Promoting Urban Teachers' Understanding of Technology, Content, and Pedagogy in the Context of Case Development

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Abstract

This study investigated the potential of a professional development program centered on case development to help urban teachers: (a) integrate technology with content and pedagogy and (b) cultivate habits of reflection required to learn from practice. Qualitative analysis revealed that case development helped teachers develop an understanding of the nuanced relationships among technology, content, and pedagogy and engage in the type of reflection that enables learning from practice. Nevertheless, variability existed in the ways that teachers applied new knowledge to practice. Factors that influenced teachers' learning and practice included beliefs about students, prescribed curricula, and lack of resources. (Keywords: professional development, technology integration, urban teachers)

Effective use of technology in teaching is an essential skill for teachers because it can help make complex subject matter ideas more accessible to students while preparing them for the demands of the modern technological workplace and the reality of their future (U.S. Department of Education, 2010). The need to equip students with the technology skills required in their future lives is particularly crucial in urban schools and communities in order to foster greater diversity in the field of information technology and widen the potential sources of employment for disadvantaged students (Tettegah & Mayo, 2005). Nevertheless, evidence indicates that teachers' integration of digital tools into instruction remains sporadic and less than optimal (Ertmer & Ottenbreit-Leftwich, 2010).

The limited and mostly low-level (e.g., word processing, Internet research) uses of technology in teaching can be largely attributed to the shortage of high-quality professional development (PD) programs available to teachers (Lawless & Pellegrino, 2007). Many technology PD programs are still short term and focus primarily on technical skills required to use specific software packages (see NCEE, 2007). This approach to PD has been criticized as ineffective because it leads to the accumulation of "inert facts," as opposed to knowledge integration or flexible application of technology to classroom practice (Mishra & Koehler, 2006). To help teachers acquire

a deeper understanding of using technology, we need to develop higher-quality PD programs that situate technology knowledge within content and pedagogical knowledge (Mishra & Koehler, 2006).

In recent years, researchers emphasized that some of the most powerful PD opportunities available for teachers are grounded in the systematic study and analysis of classroom practice (Ball & Cohen, 1999; Lampert, 2010). A specific pedagogical strategy that engages teachers in the systematic study and analysis of classroom practice is case development (Darling-Hammond & Hammerness, 2002; J. Shulman, 2002). Case development allows teachers to design, enact, and reflect on teaching experiences from their own classrooms in order to construct records of practice that they could share with other teachers. Advocates for this approach argue that the process of reflection and analysis can help teachers challenge previous values, assumptions, and pedagogical strategies, thereby creating a disequilibrium that enables learning from practice (J. Shulman, Whittaker, & Lew, 2002). At the same time, it can help teachers cultivate intellectual capacities and dispositions required to continuously inquire and learn in and from practice (Ball & Cohen, 1999). Yet evidence is remarkably lacking regarding the ways teachers may enhance their knowledge and practice of technology integration through such PD experiences.

This work investigates the potential of a PD program centered on case development to help teachers develop their strategic thinking and knowledge of when, where, and how to use technology with content and pedagogy (Niess, 2010). The conceptual foundation of this work (see Figure 1) builds on the hypothesis that we can support teachers in learning to teach with technology by providing opportunities to study and reflect on their own classroom experiences and those of their colleagues through case development, discussion, and analysis.

The investigation focuses on a group of elementary teachers in three urban charter schools. A previous study had investigated this issue with a group of teachers enrolled in a graduate course on learning technologies in a U.S. university (Mouza & Wong, 2009). The current study seeks to identify the ways that case development can advance teacher learning outside the realm of a graduate course, which heavily focused on reading theory around effective technology integration. Specifically, two questions guided this work:

1. How does PD that centers on case development influence teachers' knowledge and ability to design and implement instructional practices that link technology, content, and pedagogy within their local context?
2. How does PD that centers on case development help teachers cultivate habits of reflection required to learn from practice?

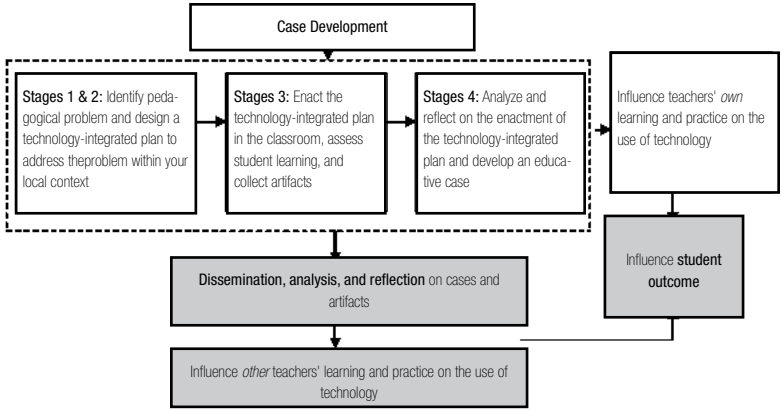

Figure 1. Conceptual framework guiding the use of case development in this work. (Note: Items in the shaded areas were not addressed in this investigation but are used to illustrate the complete hypotheses guiding the use of case development in teacher learning.)

Theoretical Framework

This work is grounded in the theoretical framework of Technological Pedagogical Content Knowledge (TPACK; Mishra & Koehler, 2006), which is used to describe teacher knowledge and skills required for effective technology integration. The TPACK framework has gained increased acceptance as a theoretical construct that helps researchers and teacher educators think about the use of technology in education (Doering, Veletsianos, Scharber, & Miller, 2009). Building on Shulman's (1986) concept of pedagogical content knowledge, TPACK consists of three primary bodies of knowledge: technological knowledge (TK), content knowledge (CK), and pedagogical knowledge (PK). TK refers to computer literacy and the ability to apply technological tools for everyday tasks (Mishra & Koehler, 2006). CK is concerned with the knowledge of the subject matter to be taught (L. Shulman, 1986). PK involves knowledge of general teaching and learning methods, knowledge of learners, and knowledge of assessment and classroom management strategies (L. Shulman, 1986). More important, TPACK emphasizes the relationships that exist among these bodies of knowledge. The relationship between technology and content results in technological content knowledge (TCK), which focuses on the manner in which technology and content are reciprocally related (Mishra & Koehler, 2006). Similarly, the relationship between content and pedagogy results in pedagogical content knowledge (PCK), which involves knowledge for teaching within a specific discipline (L. Shulman, 1986). The relationship between technology and pedagogy results in technological pedagogical knowledge (TPK), which includes the ability to identify specific pedagogical techniques and the ways they can be applied to the use of technology. Finally, the relationship among technology, content, and pedagogy results in TPACK: the ability to understand how technological tools can be combined with content and pedagogical strategies to produce

meaningful student outcomes within specific contexts (Angeli & Valanides, 2009; Mishra & Koehler, 2006).

