2018

If There's TPACK, Is There Technological Pedagogical Reasoning and Action?

Judith B. Harris
College of William and Mary

Michael Phillips

If There's TPACK, is There Technological Pedagogical Reasoning and Action?

Judith B. Harris
Educational Policy, Planning, and Leadership Department, William & Mary School of Education, USA
judi.harris@wm.edu

Michael Phillips
Faculty of Education, Monash University
michael.phillips@monash.edu

Abstract:
Substantial evidence from research done with both preservice and inservice teachers demonstrates that the nature of teachers' *knowledge* is expanded and changed when educational technologies are incorporated effectively into teaching. If teachers infuse use of digital tools and resources in their praxis — that is, if they use them to access and comprehend content and teaching materials, to facilitate students' learning, and/or to reflect upon their teaching and their students' learning — does this use of digital technologies also change the fundamental nature of their *educational planning and decision-making*? Several researchers have asserted that it does. In this critical literature review, we consider these claims in light of the original conceptions of Shulman's (1987a) knowledge base for teaching, which includes pedagogical content knowledge (PCK); of technological pedagogical content knowledge (TPCK/TPACK); and of Shulman's model of pedagogical reasoning and action. This analysis leads to recommendations for a new direction in future TPCK/TPACK research.

The notion of *pedagogical content knowledge* (PCK) was modified by multiple authors to become *technological pedagogical content knowledge* (TPCK or TPACK), spawning much active and dynamic scholarship since 2001. Currently, many researchers see TPCK/TPACK as the knowledge that teachers need to integrate technologies effectively into learning and teaching. Shulman's PCK, however, was just one element in a much larger conceptualization of a knowledge base for educators, and that full range of knowledge was posited as being used by teachers in recursive processes of *pedagogical reasoning and action* (PR&A). This begs the question: if there is TPCK/TPACK, which is rooted in PCK, as many studies have suggested, is there also *technological* pedagogical reasoning and action (TPR&A)? If so, what are its distinguishing characteristics? If not, why would TPCK/TPACK not be mirrored in TPR&A? These questions are addressed in the following critical literature review.

PCK and TPCK/TPACK

Close examination of teachers' work reveals that teaching is an "outrageously complex activity" (Shulman, 1987b, p. 11), made even more complicated when educational technologies are incorporated (Mishra & Koehler, 2006). A range of theoretical models have been proposed to help unpack the intricate, contextually situated work undertaken by teachers. One powerful idea (Papert, 1980) that has helped researchers articulate the knowledge that is required for effective teaching is pedagogical content knowledge (PCK), and its corollary, technological pedagogical content knowledge (TPCK or TPACK). PCK originated in Shulman's (1986, 1987a, 1987b) research program that investigated teachers' knowledge base for teaching. As part of his 1985 American Educational Research Association presidential address, "Lee Shulman tossed off the phrase 'pedagogical content knowledge' and sparked a small cottage industry devoted to the scholarly elaboration of the construct" (Nelson, 1992, p. 32). The extensive PCK research conducted in the years immediately following the construct's introduction has continued. This ongoing inquiry has deepened PCK's conceptualizations and added much empirical research to Shulman's initial work, but these efforts have not led to a consensus in descriptions of PCK or the ways in which it is believed to be developed and represented (Park & Oliver, 2008).

While PCK inquiry continues, educational technology researchers have begun to extend the construct to examine the knowledge required for effective integration of digital technologies into teachers' praxis. Pierson (2001) suggested adding technology knowledge to the conceptualization of teachers' PCK, noting that the effectiveness of technology integration may increase with overall pedagogical expertise. Koehler, Mishra and Yahya (2004) similarly added

technology knowledge to PCK to form TPCK, positing P-T, or "pedagogical-technology knowledge" and C-T, or "content-technology knowledge" (p. 3) as intersecting aspects. Niess (2005) proposed the term "technology PCK" (p. 510), and Angeli and Valanides (2005) named the construct "ICT-related PCK" (p. 294). While the elements and configurations of these models differed somewhat, and the methods recommended to develop the specialized knowledge that they represented varied, all shared PCK and technology knowledge as their conceptual basis.

In the ensuing years, TPCK/TPACK scholarship has examined how this knowledge is developed, applied, and assessed in diverse settings (e.g., K-12, post-secondary, and informal learning environments) and across multiple content areas. The construct has been utilized in more than 3,200 publications that have appeared in fewer than 17 years (http://activitytypes.wm.edu/TPACKNewsletters/index.html), and this work has impacted the practice of teachers, professional development providers, administrators, and other stakeholders invested in meaningful educational uses of technology (Harris, Phillips, Koehler & Rosenberg, 2017). Despite these efforts, and in a manner similar to PCK scholarship, the TPCK/TPACK research community has yet to reach consensus on definitions of the construct and its components (Cox, 2008; Cox & Graham, 2009; Willermark, 2017). Notwithstanding this disagreement, the rapid diffusion of PCK in the late 1980's and 1990's, and of TPCK in the 2000's, may well be linked to the constructs' utility as *powerful ideas*, or "concepts [that] … become tools to think with" (Papert, 1980, p. 132).

