. First-order barriers are external to teachers. They are associated with availability of resources (Ertmer, 1999). For example, lack of high-speed internet access and lack of teacher PD are first-order barriers. These barriers are more likely to exist in schools serving poorer children (Warschauer et al., 2014). Globally, first-order barriers relating to hardware are most likely to be encountered in developing countries (Ayanso et al., 2014). Nonetheless, first-order barriers exist across nations, from those with limited to high levels of technology (Goktas, Yildirim, & Yildirim, 2009; Keengwe, Onchwari, & Wachira, 2008; Lim & Khine, 2006).

Time challenges relate to both student access to ICT and teacher development and planning time (du Plessis & Webb, 2012). Furthermore, technical support emerges as a common barrier to and universal prerequisite for successful pedagogical practices in technology-rich classrooms in developed countries such as the United States (Warschauer, 2011) as well as developing countries such as Nigeria (Tella, Tella, Toyobo, Adika, & Adeyinka, 2007), where lack of technical support was found to undermine instruction. Even schools with sufficient resources may have difficulty keeping up with the ever-evolving needs for increased bandwidth and computing power, frequent needs for device updates, and hardware obsolescence or wear. When confronted with hardware or software problems, teachers and students can become frustrated and stop making use of technology in the classroom.

First-order barriers may also be more localized. For example, the lack of a coherent school vision and goals for integration of ICT also emerge as first-order barriers. If technology has not been chosen with curricular goals in mind, it can easily become a distraction. Students may have access to computers as a reward, rather than a tool to reach meaningful, authentic learning goals. Usage may focus on cutting and pasting content from the internet rather than developing higher order skills (Warschauer, 2006). These common pitfalls highlight the importance of involving teachers in creating a school's technology vision (Earle, 2002; Hew & Brush, 2007; Jhurree, 2005).

Second-order barriers. Though first-order barriers may appear daunting, second-order barriers are complex and require significant attention at the teacher instructional level. Second-order barriers associated with teachers include teachers' beliefs about the role of technology in their classroom, beliefs about their own teaching, and the willingness or ability to change their practice (Ertmer, 1999). From an instructional practice perspective, addressing second-order barriers is central to developing teacher practice through pre-service and in-service teacher support (Ertmer, Ottenbreit-Leftwich, & York, 2007). From a *skill* and *usage* perspective, if teacher beliefs do not align with effective technological pedagogy, then it is unlikely that students will have opportunities to develop their own skills and usage of technology. Furthermore, social and cultural contexts play an important role in the interaction between students and teachers and the intersection of their beliefs about the use of technology for learning. For example, in studying the use of computers in an ESL class, Warschauer (1998) found incongruence between the teacher's and students' visions of using computers for writing. The conflicting visions led to student disengagement and a lack of interest in the work of the class.

In considering teacher thinking and beliefs about the use of technology in their classroom, technology often extends teacher existing practice (Palak & Walls, 2009). That is, teachers are likely to use new technology in the same ways they used other resources and tools. If teachers held teacher-centered instructional beliefs prior to the introduction of a new technology, the introduction of that technology is unlikely to shift their approach to student-centered instruction. For example, teachers may shift their worksheets from paper and pencil to computer-based worksheets, but not change their core instructional approach (Jimoyiannis & Komis, 2007). Indeed, a resistance to change can undermine innovative technological pedagogy regardless of the number of internet-connected computers in the classroom (Ertmer, 1999; Granger, Morbey, Lotherington, Owston, & Wideman, 2002; Mirzajani & Mahmud, 2015). Thus, addressing hardware or even teacher use of software and hardware without addressing underlying pedagogical approaches is unlikely to change teacher practice or improve student learning.

Teacher backgrounds and beliefs inform their pedagogical practice (Chen, 2008). Important beliefs include teachers' valuing of constructivist approaches (moving teacher-centered instruction to student-centered instruction), their attitudes toward the use of computers in the classroom, and their teaching and technology self-efficacy (Sang, Valcke, van Braak, & Tondeur, 2010). For example, teachers' attitudes and beliefs about the use of technology in the classroom were shown to be a strong influence on student-centered technology-facilitated instruction in the classroom in Asia and in Europe (Palak & Walls, 2009; Sang et al., 2010; Tezci, 2011). Thus, teacher beliefs, their enacted practice, and student behaviors and outcomes are interconnected and influence one another. Changing teacher practice, including technological pedagogy, is contingent on addressing teachers' underlying beliefs.