Although TPACK builds on earlier notions of teacher knowledge, it is also a unique and intricate construct. Specifically, three characteristics are fundamental to TPACK: (a) It is highly situated, local, and specific; (b) it is developed in practice in response to specific needs; and (c) it is influenced by contextual factors, such as teachers' beliefs about how students learn, teachers' practice experiences with what works and what does not work in real classrooms, the availability of resources, culture, and other organization factors (Angeli & Valanides, 2009; Kelly, 2008; McCrory, 2008).

Although the TPACK framework provides a theoretical model of teacher knowledge, it does not elucidate ways of developing, assessing, and measuring TPACK within teacher PD settings. This work contributes to the literature on how the TPACK framework can be used as a lens for designing PD experiences for teachers on the use of technology. It also demonstrates ways of deploying the TPACK framework in efforts to examine and measure the impact of PD on teacher learning and practice.

Literature Review

TPACK Building and Case Development

The educational community has only recently begun to explore ways we can help in-service teachers build and use knowledge with regard to technology using TPACK as a theoretical foundation. Harris and her colleagues, for example, have proposed the use of an activity-based, curriculum-keyed approach to planning instruction that integrates technology and teaching strategies (Harris, 2008; Harris & Hofer, 2009). Niess (2010) experimented with the design of electronic portfolios within a virtual community of mathematics and science teacher-learners pursuing a graduate degree. Doering et al. (2009) tested a geography-focused PD program for the use of an online learning environment on social studies teachers' metacognitive awareness of TPACK. This work contributes to this growing body of literature by investigating the efficacy of a PD program centered on case development. An added advantage of this work is that it focuses explicitly on urban teachers, who are often less likely to be adept in their use of technology than their suburban peers (Lawless & Pellegrino, 2007).

Case development represents a promising approach to TPACK development because it is consistent with contemporary understandings of what makes PD effective. Recent empirical work, for example, indicates that PD programs designed with proximity to practice in mind are more likely to foster changes in teacher learning, classroom practice, and student outcome (Penuel, Fishman, Yamaguchi, & Gallagher, 2007). Case development allows teachers to situate learning directly into their practice by analyzing and reflecting on teaching episodes from their own classrooms. These episodes

are seamlessly connected to the curriculum, address goals and needs that matter to teachers, and utilize resources available in their local context. In this sense, PD becomes an activity that is part of daily practice, reflecting the physical and social systems in which teachers work (Putnam & Borko, 2000).

In addition to positioning learning directly into classroom practice, case development encourages teachers to develop skills and dispositions required to continuously analyze and reflect on their experiences. Given the range of tools available and constant advances in technology, a reflective expectation with each experience is essential to the development of TPACK (Niess, 2008). In particular, reflection is important for two reasons. First, it forces teachers to improve the lesson, strategies, and assessment used within specific teaching episodes. Second, it helps teachers learn from their own experiences with technology and the ways they can support their students' learning (McCrory, 2008).

The literature on teacher reflection, however, emphasizes that not all reflection is equally valuable. In particular, it distinguishes between descriptive reflection and critical reflection (Davis, 2006; Loughran, 2002). Whereas, in descriptive reflection, teachers primarily recall and describe their experiences, in critical reflection teachers look for relationships between pieces of their experiences, form hypothesis about why events occurred as they did, analyze their experiences from multiple perspectives, generate alternatives, and make connections between specific teaching events and the broader theoretical principles they represent (Hatton & Smith, 1995; Lee, 2005). Although descriptive reflection is valued in case development for helping teachers provide rich descriptions of classroom events, the emphasis is on critical reflection, which can help teachers improve their future uses of technology and learn how to learn about teaching with technology (McCrory, 2008).

Teachers and Technology in Urban Schools

Many high-need urban schools not only have inadequate technology infrastructure but also experience increased challenges in recruiting and retaining qualified teachers (Ingersoll, 2004; Wells & Lewis, 2006). As a result, these schools are often forced to fill vacancies with teachers who may be less prepared to teach (Darling-Hammond, 2000, 2006). This issue becomes more complex in charter schools, because they are often exempt from collective bargaining rules that govern teacher hiring policies in public school systems (Carruthers, 2009).

Teachers who are not adequately prepared to teach are also less likely to be adept at integrating technology in instruction (Solomon & Allen, 2003). Greenhow and her colleagues (2009), for example, found that low-income students' experiences deal mainly with simpler communication and presentation technologies. As a result, these students often perceive their role as consumers and not producers of digital content. Similarly, comparing the use of technology among low- and high-socioeconomic status (SES) schools,

Warschauer, Knobel, and Stone (2004) provided evidence of greater emphasis on research and analysis in the high-SES schools and greater use of technology for remedial literacy and numeracy in low-SES schools. Further, high-SES schools were more likely than low-SES schools to invest in teacher PD, hire full-time technical support staff, and develop lines of communication among school personnel. In turn, these practices encouraged more widespread and rigorous teacher use of technology.

These findings parallel earlier large-scale survey studies that also indicated that students in low-income urban schools are more likely to use computers for routine skill practice and are less likely to use computers for higher-order thinking tasks (e.g., doing analytic work, revising and publishing text, engaging in exploratory activities) (Becker, 2001; Wenglinsky, 1998). At the same time, use of technology for higher-order thinking tasks was associated with higher academic outcomes (Wenglinsky, 1998).

This study examines how participation in PD that emphasizes the connections among technology, content, pedagogy, and teaching context can help urban teachers leverage technology resources to create higher-order learning experiences for all students.

Process of Case Development

The process of case development was embedded in the context of a long-term university-based PD program that extended from June through December. The program was funded through the State Department of Education and aimed at using technology to improve teacher quality and student learning in high-need schools. Initially, all teachers attended a summer institute during the month of June in which they learned about and experienced a variety of technology tools that they could integrate into the various disciplines. The summer institute operated daily for three hours over the course of one week. Each daily meeting started with an introduction and demonstration of some computer tool/application (e.g., concept mapping, digital images and presentation software, spreadsheets, and Internet-based strategies). Subsequently, it continued with hands-on activities and/or collaborative work. Finally, it concluded with a discussion of the implications that demonstrated applications have on teaching and learning, particularly within the participants' own classroom context. This series of activities aimed at helping teachers build both their technological literacy and understanding of how certain tools can be linked to specific content and pedagogical strategies. All participants received personal copies of the technology tools introduced during the summer institute to facilitate application of learning into practice (although, unfortunately, copies of spreadsheets did not arrive until the end of the PD program).

Upon completing the summer institute, teachers engaged in the process of case development. This process progressed incrementally over four stages (see also Figure 1, p. 3). In the first stage (June), teachers identified a

pedagogical problem from their classroom, such as a topic that has proven difficult for teachers to teach and for students to learn. Subsequently, they considered ways that technological tools explored in the summer institute can offer solutions to this problem.

In the second stage (July through August), teachers developed a technology-integrated plan to address the problem identified in the first stage. Each plan was consistent with academic standards in core subject areas and technology standards for students (i.e., ISTE's NETS). In most instances, each plan contained a series of lessons based on a range of technology-enhanced, traditional, and other hands-on activities. To facilitate the development of complete plans, teachers received a template as well as feedback from members of the PD team. The template asked teachers to include information on the implementation context, learning objectives, content and technology standards, required resources, specific series of teacher/student activities, and assessment procedures.