Beyond PCK and TPCK/TPACK

Yet for all of the attention that PCK and TPCK have been paid during the past 30+ years, two key aspects of Shulman's pioneering work have received markedly less attention by both research communities: how teachers' knowledge *is used*, and *what is beyond PCK* that also comprises the knowledge base for teaching. Shulman's research presented another powerful idea that is beyond, but connected to, PCK: pedagogical reasoning and action (PR&A), "within which…teacher knowledge is used" (Shulman, 1987a, p. 5). Building on the work of Green (1971) and Fenstermacher (1978), Shulman's basis for PR&A is a belief that teachers should not be trained to behave in prescribed ways. Instead, they should be educated to reason soundly about their practice and perform their teaching skillfully. To Shulman, teaching "begins with an act of reason, continues with a process of reasoning, culminates in performances of imparting, eliciting, involving, or enticing, and is then thought about some more until the process can begin again" (p. 13). These interconnected, recursive reasoning and action processes both spring from and add to teachers' ever-evolving professional knowledge. They include six processes: comprehension (of what is to be taught and the purposes for teaching it); transformation (of what is to be taught, into conceptual models, learning activities, and adaptations to specific learners' needs and preferences); instruction (the observable acts of teaching); evaluation (of both students' learning and the teacher's instruction); reflection (upon teaching/learning processes); and new comprehension, which is built in an ongoing way from reflexive experience of the other five processes. Shulman (1987a) further delineated these six pedagogical reasoning and action processes with specific subprocesses, as explained in "Pedagogical Reasoning and Action with Technology," below.

It is important to note that Shulman's (1987a) conceptualization of PR&A draws upon the full range of knowledge domains that are included in his depiction of the knowledge base for teaching. These domains extend beyond PCK, because teachers require "both a process of thinking about what they are doing and an adequate basis of facts, principles, and experiences from which to reason" (p. 12). In addition to PCK, teachers' PR&A therefore draws on their knowledge of content, general pedagogy, curriculum, learners and their characteristics, educational contexts, and educational ends, purposes and values. A large proportion of teachers' PR&A depends upon their experiences or "wisdom of practice" (p. 12) relative to all of these components in their knowledge bases.

According to Shulman (1987a), teachers' knowledge-based PR&A explain both educational decisions and actions, because "[t]eaching is both effective and normative; it is concerned with both means and ends. Processes of reasoning underlie both" (p. 13). Might PR&A also explain teachers' decisions and actions regarding integration of educational technologies? Probably so. But is there a distinctive *technological* version of Shulman's pedagogical reasoning and action (TPR&A), parallel to TPCK/TPACK? Several authors have asserted that there is. Our view is somewhat different.

Does TPCK Imply TPR&A?

The notion of teachers as active decision-makers is not new. Teachers' decision-making has been investigated since the early 1970's, when several influential researchers realized that "decision making [is] central to understanding and improving teaching" (Borko, Roberts & Shavelson, 2008, p. 37). Highlighting teachers' roles as ever-adaptive, creative designers, Mishra, Koehler and Kereluik (2009) state that the TPACK construct:

> …emphasizes the role of teachers as decision makers who design their own educational technology environments as needed, in real time, without fear of those environments becoming outdated or obsolete. Using this approach, teachers do not attend to specific tools, but instead focus on approaches to teaching that endure through change in technologies, content, or pedagogies. (p. 52)

Is there something unique about this decision-making process when digital technologies are incorporated into PR&A? Richardson's (2009) in-depth study of twelve fifth-, sixth-, and seventh-grade teachers' instructional planning processes for their students' technology-infused learning in four different curriculum areas showed that the teachers followed Shulman's model of PR&A, "loosely applied" (p. viii). By contrast, the results from four other studies have been interpreted to assert that *technological* pedagogical reasoning and action is sufficiently different from Shulman's original PR&A to warrant an amended model.

One of these views states that since digital tools and resources are incorporated during each and all steps of PR&A taken by technology-using teachers, these processes are fundamentally different from the model that Shulman proposed. Smart, Finger & Sim (2016) assert, for example, "…just as Shulman suggested that the processes of pedagogical reasoning develop PCK, …with the introduction of technology, teachers technologically pedagogically reason to develop their TPACK" (p. 61). In other words, this view argues that teachers' PR&A processes change significantly when technologies are incorporated into their educational reasoning and decision-making.

