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Theoretical considerations for understanding technological pedagogical content knowledge (TPACK)

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ABSTRACT

The technological pedagogical content knowledge (TPACK) framework is increasing in use by educational technology researchers around the world who are interested in issues related to technology integration. Much that is good can be found in the TPACK framework; however considerable theoretical work needs to be done if TPACK research is to cohere and constructively strengthen the field of educational technology. This paper uses Whetten's (1989) criteria for theory building as a lens for examining the TPACK framework. Specific weaknesses are identified, which in turn suggest areas needing theoretical development. This paper calls for researchers to increase emphasis on using research findings to constructively build common definitions and understandings of the TPACK constructs and the boundaries between them.
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1. Introduction

Solid theories are essential to a robust and mature scientifically oriented discipline (Dubin, 1978). The behavioral and social science communities have engaged in much discussion about what constitutes theory and what role theory plays in the knowledge creation process (Ball, 2006; Burkhardt & Schoenfeld, 2003; Kessels & Korthagen, 1996; Korthagen & Kessels, 1999; Schoenfeld, 1999; Sikes, 2006; Suppes, 1974; Wright, 2008). One of the important roles of theory development in a community of inquiry is to provide a common language and focus for productive discussion and knowledge creation. Burkhardt and Schoenfeld (2003), speaking of the educational research community, said, "a lack of attention to coherent theory building leaves us looking balkanized and incoherent, the whole of education being less than the sum of its parts" (p. 13).

For several decades educational technology as a field has struggled to find its theoretical roots (McDougall & Jones, 2006; Roblyer, 2005; Roblyer & Knezek, 2003). Reasons for this seeming disorientation include among others the rapid pace of technological change (Richey, 1997; Roblyer & Knezek, 2003), a historical tendency for research to ask the wrong questions as evidenced by media comparison studies (Roblyer, 2005; Winn, 1989), the weakness of methodological designs, and a focus on practical matters over building on solid theoretical underpinnings (McDougall & Jones, 2006; Roblyer, 2005).

Recently a conceptual model called technological pedagogical content knowledge (TPACK) was introduced to the educational research community. Researchers have embraced the model with significant initial excitement, as evidenced by the rapid growth of special interest groups and TPACK strands at the Society for Information Technology and Teacher Education (SITE) and American Educational Research Association (AERA) conferences, as well as a book sponsored by the Innovation and Technology Committee of the American Association of Colleges for Teacher Education (AACTE Committee on Innovation and Technology, 2008). Many researchers recognize the broad appeal and potential of the TPACK model.

However, while hundreds of studies claim TPACK as theoretical framing, very little theoretical development of the model has occurred. In 2008 Cox found 89 different definitions of the central construct (TPCK) in the model, in addition to dozens of different definitions for the less attended to TPK and TCK constructs. Other researchers have lamented the fuzzy boundaries associated with the model (Angeli & Valanides, 2009; Archambault & Barnett, 2010; Archambault & Crippen, 2009; Cox & Graham, 2009; Jimoyiannis, 2010). Looking carefully at the few studies that have created instruments to try to measure TPACK reveals that the research community has not done the theoretical work required to make clear distinctions between model elements.

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If this work is not completed, the community risks generating mounds of research that ultimately does not cohere. “Absent self-conscious attempts on the part of the field to use standard definitions, methods, and benchmarks (a hallmark of engineering research), the research whole is less than the sum of the parts” (Burkhardt & Schoenfeld, 2003, p. 13).

The purpose of this paper is to examine the TPACK framework through the lens of theory development. This is a theoretical paper that identifies specific critiques of the TPACK framework that need to be addressed by the research community in order for the theory to mature.

2. Background of the TPACK framework

The concept of technological pedagogical content knowledge (TPACK) has emerged over the last decade, beginning with Pierson’s (2001) initial articulation of the idea, followed by various other researchers suggesting similar conceptions of a more content-specific orientation to technology integration (Angeli & Valanides, 2005; Koehler & Mishra, 2005; Lee, 2005; Margerum-Leys & Marx, 2003, 2004; Niess, 2005; Wallace, 2004). The term TPACK began to gain widespread popularity in 2006 after Mishra and Koehler’s seminal work outlining the model and describing each of the central constructs. TPACK was called “TPCK” in the literature until 2008, when some in the research community proposed using the more easily spoken term TPACK (Thompson, 2008).