In the third stage (September through October), teachers enacted their technology-integrated plans in their classrooms and collected relevant student artifacts. During that time, teachers also attended monthly meetings where they discussed successes and challenges associated with the implementation of their plans and brainstormed solutions with their colleagues.

Finally, in the fourth stage (November though December), teachers wrote a case based on the cycle of preparation, enactment, and reflection of the technology-integrated plan in their classrooms. Following established guidelines for case development (see Hammerness, Darling-Hammond, & L. Shulman, 2002), case reports were divided into two sections: (a) case narrative and (b) case analysis and reflection. In the case narrative, teachers were given a series of writing prompts that asked them to provide information on the context in which the technology integration plan was implemented, the pedagogical problem addressed, the learning goals, the intentions of the plan, and the learning and teaching events that unfolded. In the analysis and reflection section, teachers were given a series of reflection prompts that asked them to analyze different aspects of their practice, provide arguments on why events unfolded the way they did, and offer advice to other teachers based on what worked well, what developed poorly, and things they would change in the future to improve their use of technology. Providing a series of writing and reflection prompts was critical for helping teachers focus their analysis and develop a set of coherent cases. Each case was accompanied by a collection of student artifacts.

Methods

Participants

Participants included eight teachers from three urban charter schools (the State Department of Education identified qualified schools based on federal

Table 1. Characteristics of Teacher Participants

Name	No. of Years Teaching	Educational Background	Grade Level/ Subject Area	No. of Computers Available
Creative Academy Charter School				
George	3	BA in Elementary Education	5	5
Beth	2	BA in Liberal Studies MA in Elementary Education	1	4
Amir	22	BS in Psychology	K–5: Computers	Computer Lab
Explorers Charter School				
Anaya	8	BA in Fine Arts	5: Reading	2
Lisa	1	BA in Elementary Education	1	3
Beatriz	14	BA in Business Administration	1–8: Spanish	0
Jennifer	6	BA in Elementary/Special Education	1	2
Discovery Charter School				
Tanya	5	BA in TV Production MA in Elementary Education	K	1

policies): Creative Academy Charter School, Explorers Charter School, and Discovery Charter School (pseudonyms). Creative Academy served 243 students in grades K–5, whereas Explores and Discovery served 833 and 559 students respectively in grades K–8. All schools served predominantly African-American students, the majority of whom (70–90%) were classified as low income.

Participants had different teaching experiences and backgrounds and taught in different grade levels (see Table 1). Further, all teachers had limited access to technology in their classroom. At Creative Academy, teachers had access to a laptop cart that they could reserve and use for instructional purposes, but the laptops were dated and not equipped with contemporary software. At Explorers and Discovery, teachers had access to computer labs, but those were used primarily for teaching computer literacy and were typically unavailable unless reserved weeks in advance.

A total of 12 teachers initially enrolled in the PD program and attended the summer technology institute. Of those teachers, only 8 completed the program and submitted cases reflecting on their technology-integrated experiences. This study includes all 8 teachers who completed the program.

Data Sources

The primary data source used in this study was an examination of teachers' case narratives. According to Bartell (1990), written cases represent "rich, descriptive data viewed from an insider's perspective and lending a degree

of understanding which cannot be achieved in any other way" (p. 82). The literature on the development of TPACK also argues that, to measure teachers' knowledge over time, we need to include descriptions of why a teacher created a learning environment; what he/she was thinking in the process of planning, organizing, and implementing the activities; and why he/she chose to follow certain actions over others (Leatham, 2008). Teaching cases, therefore, provide an excellent data source for examining TPACK development, because they clearly describe teachers' planning, thinking, and reflective processes and provide rich descriptions of the instructional context in which activities are implemented. The average word count for each case was 2,084 words.

To triangulate data from teacher narratives, the author used several other data sources. First, the author observed each teacher on at least one occasion during the implementation of his/her technology-integrated plan and kept detailed notes. Second, the author observed all teachers during their participation in PD. These observations provided a picture of teachers' TPACK at various stages and the opportunity to understand their thoughts, beliefs, and ideas over time. Third, all teachers completed a two-part survey both at the beginning and end of the PD program. The first part of the survey was designed to document changes in teachers' TK. It included a range of technological skills within the following areas: word processing skills, graphics and presentation skills, spreadsheet and database skills, e-mail and Internet skills, and networking and computing skills. For the second part of the survey, the author used Teachers and Technology: A Snapshot Survey (Norris & Soloway, 2000) to investigate teachers' needs and uses of technology in the classroom. Finally, the author administered a questionnaire including a series of open-ended questions to all teachers in December. The questionnaire asked teachers to discuss the ways (if any) that PD enhanced their understanding of using technology with content and pedagogy. It also asked them to identify the most valuable aspect of the PD program.

Data Analysis

Coding and analysis for research question #1. The author analyzed data from each source using different strategies. The author analyzed survey data using descriptive statistics to illustrate changes in teacher technological competence and needs over time. The author examined teacher narratives through the methodology of verbal analysis (Chi, 1997). Verbal analysis is a methodology for analyzing qualitative data in a quantifiable way by tabulating, counting, and drawing relations between the occurrences of different kinds of utterances into the data. The goal of verbal analysis is to capture and represent the kind of knowledge one gains from learning. In this work, verbal analysis was used to capture and represent teachers' TPACK.

The process of verbal analysis progressed in two stages. First, the author repeatedly read case narratives and segmented them based on when a teacher raised a new issue about the implementation of his/her technology integration plan. Subsequently, the author used an a priori coding scheme developed through the literature as well as earlier empirical studies to identify and categorize the type of knowledge exhibited in each segment (Graham, Borup, & Burgoyne, 2010; Mouza, 2009; Mouza & Wong, 2009). Table 2 illustrates this coding scheme.

Identifying and representing TPACK is admittedly challenging because the boundaries between and among each of the knowledge domains described in the TPACK framework are still quite fuzzy (Angeli & Valanides, 2009; Archambault & Barnett, 2010; Cox & Graham, 2009). Further, recent conceptualization of TPACK indicates that TCK cannot exist in the context of teaching, as all teaching requires some type of PK (Cox, 2008; Graham et al., 2010). Thus, rather than focusing on all seven domains described in the TPACK framework, this work focuses only on technology (TK) and its relation to pedagogy (TPK) as well as content and pedagogy (TPACK). Those domains were the ones the PD explicitly targeted and, therefore, were more likely to exhibit growth. The PD program, for example, did not seek to directly influence CK, general PK, or PCK, as it included teachers from various content areas. Rather, the central focus of the PD was to help teachers bring the areas of technology, content, and pedagogy together as one knowledge base.

