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TPACK Research with Inservice Teachers: Where's the TCK?

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Abstract: Researchers are increasingly exploring the development and expression of experienced teachers' technological pedagogical content knowledge (TPACK). While the majority of extant studies focus on evidence and growth of TPACK holistically, some have begun to distinguish teacher knowledge in TPACK's subdomains, including technological pedagogical knowledge (TPK) and technological content knowledge (TCK). In reviewing this literature, one pattern has become apparent: teachers' TPK is documented considerably more often than their TCK across studies that have disaggregated results according to these subdomains. This paper reviews the studies that together illustrate this trend, offering potential explanations and suggestions for further investigation.

Since the appearance of the technological pedagogical content knowledge (TPACK) framework (Mishra & Koehler, 2006), more than 500 TPACK-based studies of teachers' technology integration knowledge have been presented and published. The majority of these studies have focused upon development of preservice teachers' TPACK. Increasingly, however, researchers have begun to explore how this knowledge develops with inservice teachers. Given experienced teachers' greater familiarity with teaching and curriculum, the nature and acquisition of their technological pedagogical (TPK), technological content (TCK) and technological pedagogical content (TPACK) knowledge are distinct from that of their more novice colleagues in many ways.

Although many studies do not seek to distinguish among teachers' knowledge in TPACK's subdomains—technological (TK), pedagogical (PK), content (CK), pedagogical content (PCK), technological pedagogical (TPK), and technological content knowledge (TCK) —TPACK scholarship within the past two years has begun to examine these related, but arguably distinct, aspects more closely. Some of this work has debated the external consistency of many of the subdomain constructs (e.g., Archambault & Barnett, 2010; Lux, 2010); more has suggested alternate ways to conceptualize and represent TPACK (e.g., Angeli & Valanides, 2009; Cox & Graham, 2009; Niess, 2011; Robertson, 2008). Even as this refinement of the construct continues, one pattern has already become apparent: *teachers' TPK is documented considerably more often than their TCK across studies that have disaggregated results according to TPACK's subdomains.*

Why might this be so? What does this pattern of results suggest for future TPACK research? To address these questions, we will first review the studies that together illustrate this trend.

Studies of Experienced Teachers' TPK & TCK

Of the twelve studies located in late 2011 that explored experienced teachers' TPACK, nine focused on teachers' knowledge during or after engaging in professional development experiences. Only one examined teachers' learning during university coursework related to TPACK. In a study of five classroom teachers enrolled in a graduate course on cognition and technology, Mouza & Wong (2009) explored writing action research-like technology integration cases as a means to build participants' TPACK. Following an analysis of the cases the teachers wrote, their course-related online discussions, and interviews conducted with each individually, the researchers concluded that though all participants developed their TPACK, the greatest change manifested within the teachers' PK. Specifically, development of the teachers' TPK was more prevalent than growth in their TCK.

The majority of the studies of experienced teachers that distinguished between TPK and TCK focused upon content-specific professional development efforts taught outside of university coursework. In science education, for example, Graham, Cox, & Velasquez (2009) reported on a pre/post study of fifteen elementary through high school classroom teachers during a university-based professional development experience focused upon content, inquiry-oriented pedagogy, and educational technologies. Participants completed a 31-item TPACK confidence questionnaire that focused on TK, TPK, TCK, and TPACK. The participants reported significant increases in all four areas. Of the four domains measured, however, TCK had the lowest mean.

In a study of ten mathematics teachers participating in a four-week summer professional learning experience designed to help them to develop their TPACK through the use of spreadsheets, Niess, Lee, Sadri, & Suharwoto (2006) analyzed pre/post questionnaire responses, course assignments, journal entries, observation notes, and peer teaching feedback. The authors reported that the participants noted TPK development primarily. In only one case did a participant reference using TCK-related knowledge that resulted from participation in the professional development experience. In a similar study of two elementary mathematics teachers' learning from a 30-hour summer professional development experience, Polly (2011a) drew upon interviews and classroom observations to gauge the growth of teachers' TPACK. He reported that both teachers were confident in their CK, PCK and TPK, but that they reported needing additional TCK and TPACK development.

In social studies education, Harris & Hofer (2011) explored the TPACK growth of seven classroom teachers during a university-based curriculum development project. Through an analysis of pre/post interviews, unit plans, and written reflections, the authors noted that participants' knowledge development focused primarily on TPK-related concerns, with comparatively little emphasis on TCK, despite the reported primacy of curriculum content during the teachers' instructional planning. Swan & Hofer (2011) arrived at similar conclusions in their study of eight secondary economics teachers following a summer professional development experience in which participants explored ways to integrate podcasting into their teaching. After analyzing project plans, structured reflections, interviews and classroom observation notes, the authors reported that participating teachers demonstrated strong TPK in planning and implementation, but only limited TCK. Even after direct prompting, only one of the participants was able to offer a TCK-based rationale for their instructional design.