Interplay between first- and second-order barriers. Furthermore, first- and second-order barriers are often intertwined, creating particularly challenging issues. Lack of time (Gamze Isci & Besir Demir, 2015; Lim & Khine, 2006), a first-order barrier, is often a significant problem associated with assessing and effectively addressing teacher thinking and beliefs, second-order barriers; time is also usually underestimated as a barrier. Indeed, changing teacher beliefs and practices to integrate technology in student-centered ways takes an extended period of time (Gorder, 2008). One reason for the time required for technological pedagogy change is the resistance to change and inertia that frequently exists in the field of education (Cuban, Kirkpatrick, & Peck, 2001; Kinchin, 2012). Additionally, the process of teacher change in integrating technology in the classroom in a meaningful way is complex and multi-staged. As Sandholtz, Ringstaff, and Dwyer (1997) detailed in their investigation of the Apple Classroom of Tomorrow (ACOT) program, teachers undergo a process of *entry*, *adoption*, *adaptation*, *appropriation*, and *invention* as they navigate through the integration of technology in their classrooms. Teachers need further support as they become more proficient at technology-based instruction in student-centered ways. The types of support teachers need change as they move through the processes of *entry*, *adoption*, *adaptation*, *appropriation*, and *invention* (Sandholtz et al., 1997). Thus, teacher beliefs and backgrounds, the types of available instructional and pedagogical supports they have, and the classrooms and schools they teach in play a role in teachers' classroom technological pedagogical practice.

Contexts for Technological Pedagogy

In schools, important contextual factors impacting teacher technological pedagogy include support from school administrators (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012) and time for teachers to reflect on their practice (Tondeur et al., 2012). To enable effective reflection, teachers need a clear understanding of both their own beliefs and alternative beliefs about technological pedagogy (Sandholtz et al., 1997), which requires professional development effort and time. Examining their own beliefs and alternative beliefs about the use of technology provides an opportunity to bridge a potential gap between beliefs and practice (Sandholtz et al., 1997). That is, when teachers are aware of their underlying beliefs, a disconnect is less likely to arise between their beliefs and their practice.

Incongruence among school vision, teacher beliefs, and student beliefs is most likely to occur when teachers and students come from different backgrounds. In the United States, this most frequently occurs in urban settings, where teachers are often white, middle-class women and students are African American and Latino and from working-class families (Anderson & Stillman, 2011). This difference in backgrounds leads to different teacher and student perceptions of *skills* and *usage* of technology, and students may resist instruction due to the technological approaches used by the teacher (Warschauer, 1998). Indeed, sociocultural considerations should be at the forefront of promoting teacher technological pedagogy.

Technological Pedagogy and Teacher Pre-Service Education

Given the complex process needed to educate teachers in technological pedagogy and then successfully implement strong practices, pre-service programs must begin the efforts to support and develop successful teachers in technologically rich environments. Globally, there are wide disparities in the requirements and quality of teacher pre-service programs. Examining three programs from developing to developed countries highlights the differences between pre-service and credentialing programs:

- In India, for example, although standards and exams have been established for teacher preparation, there remains a great deal of inconsistency in teacher preparation program quality and accountability (Goel & Goel, 2012).
- Turkey typifies other developing countries in the limited integration of ICT in pre-service programs (Tezci, 2011).
- In the United States, virtually all teacher-licensing institutions use ICT in their courses at least minimally, including e-mail and internet resources. About half of the licensing institutions in the United States have implemented standalone technology-focused courses in their programs (Kleiner, Thomas, & Lewis, 2007), although these courses are often isolated and technocentrist in their approaches.

Further, limited modeling of pedagogically sound technology use is found in teacher preparation courses even in developed countries, since the faculty in such programs are often themselves not technologically proficient. Indeed, an analysis of pre-service programs revealed that instruction supported teachers with limited technological backgrounds in their development of technological knowledge (Brown & Warschauer, 2006; Brush, Glazewski, & Hew, 2008); however, programs did little to support teacher technological pedagogical practices in the context of classroom instruction (Brush et al., 2008). Although 57% of licensing institutions in the United States reported teaching candidates how to use technology to enrich and enhance instruction to a major extent, and 40% to a moderate extent (Kleiner et al., 2007), faculty in license-granting institutions reported lack of time (87%), lack of training (83%), and lack of interest (73%) as barriers to their integration of ICT in licensing courses (Kleiner et al., 2007). These challenges seem to mirror those of classroom teachers.