The TPACK framework builds on Shulman’s (1986, 1987) conception of pedagogical content knowledge (PCK) by explicitly integrating the component of technological knowledge into the model. The TPACK framework is most commonly represented using a Venn diagram with three overlapping circles, each representing a distinct form of teacher knowledge (see Fig. 1). The framework includes three core categories of knowledge: pedagogical knowledge (PK), content knowledge (CK), and technological knowledge (TK). The framework proposes that combining these three core types of knowledge results in four additional types of knowledge: pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK). Often knowledge of context is also included as a part of the model (Akarasriworn & Ku, 2010; Mishra & Koehler, 2006). Each type of teacher knowledge represented in the framework is briefly described in Table 1.

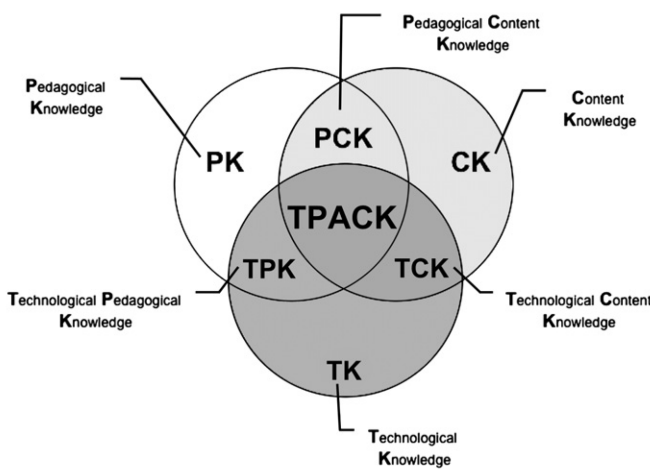

Fig. 1. The technological pedagogical content knowledge (TPACK) framework.

Table 1
Brief description of constructs in the ˇTPACK framework from Mishra and Koehler (2006).

Construct	Description
PK	“Pedagogical knowledge (PK) is deep knowledge about the processes and practices or methods of teaching and learning and how it encompasses, among other things, overall educational purposes, values, and aims. This is a generic form of knowledge that is involved in all issues of student learning, classroom management, lesson plan development and implementation. It includes knowledge about techniques or methods to be used in the classroom; the nature of the target audience; and strategies for evaluating student understanding.” (p. 1026–1027)
CK	“Content knowledge (CK) is knowledge about the actual subject matter that is to be learned or taught…. including knowledge of central facts, concepts, theories, and procedures within a given field; knowledge of explanatory frameworks that organize and connect ideas; and knowledge of the rules of evidence and proof (Shulman, 1986).” (p. 1026)
TK	“In the case of digital technologies, this includes knowledge of operating systems and computer hardware, and the ability to use standard sets of software tools such as word processors, spreadsheets, browsers, and e-mail. TK includes knowledge of how to install and remove peripheral devices, install and remove software programs, and create and archive documents.” (p. 1027)
PCK	“PCK exists at the intersection of content and pedagogy. Thus, it goes beyond a simple consideration of content and pedagogy in isolation from one another. PCK represents the blending of content and pedagogy into an understanding of how particular aspects of subject matter are organized, adapted, and represented for instruction.” (p. 1021)
TPK	“TPK is knowledge of the existence, components, and capabilities of various technologies as they are used in teaching and learning settings, and conversely, knowing how teaching might change as the result of using particular technologies.” (p. 1028)
TCK	“TCK is knowledge about the manner in which technology and content are reciprocally related. Although technology constrains the kinds of representation possible, newer technologies often afford newer and more varied representation and greater flexibility in navigating across these representations.” (p. 1028)
TPACK	“TPCK is the basis of good teaching with technology and requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students’ prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones.” (p. 1029)

3. Current challenges for the TPACK framework

This section will explain several weaknesses with the current state of the TPACK theoretical framework. Many researchers have articulated key elements for effective theories (Bacharach, 1989; Dubin, 1978; Gregor & Jones, 2007; Whetten, 1989). In 1989, the editor for the Academy of Management Review (a prestigious behavioral sciences journal in business management and organizational behavior), sought to strengthen the theoretical contributions of researchers by outlining what makes a solid contribution to theory (Whetten, 1989). Whetten (1989) succinctly summarized three important building blocks for theory development that will guide this analysis: (1) identifying "what" factors, constructs, or concepts should be considered in explaining the phenomena of interest, (2) exploring "how" the elements in the theory are related, and (3) articulating "why" the factors and relationships merit attention and interest in the larger context.