Two studies examined a mentoring model for TPACK development. Shafer (2008) reported on a year-long, one-on-one apprenticeship experience with a math teacher that focused on integrating use of *Geometer's Sketchpad* in her classroom. Through an analysis of field notes, classroom observations, and an exit interview, Shafer reported almost exclusively on the teacher's growth in TPK, despite the mathematics content focus of the work. In another study of an individual mathematics teacher's efforts to integrate use of a content-specific digital tool—the TI Nspire graphing calculator—into classroom instruction, Özgün-Koca, Meagher, & Edwards (2011) analyzed the teacher's reflective journals, classroom observation notes, and instructional materials, finding much more evidence of TPK than TCK development. They note that the teacher's "TCK did not come into play that much during this specific experience, and this domain [did] not … develop to a great extent" (p. 222).

Another two studies explored teachers' existing practice regarding technology integration knowledge, rather than differences that emerge following professional development or coursework. Richardson (2009) designed her dissertation study to determine how teachers draw upon their TPACK in planning and implementing technology-enhanced classroom lessons. In her interpretivist study of twelve fifth, sixth, and seventh grade teachers, she determined that each domain of TPACK was evident in their practice. Through an analysis of interviews, observations, and planning documents, Richardson concluded that despite the evidence of each TPACK subdomain in the participating teachers' thinking, TPK took precedence, while TCK was "the weakest area of knowledge reported" (p. 133). Also seeking to understand veteran teachers' knowledge for technology integration, Hervey (2011) designed a two-phase dissertation study in which 81 secondary teachers first self-assessed their TPACK using Schmidt, Baran, Thompson, Mishra, Koehler & Shin's (2009) self-report survey. From these respondents, Hervey identified six teachers, two of whom reported particularly strong TCK, TPK and TPACK, respectively. She then developed case studies for each of the six teachers, using videotapes of classroom instruction, stimulated recall activities, semi-structured interviews, and observational field notes. Though the six participants reported drawing upon all three domains of knowledge in their instructional planning and implementation, analysis of their survey responses indicated slightly lower levels of self-reported TCK when compared with TPK and TPACK.

Only two of the twelve studies located that examined experienced teachers' TPACK via the construct's subdomains reported results *other than* the predominance of TPK over TCK. Polly (2011b) provided fifth- and sixth-grade teachers with thirty hours of instruction to assist them in developing technology-rich instructional materials to support higher-order thinking tasks for students. Following limited classroom implementation of the materials, Polly interviewed the fourteen teachers, coding their comments according to the subdomain of TPACK represented in each. Interestingly, TCK-coded responses were the third most frequent (16.34%), following only TK (26.12%) and CK (17.65%). By comparison, TPK codes represented only 5.23% of responses. Somewhat similar results were obtained with teachers of even younger children. Chuang and Ho (2011) adapted the Schmidt et al. (2009) survey by translating it into Chinese and adding items to address early childhood teaching. After conducting a pilot test of the revised instrument to ensure validity and reliability, 335 early childhood teachers in Taiwan completed the survey. The researchers found that the teachers' self-reported TK and TCK (but not TPK) correlated with the amount of time they reported using digital technologies in their teaching. Specifically, those participants who reported using technologies in their teaching for at least 20 hours per week had significantly higher self-reported TK and TCK than those who used technology for fewer than 5 hours per week. However, time spent using technology in the classroom was *not* correlated with higher levels of self-reported TPACK.

These twelve studies demonstrate that the participating teachers drew upon multiple subdomains of TPACK knowledge as they thought about, planned for, and implemented technologically integrated teaching. Most of the studies also found that teachers were able to build their TPACK in documentable ways. Yet with only two exceptions, it appears that the teachers' TPK was more fully developed and/or more frequently displayed than their TCK. It is unclear why this is so. In the following section, we offer both suggestions for why demonstrated and self-reported TCK may lag behind TPK, and tentative recommendations for future TPACK research efforts that we hope will explore these particular aspects of teachers' technology integration knowledge.