Another research team found that seven technology-proficient teachers participating in a multiple case study also used Shulman's PR&A processes when planning and teaching with digital tools, but suggested including technology selections and technology-related "caution," or plans for what to do when technologies failed, as additional processes in the PR&A sequence (Feng & Hew, 2005, p. 3177). Based upon the results of data analysis, these researchers, like Smart (2016), combined and renamed several of the reasoning processes in Shulman's (1987a) PR&A model. Still, like Richardson (2009), they found that participating teachers generally engaged in PR&A while actively using technologies.

Six "digitally able" (p. 236) teachers in Starkey's (2010) multiple case study also appeared to follow the processes described in Shulman's model when explaining their pedagogical reasoning and action. Starkey, like Smart, Sim and Finger (2015), noted that "the greatest variation appeared to depend on the resources the teachers chose to use" (p. 240). However, when describing the nature of each of the PR&A processes that she observed, Starkey recognized "a fundamental change since 1987: …students creating knowledge in the digital era through connections in an open and flexible curriculum, rather than the teacher transmitting the 'truths' and methodologies of a subject according to a prescribed curriculum" (p. 241). Loveless (2011) observed and described a similar shift, citing the student, rather than the teacher, as central in the connection-making:

> Learning experiences [now] can be more fluid, interactive and multimodal. They are more mobile, not because the technologies are necessarily mobile, but because the learner can be placed more centrally, given access to information and opportunities to make meanings in a variety of linked environments. (pp. 305-306)

Starkey ascribed this change to the theory of connectivism, within which "a teacher…would transform existing knowledge as outlined in Shulman's model, but would also encourage students to go beyond the teacher's existing knowledge base by making or enabling connections" (p. 240). Starkey, therefore, adapted Shulman's model "for the digital age" (p. 243) by renaming and redefining Shulman's knowledge transformation processes to emphasize "enabling connections" (p. 242) in the ongoing customization of students' learning opportunities. She also recommended fusing teaching, learning, and formative evaluation, rather than conceptualizing them as separate processes.

Niess and Gillow-Wiles (2017) used Starkey's interpretation of PR&A as part of an in-depth study of master's-level mathematics teachers' electronic portfolios. Their study described the teachers' technological PR&A that was applied at a systems level (p. 78). During several years of mathematics education degree work, participating teachers learned how to select and utilize multiple technologies in concert (as a system), and in content- and pedagogically appropriate ways. The researchers concluded:

> Teachers must develop a pedagogical reasoning process that makes valid and important connections with multiple technologies for the students as they are learning, beginning with comprehension of the subject matter and continuing with new comprehension after reflection on the instruction – a technological pedagogical reasoning process. (p. 79)

Clearly, Niess & Gillow-Wiles' students engaged in conscious PR&A regarding educational technologies in their professional learning and work. These particular decisions and acts do differ from those that do not incorporate digital tools and resources. They are based in the teachers' TPCK/TPACK; *knowledge* that multiple researchers have described as fundamentally different from PCK (e.g., Angeli & Valanides, 2005; Mishra & Koehler, 2006; Niess, 2005). But does having a greatly expanded set of (digital) tools available for learning and teaching change the essential nature of teachers' comprehension, transformation or connection-enabling, instruction/evaluation or teaching/learning, and/or reflection/new comprehension processes (Shulman, 1987a; Starkey, 2010)?

Starkey later summarized her views on the essential differences between PR&A when it was conceived and shared more than 30 years ago, and what she sees it to be now, by saying:

> In the digital age, teachers will prioritise student learning over teaching. There is a subtle but important difference between teacher decisions which prioritise teaching above learning and those which prioritise learning over teaching. They are two perspectives; both value teaching and learning, but they approach the teaching process from different perspectives. The former is to keep the students engaged through the use of resources and carefully designed lessons, the latter is to monitor student learning through use of formative assessment and base teaching decisions on the learning progress of the students. (2012, p. 92)

Yet Shulman (1987a) seems to acknowledge this particular type of active monitoring and connection-making that Starkey (2010) and Loveless (2011) describe when he suggests that

> …students can literally initiate the process [of PR&A], proceeding by discovering, inventing, or inquiring, to prepare their own representations and transformations. Then it is the role of the teacher to respond actively and creatively to those student initiatives. (p. 14)

Further, Shulman (1987a) suggests that comprehension can focus upon values, or "the characteristics, needs, interests, or propensities of a particular individual or group of learners." (p. 14) Given these rather flexible parameters offered by Shulman in his original description of PR&A, we question whether the interpretations of Smart, Feng and Hew, Starkey, and Loveless' research results, as summarized above, depict truly fundamental differences in 21st-century pedagogical reasoning and action beyond the incorporation of new (digital) tools, resources, and communication networks in all aspects of teachers' decision-making and pedagogical actions. Shulman's model did not eschew student-centered, formative, constructivist approaches to learning and teaching. It also did not describe types of tools and resources that are used in learning and teaching in any detail. It did imply, however, that teachers hold primary responsibility for planning, facilitating, assessing, and customizing students' learning. It with this basic assumption that another view of digital age pedagogical reasoning and action disagrees.