Using the coding scheme presented in Table 2, the author and a research assistant independently coded case narratives. In previous work, data were not explicitly coded for evidence of TPACK (Mouza & Wong, 2009). Rather, only constituent TPACK components were coded consistent with the idea that shifts in individual knowledge bases also suggest gains in TPACK (Doering et al., 2009). In this work, the author considered those individual knowledge bases that teachers are more likely to lack, such as TK and TPK, but the coding also explicitly addressed TPACK as a distinct knowledge construct that is more than the sum of its parts (Angeli & Valanides, 2009). Inter-rater reliability was initially 76%. Raters discussed all differences and resolved them through consensus by looking at the overall context in which statements were made in teacher narratives. Once all data were coded, the author calculated percentages to quantify emergent patterns.

To establish a clear connection between case development and teachers' TPACK, the author reviewed case narratives and teacher questionnaires with an eye toward identifying passages that discussed (a) the impact of case development on teachers' ability to integrate technology, content, and pedagogy and (b) the contextual factors that influenced teachers' learning and practice. Finally, the author used classroom and PD observations to triangulate findings from case analysis and situate teacher learning in the larger context in which they worked.

Table 2. Coding Scheme Representing Teacher Knowledge

Technology Knowledge (TK)
Evidence: Operating computer hardware Using standard software tools (e.g., MS Word, PowerPoint, Internet browsers, e-mail) Installing and removing peripheral devices (e.g., USB drives, microphones) and software Troubleshooting equipment Using appropriate vocabulary (e.g., technology terms)
Technological Pedagogical Knowledge (TPK)
Evidence: Motivating students through technology Differentiating instruction when technology is used Ability to organize collaborative work with technology Holding students accountable for equipment used Developing strategies for assessing student work with technology Knowing about the existence of a variety of tools for particular tasks Knowing about the time required to teach with particular technologies Ability to envision potential student problems with particular technologies and plan relevant activities to support those students Generating alternatives in the event of technological failures Ability to explain a computer procedure to students (e.g., through modeling)
Technological Pedagogical Content Knowledge (TPACK)
Evidence: Use of technology to facilitate subject-specific pedagogical methods (e.g., science inquiry, primary sources in social studies, etc.) Use of technology to facilitate content representation Use of technology to address learner content understanding (e.g., prior content knowledge, address misconceptions, improve content understanding)

Coding and data analysis for research question #2. The second question examined whether teachers exhibited skills needed to reflect on their teaching with technology and learn from their practice. To accomplish this, the author repeated the verbal analysis process described above. Specifically, the author read case narratives again with an eye toward habits of reflection that the teachers exhibited. Instances where teachers simply recalled or described their experience with technology integration without looking for alternative explanations were coded as descriptive reflection. Instances where teachers exhibited one or more of the following elements of effective reflective practice described in the literature were coded as critical reflection: (a) hypothesizing about why events occurred as they did, (b) questioning assumptions, (c) providing evidence for claims, (d) analyzing experiences from multiple perspectives, (e) generating alternatives for future practice, and (f) making connections between teaching events and broader theoretical principles (Davis, 2006; Hatton & Smith, 1995; Lee, 2005).

The author and a research assistant independently coded each case narrative. Inter-rater reliability was initially 85%. The raters again discussed differences until reaching 100% agreement in coding. The author completed analysis for each individual teacher while comparing data with those of other teachers to identify similarities and differences and to detect patterns of reflection that cut across all cases. The author also used data from written

Table 3. Teacher Technology Skills

Topic	Number of Questions	Initial Survey Mean Score*	*SD*	Follow-Up Survey Mean Score*	*SD*
Word Processing Skills	12	2.9	0.18	3.0	0.00
Graphic and Presentation Skills	14	2.0	0.60	2.6	0.56
Spreadsheet and Database Skills	17	1.9	0.54	2.1	0.48
E-mail and Internet Skills	10	2.7	0.46	2.8	0.49
Networking and Computing Skills	11	2.7	0.33	2.9	0.33

**1 = No familiarity with this skill, 2 = Can accomplish with some stumbling or with help, 3 = Can accomplish with ease*

Table 4. Teacher Needs (Teachers and Technology: A Snapshot Survey)

Question	Initial Survey Mean Score*	SD	Follow-Up Survey Mean Score*	SD
Technology Needs				
Need access to more computers for my students	4.00	0.93	3.50	1.51
Need more access to the Internet	3.25	1.58	2.50	1.51
Need more software that is curriculum based	4.37	0.91	3.50	1.50
Need more technical support to keep the computers working	3.37	1.59	2.67	1.50
Pedagogical Needs				
Need more training with technology	3.87	0.99	2.67	1.36
Need more training with curriculum and pedagogy that integrates technology	4.00	0.93	3.00	1.09
Need more resources that illustrate how to integrate technology into the curriculum	4.00	0.75	2.50	1.22
Need more compelling reasons why I should incorporate technology into the classroom	1.75	1.16	2.17	1.33
Need more time to learn to use computers and the Internet	3.00	1.07	1.83	1.33
Need to be able to try out technology-enhanced curriculum units in my classroom before I am comfortable with them	3.25	1.39	2.83	1.47
Need more time to change the curriculum to better incorporate the technology	3.25	0.70	2.33	1.03
Need more opportunities to work with colleagues to become more proficient using technology-enhanced curriculum units	3.75	0.88	2.50	1.22

**1= less urgent to 5 = more urgent*

questionnaires to interpret the results of the analysis and look at the ways that case development prompted reflective practice.

Findings

Research Question #1: Teacher Knowledge and Practice

The first question examined the influence of a PD program centered on case development on teachers' knowledge and ability to design and implement instructional practices that link technology, content, and pedagogy within their local context. Results presented below are organized in three sections: (a) teachers' knowledge and practice prior to PD,

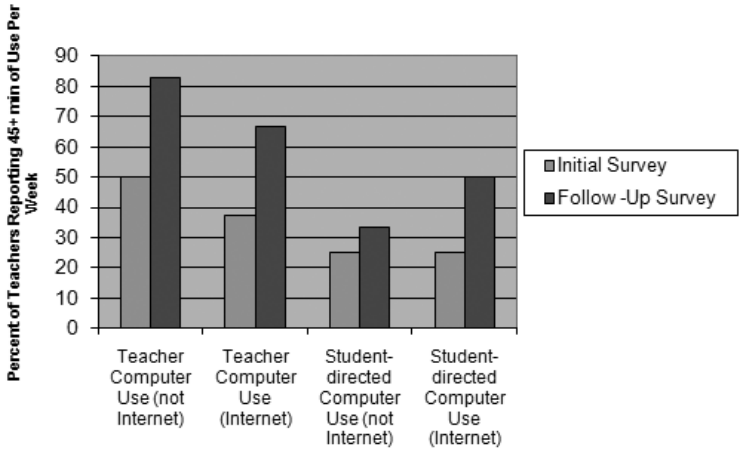

Figure 2. Teacher use of technology.

(b) teachers' knowledge and practice during PD, and (c) factors influencing transfer of learning into practice.