Discussion

As we began our literature search, we noted that the majority of studies of experienced teachers' TPACK do not discuss the expression or development of TPK or TCK separately. In most studies, researchers focus their analysis and discussion around the integrated knowledge represented by the TPACK construct. This may be due, in part, to the challenges involved in teasing out particular domains of applied knowledge that are interdependent (Mishra & Koehler, 2006) within a larger and more complex framework. Some researchers even go so far as to suggest that some or all of TPACK's postulated subdomains of knowledge may not exist in practice. Archambault & Barnett (2010), for example, were able to identify only TK in their study of almost 600 K-12 online teachers. Lux (2010) was not able to identify TCK in the data generated to test his TPACK survey. Robertson (2008) used a theoretical argument to determine that TCK does not exist in the pragmatic application of teachers' technology integration knowledge:

> ...the astute will notice that this modified model purports there is no such thing as an educationally-important "TC:" one cannot have meaningful expressions of technological content in education
> without first having a specific set of students, goals, and environment in mind (pedagogy). (p. 2219)

In those studies that *do* attempt to isolate and describe knowledge in each of TPACK's subdomains, however, TPK is considerably more evident than TCK in explorations with experienced teachers. Assuming that these results are accurate, why might this be so? At least five possible explanations can be suggested.

1. *Practicing teachers may focus more of their attention upon pedagogy than content, therefore being more aware of technological pedagogical (TPK) than technological content knowledge (TCK).* This may be particularly true as they participate in technology-focused professional development efforts. In the Swan and Hofer (2011) study, for example, the technology choice (podcasts) was pre-determined. It fell to the teachers then to find ways to integrate this technology in their instructional practice. This may explain the focus on TPK-related thinking displayed by the teachers. This same emphasis on TPK was also reflected in the other studies conducted in the context of educational technology professional development experiences.

2. *Experienced teachers may unknowingly include their technological content knowledge within their content/curriculum knowledge*, since, as Deng (2007) and others have indicated, school curricula are not

comprised primarily of disciplinary (or "content") knowledge. Instead, school curricula are situated, applied constructions existing almost exclusively within school environments. Teachers may, for example, accept the use of the primary source documents available digitally online in secondary-level history classes as a part of the curriculum for which they are responsible. Indeed, multiple curricula are beginning to be written to specify use of particular technological tools (e.g., MSDE, 2006).

Recent analyses of Shulman's PCK construct (e.g., Henze, van Driel, & Verloop, 2008; Park & Oliver, 2007) have similarly suggested that teachers' knowledge of students is encompassed within their PK and PCK. In this conceptualization, knowledge of educational uses for technologies is also incorporated within PCK.

3. *Similarly, inservice teachers' technological content knowledge (TCK) may be a subdomain of their pedagogical content knowledge (PCK),* given the curriculum-specific nature of tools such as graphing calculators, scientific probeware, and historical primary source documents. In this sense, the tools and resources become curricular materials similar to textbooks, data sets, collections of documents, and other "thinking tools."

4. Professional development in technology integration is still largely technocentric (Harris, Mishra & Koehler, 2009) and focused upon use of general-purpose technologies, rather than content-specific implementations. Given this emphasis and its 30-year history, *teachers may be focusing more upon "how to teach with the tools" rather than "what to teach with which tools" out of habit.*

5. *Many of the teachers who participated in these studies may either not have access to a sufficient variety of tools from which to choose for use in their teaching, or may be unaware of many of the content-specific ways in which general productivity tools can be used instructionally.* Either or both of these reasons could cause less identifiable TCK to be used in a teacher's plan.

Suggestions for Future Research

While some suggest that attempting to tease out TPK and TCK in research about teachers' practice is difficult if not impossible, we argue that findings from those studies that do focus on these subdomains can be helpful in both understanding teachers' technology integration practices and in identifying opportunities for targeted professional development experiences.

However, different researchers have defined TCK differently, and this presents a considerable challenge. For example, in their seminal article on TPACK, Mishra & Koehler (2006) define TCK as "…knowledge about the manner in which technology and content are reciprocally related. ... Teachers need to know not just the subject matter they teach but also the manner in which the subject matter can be changed by the application of technology" (p. 1028). In contrast, Polly (2011a) defines TCK as "knowledge about how technology aligns to various [curriculum] concepts" (p. 40). In their study of TPACK development in science, Graham, Cox, & Velasquez (2009) suggested that "TCK in science represents knowledge of the technologies and representations that are relevant to functioning within a scientific domain" (p. 74). These different conceptualizations of TCK – and the ten more identified by Cox (2008) – undoubtedly lead to inconsistencies in research findings. It is possible that with a more concrete and applied definition of TCK, future studies may be better able to identify, describe, and measure how teachers think about technologies vis-à-vis curriculum content.

It is also possible that some of the current approaches to measuring and interpreting teachers' technology integration knowledge that were used in this review are simply not sensitive enough to identify specific instances of teachers' thinking related to TPK and TCK with sufficient reliability. As the TPACK research community continues to develop more content-specific ways to assess and understand TPACK, it may be possible to more closely examine and identify with better reliability and validity the subdomains of knowledge included within the TPACK framework. Using more precise instruments, more focused interview prompts, more accurate stimulated recall techniques, and more effective data analysis techniques, researchers may be better able to understand both the composition and the complexities of teachers' applied TPACK.

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