Notions of TPR&A

Like Smart (2016) and Feng & Hew (2005), Webb and Cox (2004) argued that "knowledge of affordances of ICT and decisions about their use" should be added "to the pedagogical reasoning process when teachers are planning and teaching lessons that incorporate ICT use," (p. 238) especially during the process of representation. Representation, according to Shulman (1987a), is one of four processes that comprise transformation, which builds upon comprehension, in teachers' PR&A: preparation of material to be taught/learned, representation of the material in

ways accessible to students, selection of instructional materials and methods, and adaptation of the materials and methods to both general and specific student characteristics. In Shulman's model, teachers' transformations form the basis of ongoing pedagogical decisions during planning, teaching, and evaluation. Webb and Cox (2004) remind us that expanding the knowledge base for teaching by adding technology knowledge makes PR&A considerably more complex.

Later, Webb (2011; 2014) extended these notions to assert that learning and teaching in technology-rich environments have begun to change the basic roles that students and teachers play. ICTs' affordances permit teachers to design learning experiences for students in which "much of the traditional role of the teacher in structuring and scaffolding learning is done by the technology" (p. 4). Therefore, Webb says, learning and teaching are not as clearly differentiated in this digital age as they once were, with learning becoming more self-directed and metacognitive, and teaching and assessment becoming more collaborative. To Webb, this means that students "are undertaking some of the pedagogical reasoning that is traditionally done by teachers" (2011, p. 4).

Webb (2011) acknowledges that this fundamental shift in responsibility for learning and teaching can present significant challenges, especially as students and teachers are becoming accustomed to the expectations of their new roles. She recommends "extensive modelling and interaction…for students to (1) come to understand what is required of them and why it is important; (2) self-assess their current achievements; and (3) increase their involvement in pedagogical reasoning" (p. 11). Webb admits to the deluge of complexities that result from shared responsibilities for PR&A. She notes "major challenges" that this particular type of teacher-student collaboration causes, and the need for finding "ways of enabling learners to share as much as possible of the pedagogical reasoning process to manage their own learning and to engage in interactions…to support the learning of other students" (p. 12).

We wonder, however, whether the fundamental changes in teachers' and students' roles that Webb describes are more actual or aspirational at the present time. The presence of networked technologies with affordances that *can* support highly individualized, comparatively independent, self-monitored, self-assessed learning doesn't necessarily suggest that most school-based activity has or will shift to this mode soon. With ever-increasing requirements of teachers and schools to ensure students' measurable, reportable learning that is aligned to externally derived curriculum standards, societal and professional expectations of teachers to be the ones who are ultimately—but not necessarily exclusively—responsible for PR&A may be unstated, but strongly assumed. Moreover, teachers shouldering these decision-making and instructional responsibilities does not obviate the rich possibilities of student choice, self-assessment, peer feedback, or collaborative learning that can be supported by well-informed uses of educational technologies.

Does Knowledge Change Require Process Change?

Our central question, then, can be stated as follows. Do the educational affordances of digital technologies used in learning and teaching *require* a reconceptualization of the processes of teachers' PR&A, similar to the ways in which the addition of technology knowledge to PCK fundamentally redefined it as TPCK/TPACK? If so, what is the nature of the essential and necessary differences between PR&A and TPR&A, beyond the pervasive use of digital technologies in the latter?

To answer this question, we first examine how adding technology knowledge to a part of the knowledge base for teaching (PCK) required us to change our understanding of that particular aspect of teachers' knowing.

PCK with Technology

The TPCK/TPACK construct builds on Shulman's (1986, 1987a) conception of PCK by integrating technology knowledge into this component of the knowledge base for teaching. TPACK (Thompson & Mishra, 2008) is most commonly represented as a Venn diagram with three overlapping circles: pedagogical knowledge (PK), content knowledge (CK) and technology knowledge (TK) (http://www.tpack.org/). In addition to these core forms of knowledge, this illustration of the TPACK construct also draws attention to combinations that represent specific aspects of teachers' knowledge, including PCK, technological content knowledge (TCK), technological pedagogical knowledge (TPK) and TPACK, which sits at the nexus of all of the elements in the diagram. Despite the simplicity of

this representation, the addition of technology knowledge (TK) "increases the conceptual complexity [of PCK] by at least an order of magnitude" (Graham, 2011, p. 1955).