Teachers' knowledge and practice prior to PD. To gain a better understanding of the ways that case development can facilitate teacher learning, it is important to look at teachers' knowledge and capacity for using technology with content and pedagogy prior to their participation in PD. Data collected at the beginning of the PD program indicated that most teachers were fairly comfortable with technology bud did not make substantial use of it in their classroom. Table 3 demonstrates teacher competence in basic computer and Internet skills (TK). As shown in Table 3, most participants felt comfortable using word processing, Internet, e-mail, networking, and other computing skills. In these areas, the mean score was well above 2, which indicates that teachers were able to perform the majority of the tasks either with some help or with ease. Results also indicated that teachers needed help using graphics and presentation software as well as spreadsheets.

When asked about their actual use of technology in the classroom, most teachers acknowledged that they had minimally integrated technology in their teaching (see Figure 2). Even when they did implement technology, they often used it in teacher-directed ways and not in support of meaningful student-centered instruction. The limited and mostly low-level use of technology in teaching was largely attributed to the lack of technological and pedagogical resources and support in their schools. Table 4 shows teacher needs in those areas.

Teachers' knowledge and practice during PD. Results from case narratives and teacher surveys indicated that case development provided a fruitful context for helping teachers improve their TK and gain a deeper understanding of the interrelations among technology, content, and pedagogy (TPK and TPACK). Nevertheless, the ways that teachers used their developing knowledge in practice varied.

Table 5. Pedagogical Problems Addressed, Technologies, and Activities in Teacher Cases

Name	Topic/Problem Addressed	Technologies	Activities
George	Promote student understanding of how European explorers shaped American history and culture	Inspiration Internet browser Web-based bookmarking site MS Word	KWL (what I Know/what I Want to know/what I Learned) for background knowledge
			Students conduct Internet research
			Students develop concept maps representing their knowledge and findings
			Students write and present a report
Beth	Cultivate students' descriptive writing skills by describing a favorite object	Digital camera	Read and discuss the book *Velveteen Rabbit*
			Students take digital pictures with their favorite objects
			Students use the digital pictures to produce descriptive writings of their favorite objects
Amir*	Promote student social responsibility by identifying ways that can promote change in the world	MS PowerPoint Internet browser	Introduce PowerPoint
			Search for images online
			Construct a presentation on ideas for social change
Anaya	Help students use visuals and diagrams to connect new and prior knowledge in reading	Inspiration Internet browser	Students define new vocabulary words by providing antonyms, synonyms and sentences
Lisa	Promote student understanding of why seasons change and how weather affects nature (yearlong project; case focused only on fall weather)	Inspiration Digital camera	Read and discuss the books *Sunshine Makes the Seasons* and *The Reasons for the Seasons*
			As a class, students brainstorm ideas on why seasons change using Inspiration
			Students take a nature walk to make weather observations and take digital pictures
			Students reconsider their Inspiration concept maps
Beatriz	Students identify that people from different cultures celebrate winter holidays	Internet browser Inspiration	Students conduct research on different holiday celebrations
			Students develop compare/contrast concept maps of various holidays using Inspiration
			Students write a report on one holiday celebration
Jennifer	Students identify characteristics of communities and productive citizens	Inspiration Digital camera	KWL for background knowledge
			Read and discuss the books *On the Town* and *Living in a Community*
			Digital pictures of the surrounding community as stimulus for discussion
			Comparing different communities
Tanya	Cultivate students' narrative writing skills through field trips and visual prompts	Digital camera	Read and discuss the book *A Day at the Apple Orchard*
			Students take a field trip to an apple orchard and take digital pictures of their choice
			Student use the pictures to produce narrative accounts of their visit to the orchard

**Amir was a technology teacher, so his role was to improve students' technological literacy.*

To illustrate teachers' developing knowledge and practice using the TPACK construct as a lens, this article presents two cases: George's and Anaya's. The author selected these cases to demonstrate differences in the ways teachers integrated their individual knowledge bases to inform teaching with technology. Subsequently, the article presents and discusses findings on all teachers' knowledge and practice.

George's case. George taught fifth grade at Creative Academy. George designed and implemented an interdisciplinary unit (English and social studies) on famous explorers who helped shape the United States and the world (see also Table 5). In the past, George taught this unit by having students read materials from a social studies text and creating paper-based timelines of major explorers and the regions they had explored. The problem, according to George, was that the text was written in language that fifth graders did not easily understand, and the timelines focused primarily on factual knowledge. To make the topic more engaging, George realized he needed a different approach that leveraged technology tools to make content more meaningful and comprehensive for students.

Initially, George developed and presented a set of guiding questions to scaffold student work (e.g., "Why would people want to leave their native land?" "What motivated explorers to go on their voyages?"). He also spent a class period familiarizing students with Inspiration, a concept-mapping software he learned about at the summer institute. He then asked students to research an explorer of their choice using the scaffolding questions as a guide. To conduct their research, students used the mobile computer cart available at the school and a collection of Internet resources that George had assembled on a Web-based bookmarking site, which he also learned about at the summer institute. As students conducted research on famous explorers, they gathered, organized, and synthesized their findings using Inspiration. Subsequently, they transferred their outlines to MS Word documents and used them to prepare written and oral reports.

To assess student work, George employed a two-pronged strategy. First, he looked at students' concept maps in terms of accuracy and organization. Second, he graded their written reports using the writing rubric used by his State Testing Program.

In this example, George demonstrates various knowledge facets. His knowledge of Web-based bookmarking sites and curriculum-based software such as Inspiration constitutes his TK. Several instances of TK were also exemplified in George's narrative as he gave instructions to students on how to use Inspiration and helped them with various technical problems. George's knowledge of how to use the Internet and Inspiration with general pedagogical strategies, such as conducting research, motivating students, differentiating instruction (e.g., every student selected an explorer of their interest), and assessing student work constitutes his TPK. Finally, George's

ability to integrate the Internet and Inspiration with content-specific activities and representations to facilitate student learning constitutes his TPACK. Throughout his narrative, George clearly explained how the use of the Internet allowed students to find information on famous explorers and examine historical documents not available in school textbooks. He also explained how Inspiration helped his students create visual representations of their research findings and facilitated the writing process by providing them with an outline. These activities are specific to social studies and language arts and demonstrate the connections among technology, content, and pedagogy.

George's case also demonstrates that students had the opportunity to work directly with the technology using the mobile computer cart. They were allowed to select their own explorers, use bookmarked sites of their choice, identify relevant information, and organize their findings using Inspiration. In the process, they were also allowed to experiment with fonts, colors, and images that helped them represent their ideas. Once their research was completed, students prepared written and oral reports with their findings. These activities illustrate a student-centered approach to technology that allowed students to engage with meaningful activities while experimenting directly with new and unfamiliar technology tools.

Anaya's case. Anaya was a fifth grade reading teacher at Explorers Charter School, where she taught primarily special education students. The technology-integrated plan she developed aimed to familiarize students with new vocabulary. She thought that technology would make this task more efficient and enjoyable.