Addressing these challenges more meaningfully in pre-service could help mitigate technological pedagogy challenges for teachers once they enter the classroom. Pre-service teachers would benefit from using technology in authentic, contextualized ways as they prepare for the classroom. By experiencing curricular-focused usage of technology, they would be better able to understand the affordances (both positive and negative) of using technology in their future classes. Because many of today's teacher candidates have not experienced schooling with high-quality technology tools, they would benefit from the modeling of potential applications to increase their knowledge and comfort level.

Technological Pedagogy and Teacher In-Service Professional Development

As teachers move from pre-service to the classroom, in-service PD becomes a potential source for the support and development of technological pedagogy; however, in-service PD has had mixed results (Warschauer, 2011). Improved teacher practice and student outcomes are more likely to arise from developing teacher classroom practices in tandem with technological pedagogy, rather than developing isolated technology acumen (Warschauer, 2011). Indeed, developing teacher practice along with technology use has resulted in more meaningful teacher integration of technology in the classroom and student learning (Gerard, Varma, Corliss, & Linn, 2011; Matzen & Edmunds, 2007).

Effective PD has been guided by previously defined principles (Desimone, 2009; Garet, Porter, Desimone, Birman, & Yoon, 2001), and these principles should continue to guide technology-specific PD. However, special consideration should be given to technology PD in three areas: the alignment of technological and instructional pedagogies; the ongoing nature of PD; and situating PD in schools. Aligning technology instruction with reform-minded teaching approaches has supported change in teacher instructional practice as well as student learning (Matzen & Edmunds, 2007; Walker et al., 2012). Though the importance of the duration of PD has been detailed in frameworks for effective PD (Desimone, 2009), with technology-based PD, longer duration becomes a critical element. PD programs lasting two years produced promising outcomes (Brinkerhoff, 2005; Martin et al., 2010), whereas programs lasting one year showed mixed results (Gerard et al., 2011). Finally, situating PD at teachers' school sites works to promote a sense of safety, collaboration, and community that supports their learning (Klieger, Ben-Hur, & Bar-Yossef, 2010; Mouza, 2009).

IMPLICATIONS

In this chapter, we conceptualized technological pedagogy within TPACK and looked at developmental trajectories and challenges for teachers as they enact technological pedagogy. In examining the integration of technology in the classroom, we found that technocentrist tool-focused, rather than practice-focused, approaches persist. We argue that practically and theoretically, the design and development of technology-rich programs should begin with student outcome goals. Technology should be used to the extent and in ways that extend and enhance opportunities for students to learn. Meaningful implementations of technology can allow diverse learners to access curriculum in multi-modal ways, hone their knowledge with analytical tools, collaborate better with students and mentors inside and outside the classroom, and present their understanding in multiple ways to diverse audiences. This suggested focus on *learning* contrasts sharply with the more typical focus on a specific *technology* in isolation.

Additionally, the challenges that teachers and students experience in their classroom and context should guide program design and support of technology-based programs. Indeed, teacher practice and enactment of technological pedagogy is often viewed as an outcome, not the starting point, for teacher development and program design. We suggest that inclusion of teachers, students, and other stakeholders in the development of school technology programs and initiatives provides practical insights, improved collaboration, and increased investment in the project's success.

This same practice-based approach could be used in pre-service and in-service teacher development. For example, rather than preparing teachers to use technological tools, pre-service programs can focus more on identifying candidate instructional challenges and then on addressing those challenges with technological tools when those tools are appropriate. In evaluating use of technology in pre-service teacher credentialing and in-service PD, researchers and practitioners should be guided by how teacher problems of practice are addressed through technology. If problems of practice are not being addressed by technology, than what is technology addressing?

From a research perspective, continuing to look beyond a snapshot of teacher technological pedagogy and examining teacher pedagogical change over time would provide increased insight into teachers' developmental trajectories. Better understanding teacher technological pedagogical developmental trajectories could then inform development efforts across schools and countries. Tracking teacher technological practices from pre-service through the early years of classroom practice, as well as through implementation of technology initiatives, could inform design and assessment of programs. Identifying changes in teacher trajectories and emerging challenges is especially important given the rapid and continuous change in technology.

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