When contrasted with PCK, the comparative complexity of the TPACK construct is usually attributed to the introduction of TK. An argument can be made, however, that technologies are not a new aspect of the educational landscape, and that teachers have been required to think about tools such as books and pens for many decades. Bruce and Hogan (1998) have suggested that the ubiquity of such technologies renders them "transparent," however, "or in other words, they [have] become commonplace and [are] not even regarded as technologies" (Mishra & Koehler, 2006, p. 1023). Graham (2011) extended this idea, suggesting that the knowledge needed to integrate use of transparent technologies in teaching and learning could be considered to be part of Shulman's original knowledge base for teaching, specifically within "content representation or even curriculum and media" (p. 1965).

To support this perspective, Graham (2011) notes that Angeli and Valanides (2009) also stated that Shulman intended for technology to be included as part of his knowledge base for teaching—specifically within curricular knowledge and associated materials—but that he

> …did not *explicitly* [emphasis in original] discuss technology and its relationship to content, pedagogy and learners, and thus PCK in its original form does not specifically explain how teachers use the affordances of technology to transform content and pedagogy for learners. (p. 156)

If the use of transparent technologies can be considered to be part of the knowledge base for teaching, and if PR&A is the process by which teachers use tools (in part) to assist their students' learning, then the introduction of *transparent* technologies into a teacher's repertoire should not require *technological* pedagogical reasoning and action (TPR&A).

Not all educational technologies are transparent, however. Cox (2008) made a useful distinction between transparent and "emerging" technologies. She defined emerging technologies as new (in individual teachers' experiences), typically digital, technologies "that are not yet transparent in the context under consideration" (p. 73). According to Cox, emerging technologies can become transparent over time if they are used habitually. The use of emerging, instead of transparent, technologies requires, in Cox's view, the addition of TK to PCK. This definition of TK that sits outside PCK has two important implications.

First, emerging technologies' ongoing proliferation has necessitated the introduction of TK to the knowledge base for teaching. This is not simply a matter of adding TK to Shulman's original list of knowledge domains. In addition, and in a manner similar to the intersection of PK and CK to become PCK, the introduction of TK to PCK adds new overlapping dimensions: TCK, TPK and TPACK. Second, adding TK to the knowledge base for teaching, plus expanding PCK to become TPACK, reveals the temporal, "'sliding' nature of TCK, TPK, and TPACK" (Cox, 2008, p. 78). Cox explains this characteristic by suggesting that now-transparent technologies were once emerging technologies, as books were approximately five hundred years ago. Initially, the pedagogical use of books required TPACK in this sense, but now requires PCK, plus the curricular knowledge (and associated materials knowledge) that Shulman listed as part of the total knowledge base for teachers.

Does the use of presently emerging technologies (in Cox's way of describing them), which requires TPACK (not PCK), in addition to the other parts of the knowledge base for teachers, also require a sliding version of PR&A; that is, TPR&A? To answer this question, we will consider each of the six PR&A processes in Shulman's model next.

Pedagogical Reasoning and Action with Technology

We have argued above that the professional knowledge base needed for teaching changes as educational technologies emerge in the sense that Cox (2008) suggested: specifically by adding TK to the base (Smart, Sim & Finger, 2015) and transforming PCK into TPCK/TPACK. By implication, this suggests that instruction and evaluation that utilize emerging technologies according to their particular educational affordances (Bower, 2008) or "action potentials" (p. 3) also will change. Instruction and evaluation were two of the six primary processes that comprised Shulman's (1987a) model of PR&A. He described instruction as "active teaching, discovery or inquiry instruction, and the observable forms of classroom teaching" (p. 15) and evaluation as "checking for student understanding" (p. 15) both during and after teaching, plus self-evaluation of teaching performance. Thus, pedagogical *action* likely changes when

incorporating emerging technologies in accordance with their particular educational affordances. What about pedagogical *reasoning*?

To answer this question, we will consider the other four primary processes named in Shulman's PR&A model: comprehension, transformation (involving preparation, representation, selection, and adaptation/tailoring to student characteristics), reflection, and new comprehension.