Anaya started the lesson by dividing students into groups, which, as she explained, is a standard practice in her reading instruction. She gave each group a set of eight vocabulary words and a dictionary. Students were responsible for providing a definition as well as three synonyms, antonyms, and sentences for each word. Three students were allowed to gather information using a Web-based dictionary. As students provided synonyms, antonyms, and sentences for each word, Anaya entered the information into Inspiration to provide a visual representation that helped students link prior knowledge (e.g., synonyms or antonyms) with new words. Once all work had been completed, Anaya compiled concept maps into a booklet and gave it to students as a study guide.

In this example, Anaya's knowledge of Web-based resources and Inspiration software constitutes her TK. Her ability to use general pedagogical strategies with technology, such as organizing group work and motivating students through visuals, constitutes her TPK. Finally, her ability to repurpose Inspiration software to help students connect new vocabulary words to previous knowledge constitutes her TPACK.

Although Anaya demonstrated various facets of knowledge in this example, her implementation was drastically different from George's case. Anaya allowed her students to use only one specific website on the computer, and

she was the only one who made direct use of Inspiration. Arguably, part of the problem was access. Anaya had only one computer available in her classroom, and the school's computer lab did not have access to Inspiration at the time. Toward the end of her case, Anaya acknowledged that, in the future, she may have one of her "responsible" students use her laptop to organize class work in Inspiration.

Collective knowledge and practice. Survey results demonstrated that all teachers improved their working TK, with the greatest gains in the area of graphics and presentation (see Table 3, p. 12). This finding can be attributed to the increased use of the digital camera teachers received as part of their participation in the PD program. As teachers felt more comfortable with technology, the amount of time they spent on technology-enriched activities also increased. Figure 2 (p. 13) shows the percentage of teachers who reported using computers for a range of teacher-directed and student-directed tasks at least 45 minutes per week at the beginning and end of the study. As shown in Figure 2, a larger percentage of teachers indicated using technology tasks more frequently in their classrooms.

This shift in actual use of technology in teaching was partly expected, as teachers were required to implement the technology-integrated plan in their classrooms, but it can also be attributed to the increase in technological and pedagogical support provided during PD. Although teacher needs in those areas persisted, they were not expressed with the same urgency (see Table 4, p. 12). It is possible that, as teachers increased their pedagogical understanding of how to use existing resources in their classroom, they realized that it is not necessary for all students to be working simultaneously on the computer or the Internet. Further, as they learned how to use curricular-based software, such as concept-mapping and other Web-based strategies, their need for such resources had also decreased. In addition, as teachers became more comfortable troubleshooting minor technical difficulties, their need for more technical support diminished. Finally, given that participants received multiple opportunities to interact with other teachers, their expressed need for working with colleagues had also declined.

Results from verbal analysis of case narratives also demonstrated clear evidence of both TPACK development and its constituent elements of TK and TPK (see Figure 3, p. 18). Although there were fewer instances of TPACK than of TK or TPK, this outcome is not surprising. The pedagogy of case development asked teachers to elaborate on the implementation of their technology-integrated plan, thereby encouraging them to discuss pedagogical decisions with regard to technology more extensively than content.

In addition to demonstrating evidence of knowledge development, results from case narratives indicated that teachers were able to use their new knowledge in practice. In all cases, teachers chose to address important pedagogical problems and identified instructional activities and

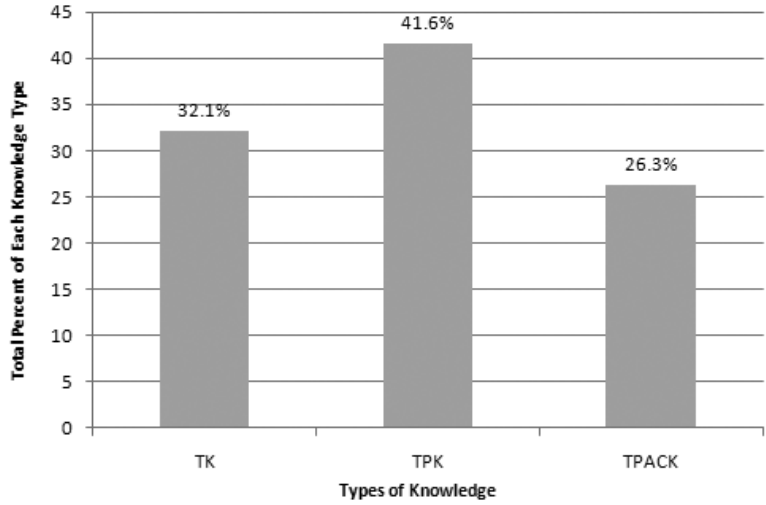

Figure 3. Total percentage of knowledge instances exhibited in teachers' cases.

technologies that could support student learning of curriculum content. Table 5 (p. 14) presents the pedagogical problems addressed in teacher cases, the technology tools they selected, and the instructional activities they designed.

Clearly, there were differences in the ways teachers used their knowledge in practice. Whereas some teachers focused primarily on teacher-directed activities that encouraged similar understandings of content, other teachers implemented a range of student-centered activities that encouraged students to develop and express their own understandings through written reports, multimedia presentations, and concept maps.

This finding is consistent with previous work by Niess, et al. (2009), who found that teachers acquire TPACK progressively and do not suddenly display this knowledge in their professional practice. In fact, using Rogers' (1995) model of the innovation-decision process, Niess et al. (2009) proposed a five-stage developmental process for teachers learning to integrate a particular technology in teaching and learning. Those stages include recognizing (knowledge), accepting (persuasion), adapting (decision), exploring (implementation), and advancing (confirmation).

Based on this framework, it appears that most of the teachers in this study remained in the early stages of TPACK development, where they could recognize the alignment of technology with curricular content (recognizing), form favorable attitudes toward teaching and learning with technology (accepting), and engage in activities that will help them adopt or reject teaching and learning particular subject matter with technology (adapting). Although teachers started implementing technology in teaching and learning (exploring), more work is required in helping them integrate technology in pedagogically rich ways (advancing).

Contextual factors influencing teacher learning and practice. Having relevant knowledge is not enough to help teachers meaningfully integrate technology with content and pedagogy. Teachers' knowledge is heavily contextual; it interacts with their beliefs and existing context, culture, and policies to create action (Angeli & Valanidis, 2009; Doering et al., 2009; Ertmer & Otternbreit-Leftwich, 2010). Evidence from case narratives illustrated that teachers' reluctance to integrate technology in complex student-centered ways was largely attributed to three factors: (a) beliefs about students' deficits, (b) prescribed curricula, and (c) limited amount of resources.

Teachers' beliefs about their students' deficits. Teacher narratives contained several examples of a deficit ideology, which consistently exhibits low academic expectations for students of color (Farkas, 1996). Asset-oriented comments related to students' positive behavioral or academic qualities were few and far between. Further, most teachers believed that the students' family contexts contributed to students' deficits, even though all schools emphasized in their mission the importance of involving parents in students' education. Lisa, for example, noted that many of her students "have a minimal home life that leaves them with many questions about life and nature." Describing the context surrounding her case, Jennifer also wrote:

> The students in my class are considered difficult to teach. They are constantly inattentive, disruptive, and impulsive. A recent school assessment also indicated that the majority of them possess poor oral language skills and auditory/visual conceptual perception. These factors make it difficult to introduce instructional activities at their grade level.