Comprehension

Shulman (1987a) asserted that "teaching necessarily begins with a teacher's understanding [and analysis] of what is to be learned and how it is to be taught" (p. 7). This "comprehension" is the first of the six named PR&A processes. However, Shulman reminds us that

> …the rhetoric of the analysis [of what is to be taught]…is not meant to suggest that education is reduced to knowledge transmission, the conveying of information from an active teacher to a passive learner, and that this information is viewed as product rather than process. (p. 7)

Instead, Shulman explains that even in the "most student-centered forms of education, where much of the initiative is in the hands of the students, there is little room for teacher ignorance. Indeed…teacher comprehension is even more critical for the inquiry-oriented classroom than for its more didactic alternative" (p. 7). This statement seems to refute Starkey's (2010) argument that a "fundamental change" has occurred in the teacher comprehension processes that Shulman posited in 1987; that students now create knowledge "through connections in an open and flexible curriculum, rather than the teacher transmitting the 'truths' and methodologies of a subject according to a prescribed curriculum" (p. 241). Comprehension in Shulman's PR&A model does not imply a teacher-centered, didactic, or transmission model of teaching. It does acknowledge, however, that teachers bear the primary responsibility for PR&A, even when it is done in collaboration with students.

Transformation

Shulman (1987a) also reminded us that comprehending both content to be taught and its purposes for being learned "does not particularly distinguish a teacher from non-teaching peers. We expect a math major to understand mathematics or a history specialist to comprehend history" (p. 15). Instead, incorporating PCK, he explained:

> …the key to distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy, in the capacity of a teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the students. (p. 15)

Shulman (1987a) said that "comprehended ideas" (p. 16) must be processed by preparing and/or interpreting teaching materials, deciding how to represent the comprehended ideas to students, selecting appropriate teaching methods and models, and adapting/tailoring these representations to students both as a group and as individuals. All of these actions are aspects of transformation within pedagogical reasoning. While the *knowledge* used by teachers within each of these transformation sub-processes can change when emerging technologies (Cox, 2008) are incorporated, we argue that the processes themselves—that is, the pedagogical reasoning used—does not change fundamentally from what Shulman explained in his PR&A model. With this statement, we acknowledge a disagreement with Webb's (2010; 2014) assertion that, with the use of emerging technologies, pedagogical reasoning is now shared by teachers and students. While this role change may be observable in some higher education contexts—for example, as described in Fielding's (2011) sixth and final level of partnership between instructors and students called "intergenerational learning as lived democracy" (p. 53)—the primary responsibility for PR&A in most classrooms still rests with teachers, given professional, organizational, and societal expectations both at the present time and in the foreseeable future. However, as explained in the previous section, this reality does not necessarily relegate students to being passive, disempowered, or less active learners.

Reflection and New Comprehension

Shulman (1987a) says that PR&A incorporates professional reflection (review, reconstruction, re-enacting, and critical analysis) continuously, which leads to new professional learning, or "new comprehension" (p. 19) for teachers. Smart, Sim and Finger (2015) suggest that these two processes are "fundamentally the same" (p. 3424). We agree that the processes co-occur and feed each other. However, as an important aspect of pedagogical reasoning, and like the transformation processes explored above, we suggest that when use of emerging technologies is considered by teachers, the acts of reflection and new comprehension themselves (not the technology-related knowledge *used* in these thinking processes) are not fundamentally different than when emerging technologies are not incorporated in teachers' pedagogical reasoning.

This, then, suggests a direct answer to our central question. Teachers' knowledge is used to "provide the grounds for [their] choices and actions" (Shulman, 1987a, p. 13). Although teachers' *knowledge* (e.g., TPCK/TPACK), and therefore their pedagogical *actions*, can change in fundamental ways when emerging technologies are incorporated, their pedagogical reasoning *processes*—that is, the ways in which they ponder and arrive at pedagogical decisions—typically do not, because it is not necessary that they do so. Why, then, is it believed that PR&A must become TPR&A? To conclude this chapter, we will offer a response.

Technocentrism and TPR&A

Finding ways to exploit emerging technologies' affordances (Bower, 2008) in service of students' learning can expand learning and teaching *possibilities*—especially instructional selection, adaptation, and evaluation—in great measure, making many more options (e.g., types of learning activities; students' choices of expression; opportunities for collaborative learning) available to teachers engaged in PR&A. These options encompass a plethora of ways in which students can interact with what they learn, with each other, and with those outside of the classroom, school, or geographic community, and how that learning can be personalized. Familiarity with these learning and teaching possibilities–constituting TPCK/TPACK that extends far beyond merely knowing the educational affordances of particular digital tools and resources—is essential for teachers to build and use, so that they can address their students' learning needs and preferences with 21st-century expertise. While this is very important additional *knowledge* that teachers need, in most cases, it does not require substantially different *processes* for planning and reflecting upon students' learning from what Shulman (1987a) described so expansively more than 30 years ago.