As a result of these ideas, Jennifer modified her lesson on different types of communities to start from the "basics." She introduced the notion of community and explained the characteristics of urban versus rural communities. She used a digital camera and the Internet to find relevant pictures to help students visualize these ideas, but she did not allow students to use the technology because of fear of damaging the equipment.

Similarly, Tanya indicated that kindergarten students come to her school as "blank slates," not knowing any of the alphabet letters and with minimal knowledge of the world around them. Further, she noted how kindergarten students were not allowed to use the school's computer lab because of fear that they will break the machines. Other teachers also expressed low academic expectations, characterizing their students as "aggressive, boisterous, not cooperative youth" who have "no idea or awareness of their surrounding environments." As a result, many teachers were apprehensive of letting students handle expensive technological equipment. Lisa illustrated this idea in her narrative:

> I prefaced the lesson with a discussion about the importance of using technology correctly and being mature. I was very fearful of student behavior while outside and while holding expensive equipment. Unfortunately students behaved as I had expected yet feared. They were very antsy and impatient. Students were to stand in line as we walked around and each student took a turn snapping a picture. However, this did take a great deal of time and many students lost interest once they had taken their picture.

These findings are consistent with accounts found in the literature on teaching in urban schools. Diamond, Randolph, and Spillane (2004), for example, found that teachers were reluctant to try "new things" because they feared that students would not be able to handle more innovative practices. Further, teachers tied students' difficulties to their home environments and family backgrounds, much like teachers in this study. The teacher comments presented above illustrate the belief that students' deficits are barriers to learning, and, therefore, any technology use should be introduced in a teacher-controlled environment rather than an enriched environment that encourages experimentation and inquiry. In this sense, use of technology was conditioned within the practice of "defensive teaching," a mode of teaching that is concerned with maintaining control (McNeil, 1986, as cited in Garrison & Bromley, 2004).

Interestingly, George was the only teacher who did not exhibit this deficit ideology. Although he acknowledged that his classroom consisted of a mixed-ability group of students, he saw this as an asset in that it enabled the "slower learners" to get help from the "quicker learners." Further, when students exhibited difficulty following the guiding questions he posed early in the lesson, he held himself responsible. He suggested that, in the future, he needs to revise the questions to make them more comprehensible and perhaps have students work in groups rather than individually so they can assist one another. The lack of cultural stereotyping enabled George to place more "trust" in his students. He allowed them to work on the mobile computer cart, explore different tools, and conduct their own research on the Internet independently.

Prescribed curricula. Although charter schools are often envisioned as laboratories for curricular innovation (Chubb, 2005), the study's findings demonstrated that participating teachers had very little room for variation in what and how they taught and structured their learning environment. In particular, all teachers spoke about the difficulty implementing innovative technology practices as a result of the prescribed curricula used in their respective schools. Anaya discussed this issue extensively in her case narrative. She noted that the reading program adopted in her school is highly structured, requiring teachers to select books from an assigned list and follow a "script" of what to say and do. Given the scripted curriculum and tight timeline at her school, Anaya had to come up with a

technology-integrated plan that would fit her students without forcing her to deviate much from the pacing guide. Because covering new vocabulary was part of the reading program, she chose to use Inspiration to familiarize students with new vocabulary.

Tanya discussed a similar problem. At her school, not only did they have to use a strictly scripted reading program, but all kindergarten teachers had to follow the same timeline. When she talked to her administrator about the need to deviate from this timeline in order to implement her technology-integrated plan, she was told that she needed to follow the kindergarten schedule. As a result, Tanya struggled to find time to implement her lesson in an already over-packed schedule and planned for activities that would not take up too much extra time.

Regrettably, these findings are not unique to this study. Rather, they are consistent with a national trend stemming from an increased pressure to improve test scores in urban schools. According to Sleeter (2004), "Growing pressure to follow state standards and raise test scores is draining classrooms of creativity and intellectual spark, and this seems most pronounced in schools serving large proportions of students of color or students from impoverished communities" (p. 2). The pressure to score well is particularly strong in charter schools, which must demonstrate yearly academic progress to maintain their charters.

Resources. Finally, lack of resources was definitely a hindering factor in teachers' efforts to use technology. Although two schools had computer labs, those were usually booked for computer classes and, therefore, were mostly unavailable during the day. At Creative Academy, teachers had access to a mobile computer cart, but, as noted earlier, the computers were dated and lacked access to commonly used software. Even though the teachers received some resources as part of their participation in the PD program, those resources were insufficient to engage all students productively in technology-enriched activities. Although access to technology resources is still a major issue in urban schools across the board, it is sometimes an even bigger problem in charter schools, which typically do not receive start-up funds for facilities.

Research Question #2: Teacher Reflective Practice

To promote learning from practice, interpretation and reflection on classroom experiences is essential (Kolodner, 2006). Thus, the second question examined how case development helps teachers cultivate the habits of reflection required to learn from practice. Findings from this work demonstrated that all teachers exhibited elements of both descriptive and critical reflection. Specifically, analysis of case narratives revealed that 38% of teachers' reflective entries could be categorized as *descriptive*, whereas the remaining 62% could be categorized as *critical*. Analyzing and reflecting on her classroom use of technology, for example, Beatriz noted:

> Overall the lesson went well and suited every child's needs. When I faced a child who had a special need in writing, I allowed him/her to record his/her responses. If I had to do this lesson again, I would not hesitate to do so because I feel satisfied with the outcome.

Beatriz's excerpt represents an example of descriptive reflection. Beatriz described how she felt about the lesson and its outcomes and how she was able to differentiate the lesson to address students' needs. Beatriz, however, did not offer any hypotheses as to why the lesson went well, what kinds of things she may change in the future, or how this experience was similar or different from previous attempts to cover the assigned materials. In contrast, reflecting on her use of digital cameras to support student learning, Tanya noted:

> Students did a nice job handling the camera, partly because I enforced the use of the arm strap. This worked great because it secured the camera and prevented the students from dropping it. Another great technique that helped was the use of the term the "shiny button." Students liked the term and it was a great way of reminding them how to capture their images. However, when it came to the written part of the lesson, some students had difficulty spelling out words phonetically. This actually surprised me the most, because I expected that they should be able to do a great job considering the fact that they had such a good start on letter sounds. It looks like students were able to decode sounds but they had difficulty writing the sounds. In the future I need to pay more attention on how to sound out words and how to write phonetically. On a good note, I realized that I no longer need to follow the "one size fits all" mentality that the whole kindergarten team adopts. This lesson helped me realize the importance of technology as a mindtool. In the future, I would like to include a lesson on the difference between a photograph and an illustration. I may also consider using disposable cameras to make it easier for students to snap their pictures on a timely fashion.