When might teachers' PR&A shift in a way that could be described accurately as TPR&A? Only when teachers' reasoning and/or action are *technocentric*. Seymour Papert (1987) coined this term to describe an excessive and shortsighted focus upon digital tools, similar to the ways in which a child at an egocentric stage of development has "difficulty understanding anything independently of the self" (p. 23). If, for example, a teacher was forced to surrender his PR&A to using scripted technology-based curriculum materials (e.g., a comprehensive, tracked learning management system) without customizing them to address his students' specific learning needs, he would be using *technocentric* pedagogical reasoning and action, since the decision to use the technology-based materials would have preceded, and provided a focal point for, his pedagogical decision-making and action. Similarly, if another teacher built a lesson around students' use of a digital tool (e.g., an interactive whiteboard) that had just been acquired in her school—at the urging of the school's principal, who wanted to be sure that the new technology was being used in classrooms—the teacher's PR&A could legitimately be described as TPR&A, due to its primary focus upon particular technology use, rather than student learning. Although pedagogical *action* can change in fundamental ways when emerging technologies are used educationally, non-technocentric processes of pedagogical *reasoning* typically do not.

Recommendations for Future Research

Given the past decade-plus of active research about teachers' TPCK/TPACK, and the comparative dearth of extant research about teachers' planning and decision-making with educational technologies (Richardson, 2009), we still have much to discover about how and why teachers' TPCK/TPACK—as one important part of a comprehensive knowledge base for teachers—is applied and expanded within the processes that comprise teachers' reasoning, planning, and reflection. What, then, is the nature of teachers' PR&A when they incorporate emerging educational technologies in their praxis? We invite our colleagues to join us in exploring this important conceptual expansion of TPCK/TPACK-based inquiry.

References

Angeli, C., & Valanides, N. (2005). Preservice elementary teachers as information and communication technology designers: An instructional systems design model based on an expanded view of pedagogical content knowledge. *Journal of Computer Assisted Learning, 21*(4), 292-302. doi:10.1111/j.1365-2729.2005.00135.x

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

Borko, H., Roberts, S. A., & Shavelson, R. (2008). Teachers' decision making: From Alan J. Bishop to today. In P. Clarkson & N. Presmeg (Eds.), *Critical issues in mathematics education: Major contributions of Alan Bishop* (pp. 37-67). New York: Springer Science+Business Media, LLC.

Bower, M. (2008). Affordance analysis--Matching learning tasks with learning technologies. *Educational Media International, 45*(1), 3 - 15. doi:10.1080/09523980701847115

Bruce, B. C., & Hogan, M. C. (1998). The disappearance of technology: Toward an ecological model of literacy. In D. Reinking, M. McKenna, L. Labbo, & R. Kieffer (Eds.), *Handbook of literacy and technology: Transformations in a post-typographic world* (pp. 269-281). Hillsdale, NJ: Erlbaum.

Cox, S. (2008). *A conceptual analysis of technological pedagogical content knowledge* (Doctoral dissertation). Retrieved from http://scholarsarchive.byu.edu/cgi/viewcontent.cgi?article=2481&context=etd

Cox, S., & Graham, C. R. (2009). Diagramming TPACK in practice: using an elaborated model of the TPACK framework to analyze and depict teacher knowledge. *TechTrends, 53*(5), 60-69. doi:10.1007/s11528-009-0327-1

Feng, Y. & Hew, K. (2005). K-12 teachers' pedagogical reasoning in planning instruction with technology integration. In C. Crawford, R. Carlsen, I. Gibson, K. McFerrin, J. Price, R. Weber & D. Willis (Eds.), *Proceedings of SITE 2005—Society for Information Technology & Teacher Education International Conference* (pp. 3173-3180). Chesapeake, VA: Association for the Advancement of Computing in Education.

Fenstermacher, G. D. (1978). A philosophical consideration of recent research on teacher effectiveness. In L. S. Shulman (Ed.), *Handbook of research on teaching* (Vol. 6, pp. 157-185). Itasca, IL: Peacock.

Fielding, M. (2011). Patterns of partnership: Student voice, intergenerational learning and democratic fellowship. In N. Mockler & J. Sachs (Eds.), *Rethinking educational practice through reflexive inquiry* (pp. 61-75). New York: Springer. doi:10.1007/978-94-007-0805-1_5

Graham, C. R. (2011). Theoretical considerations for understanding technological pedagogical content knowledge (TPACK). *Computers & Education*, *57*(3), 1953-1960. doi:10.1016/j.compedu.2011.04.010

Green, T. F. (1971). *The activities of teaching.* New York: McGraw-Hill.