In the above excerpt, Tanya exhibited multiple instances of critical reflection. She not only described her activities, but she hypothesized why things went well (e.g., because students used the arm strap to secure the camera) or not so well (e.g., students had difficulty spelling out words phonetically) and generated alternatives for improving the lesson in the future (e.g., pay more attention to how to sound out words and use disposable cameras). This analysis and reflection also influenced her thinking and practice with respect to technology. She came to realize that she does not need to follow precisely the planning and timeline of the kindergarten team when she sees an opportunity to enrich student learning (e.g., through the use of technology). This is the kind of reflection that case development seeks to promote.

Absent from teacher reflections was any effort to link their ideas to larger theoretical principles as a way of making sense of their experiences. This finding is not surprising, as teachers were not required to read relevant literature on teaching with technology, except for two practitioner-oriented articles. In contrast, findings of the earlier study, conducted in the context of a graduate course, illustrated that teachers made multiple connections between their own experiences and the theoretical principles they represented (Mouza & Wong, 2009). This finding suggests that integrating relevant literature in the context of case development is crucial to helping teachers connect their experiences to a larger body of knowledge.

Nevertheless, participants appreciated the opportunity to design, implement, and reflect on their classrooms experiences with technology. When asked to report on the most valuable aspect of the PD program, the majority of teachers commented on the importance of implementing technology into their classrooms and how this experience forced them to "get out of their comfort zone," "think outside the box," "utilize new resources in their instruction," and "reflect on the outcomes of their lesson." Amir noted:

> Technology integration is part of my daily routine as a technology teacher at my school. Case development, however, allowed me the opportunity to reflect more on the outcomes of my lesson plan as opposed to just implementing the lesson and moving on.

Discussion and Conclusion

This study investigated the ways in which participation in a PD program centered on case development helped teachers bring the areas of technology, content, and pedagogy together as one knowledge base that can guide effective teaching with technology. Results demonstrated that case development enabled teachers to build connections among the different components of TPACK. What is most promising is the fact that issues related to technology did not dominate case narratives, as is typical in traditional PD opportunities on the use of technology. Rather, issues related to pedagogy, such as learners, instruction and assessment, both in relation to content and technology, were emphasized. In addition, teachers not only strengthened their ability to connect technology with content and pedagogy, but they also had an opportunity to connect their knowledge to the daily work of the classroom, albeit with different levels of success. As noted, many teachers were reluctant to implement technology in complex student-centered ways, despite their ability to design lessons that articulated the connections among technology, content, and pedagogy.

In their efforts to address teacher learning within the context of PD, Kazemi and Hubbard (2008) made a distinction between knowledge that is

possessed and knowing that is deployed in action. Learning to improve teaching (e.g., teaching with technology) entails developing both knowledge and knowing. Findings from this work demonstrated that teachers acquired TPACK—a form of knowledge required for teaching with technology—but many of them had difficulty applying it in action in innovative ways. Other researchers have also distinguished between the knowledge that teachers possess and the knowledge they use in action (Doering et al., 2009). This finding points to the need for looking more closely at the ways teachers draw on their TPACK when they interact with students. It also indicates that novice technology-using teachers may need repeated classroom experiences with technology before they can achieve a more effective correlation between knowledge and knowing. This idea is certainly consistent with the developmental process of teacher learning proposed by Niess et al. (2009) as well as earlier work in the field that articulated several stages of technology adoption (Sandholtz, Ringstaff, & Dwyer, 1997).

Clearly, the cultural and organizational context in which teachers worked also had an impact on the ways in which they applied their learning to practice. Despite the promise of reform touted by charter school advocates, those located in predominantly segregated urban areas face constraints similar to those faced by conventional public schools, such as teacher ideology, limited resources, prescribed curricula, and pressure stemming from standardized testing and charter renewal processes. These constraints leave little room for innovative thinking.

Although other researchers have also noted the important role of school context and teacher beliefs in the development and use of TPACK (e.g., Ertmer & Ottenbreit-Leftwich, 2010), this study points to the need for looking more closely into the relationship between teachers' deficit theorizing and technology use. It appears that PD efforts aimed at helping urban teachers link knowledge to classroom practice can benefit from incorporating principles aligned with a growing body of literature on culturally relevant pedagogy (Ladson-Billing, 1994). Culturally relevant pedagogy is an effective means of meeting the academic and social needs of culturally diverse students, found primarily in urban settings (Santamaria, 2009). It helps teachers learn how to recognize their students' cultural capital and construct relevant and socially meaningful pedagogical practices. Culturally relevant pedagogical strategies can potentially help teachers move from regimented uses of technology to more innovative, student-centered practices.

Despite the above, findings from this work demonstrated that case development provides a promising venue for both developing and assessing TPACK. As a strategy rooted in professional practice, case development enabled teachers to focus on authentic pedagogical problems that were directly applicable to their classrooms. Further, the reflective element

embedded in case development provided teachers the opportunity to reflect on their technology-integrated experiences. Through the reflective process, teachers brought forth a variety of issues and dilemmas that illustrated the realities of teaching with technology and highlighted the complexity of classroom interactions and teacher decisions. Finally, case development enabled teachers to create records of practice that could be shared and critiqued by other colleagues. In fact, to facilitate such sharing and critique, a Web-based learning environment called CASEwise has been developed in conjunction with this work. CASEwise integrates technological and pedagogical components to support case development, foster the dissemination of cases, and cultivate a community of teacher learners.

As far as future steps, it seems important to document the ways in which teachers who engage in this kind of practice-based PD continue to learn from their own classroom teaching through the process of analysis and reflection. Such learning is essential for continuously improving their use of technology in teaching and learning, especially in light of the rapid technological changes and advances occurring in our society. Further, as the field moves forward, it is important to demonstrate connections between TPACK growth and changes in student learning. Focusing on student learning will allow researchers to test both theories of teacher change (that PD alters teacher knowledge and practice) and theories of instruction (that changes in practice influence student outcomes), which are both necessary for advancing our understanding of how PD works (Desimone, 2009).

Finally, questions still remain about the ways the TPACK framework can inform both the design of PD programs and the methods of analyzing data to depict teacher learning and practice. Although the TPACK framework is useful for PD designers because it illuminates what teachers need to know about technology, pedagogy, and content (Harris, Mishra, & Koehler, 2009), more specific guidelines are needed for how to apply these new insights into effective PD approaches. For example, it is not clear whether we should place emphasis independently on each knowledge domain or on helping teachers bring the TPACK constituent elements into a coherent knowledge base. In this work, the researcher followed the latter approach because teachers came from different content areas and had a range of classroom experiences. In content-specific PD approaches, however, or in PD approaches for novice teachers, perhaps more explicit attention to content or pedagogy may be required. Further, researchers need to pay closer attention to the ways that classroom experiences with technology can facilitate the progressive growth of TPACK. Identifying concrete examples of the ways that teachers exhibit TPACK in the classroom at the initial and more progressive stages seems like a fruitful line of future inquiry.

Author Note

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