Harris, J., Phillips, M., Koehler, M., & Rosenberg, J. (2017). TPCK/TPACK research and development: Past, present and future directions. *Australasian Journal of Educational Technology, 33*(3), i-viii. doi:10.14742/ajet.3907

Koehler, M. J., Mishra, P., & Yahya, K. (2004, April). *Content, pedagogy, and technology: Testing a model of technology integration.* Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA. Retrieved from http://www.matt-koehler.com/publications/Koehler_et_al_AERA_2004.pdf

Loveless, A. (2011). Technology, pedagogy and education: Reflections on the accomplishment of what teachers know, do and believe in a digital age. *Technology, Pedagogy and Education, 20*(3), 301-316. doi:10.1080/1475939X.2011.610931

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054. doi:10.1111/j.1467-9620.2006.00684.x

Mishra, P., Koehler, M. J., & Kereluik, K. (2009). The song remains the same: Looking back to the future of educational technology. *TechTrends, 53*(5), 48-53. doi:10.1007/s11528-009-0325-3

Nelson, B. (1992). Teachers' special knowledge. *Educational Researcher, 21*(9), 32-33. doi:10.2307/1177020

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education, 21(*5), 509-523. doi:10.1016/j.tate.2005.03.006

Niess, M., & Gillow-Wiles, H. (2017). Expanding teachers' technological pedagogical reasoning with a systems pedagogical approach. *Australasian Journal of Educational Technology, 33*(3), 77-95. doi:10.14742/ajet.3473

Papert, S. (1987). Computer criticism vs. technocentric thinking. *Educational Researcher, 16*(1), 22-30. doi:10.2307/1174251

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas.* New York, NY: Basic Books.

Park, S., & Oliver, J. S. (2008). Revisiting the conceptualisation of pedagogical content knowledge (PCK): PCK as a conceptual tool to understand teachers as professionals. *Research in Science Education, 38*(3), 261-284. https://doi.org/10.1007/s11165-007-9049-6

Pierson, M. E. (2001). Technology integration practice as a function of pedagogical expertise. *Journal of Research on Computing in Education, 33*(4), 413-430. doi:10.1080/08886504.2001.10782325

Richardson, K. W. (2009). *Looking at/looking through: Teachers planning for curriculum-based learning with technology* (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3371354)

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14. doi:10.3102/0013189X015002004

Shulman, L. S. (1987a). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-22. doi:10.17763/haer.57.1.j463w79r56455411

Shulman, L. S. (1987b). The wisdom of practice. In D. Berliner & B. Rosenshine (Eds.), *Talks to teachers: A festschrift for N.L. Gage* (pp. 369-386). New York: Random House.

Smart, V. L. (2016). *Technological pedagogical reasoning: The development of teachers' pedagogical reasoning with technology over multiple career stages* (Doctoral thesis, Griffith University, Queensland, Australia). Retrieved from https://www120.secure.griffith.edu.au/rch/items/b658444f-8e00-4c61-9b95-a3b19c62d545/1/

Smart, V., Finger, G., & Sim, C. (2016). Developing TPACK: Envisioning technological pedagogical reasoning. In M. C. Herring, M. J. Koehler, & P. Mishra (Eds.), *Handbook of technological pedagogical content knowledge (TPACK) for educators* (2nd ed., pp. 53–62). New York: Routledge.

Smart, V., Sim, C., & Finger, G. (2015, March). *Are teachers lost in thought with technology? Moving from pedagogical reasoning to technological pedagogical reasoning.* Paper presented at the annual meeting of the Society for Information Technology in Teacher Education, Las Vegas, NV.

Starkey, L. (2010). Teachers' pedagogical reasoning and action in the digital age. *Teachers and Teaching: Theory and Practice, 16*(2), 233-244. doi:10.1080/13540600903478433

Starkey, L. (2012). *Teaching and learning in the digital age.* New York: Routledge.

Thompson, A. D., & Mishra, P. (2007-2008). Breaking news: TPCK becomes TPACK! *Journal of Computing in Teacher Education, 24*(2), 38.

Webb, M. (2011). Changing models for researching pedagogy with information and communication technologies. *Journal of Computer-Assisted Learning, 29*(1), 53-67. doi:10.1111/j.1365-2729.2011.00465.x

Webb, M. (2014). Pedagogy with information and communications technologies in transition. *Education and Information Technologies, 19*(2), 275-294. doi:10.1007/s10639-012-9216-x

Webb, M., & Cox, M. (2004). A review of pedagogy related to information and communications technology. *Technology, Pedagogy, and Education, 13*(3), 235-286. doi:10.1080/14759390400200183

Willermark, S. (2017). Technological pedagogical and content knowledge: A review of empirical studies published from 2011 to 2016. *Journal of Educational Computing Research.* Advance online publication. doi:10.1177/0735633117713114