3.1. The what

The first part of building any theoretical framework is to identify what essential variables or constructs contribute to the phenomenon of interest. At first glance the TPACK framework seems to have done this; the model identifies seven distinct constructs (see Fig. 1 and Table 1). However, much theoretical work needs to be done to develop construct clarity. This section of the paper describes several challenges that researchers still face in trying to understand the TPACK constructs. The first challenge grows out of the fact that the TPACK framework is built on an existing theoretical framework that lacks theoretical clarity. The second challenge involves finding a balance between the parsimony and complexity of the framework. A third challenge is to develop precise definitions for each of the constructs in the TPACK framework.

3.1.1. Building on an unsure foundation

The TPACK framework builds upon Shulman's (1986, 1987) concept of pedagogical content knowledge (PCK). While PCK has been heavily researched over the past two decades, much debate continues regarding how to define the construct and distinguish it from related constructs. Several years after the introduction of PCK, Marks (1990) wrote, "Researchers in this area have used Shulman's characterization of pedagogical content knowledge productively but have done little to clarify it" (p. 3). A decade later researchers were still lamenting the "fuzzy" definitions leading to difficulty in understanding PCK (Gess-Newsome, 2002; Magnusson, Krajcik, & Borko, 1999). In her discussion of PCK, Gess-Newsome (2002) recognized the "difficulty of producing adequate definitions of complex concepts and of establishing clear, discrete, and manageable categories that avail themselves to examination" (p. 6). As recently as 2007, researchers stated in a review of the prominent PCK models that "the concept of PCK is still difficult to pin down theoretically" (Lee, Brown, Luft, & Roehrig, 2007, p. 1345). While the imprecise definitions of PCK have lead to many productive threads of research conversation, they have been a barrier to the measurement of PCK (Baxter & Lederman, 1999; Kagan, 1990).

The TPACK framework builds on the PCK framework and increases the conceptual complexity by at least an order of magnitude. Because PCK is foundational to the TPACK framework, researchers must clearly understand PCK before they can productively understand and effectively measure TPACK constructs.

3.1.2. Parsimony and TPACK's hidden complexity

Those considering the elements in a theory must deal with two competing criteria: comprehensiveness and parsimony (Whetten, 1989). Comprehensiveness calls for including all factors relevant to the phenomena of interest – a particularly difficult task in educational research. In contrast, parsimony calls for simplification by including only factors that have the greatest value in understanding the phenomena. An important challenge of theorist is to be sensitive to the tradeoffs between these two competing values. One of the underlying reasons for the popularity of the TPACK framework is that it has a high degree of parsimony. The model simply represents the interaction between three major knowledge domains (pedagogical, content, and technological), attempting to build on the familiar and heavily researched concept of pedagogical content knowledge introduced by Lee Shulman (1986). Like PCK, TPACK is easy to understand at a surface conceptual level. One intuitively recognizes the importance of integrating knowledge domains related to pedagogy, subject matter, and technology. However, the simplicity of the model hides a deep underlying level of complexity, in part because all of the constructs being integrated are broad and ill-defined.

Referring to the TPACK framework, Angeli and Valanides (2009) directly addressed the challenge this way:

> While it is perfectly understood that the preference for a general model might be directly related to its potential wide applicability in different contexts, the lack of specificity is problematic, because the very important issue of how tool affordances can transform content and pedagogy is not addressed. Also, the framework in its present form does not take into consideration other factors beyond content, pedagogy, and technology, such as, for example, teachers' epistemic beliefs and values about teaching and learning that may be also important to take into account. This simplified or general view, one might argue, may lead to possible erroneous, simplistic, and naïve perceptions about the nature of integrating technology in teaching and learning. (p. 157)

In their introduction of the TPACK framework, Mishra and Koehler (2006) acknowledged the "complex, multifaceted, and situated nature" of the proposed TPACK constructs (p. 1017). The challenges associated with the underlying complexity of TPACK are so daunting that it has been referred to as a "wicked" problem (Borko, Whitcomb, & Liston, 2008; Koehler & Mishra, 2008; Mishra & Koehler, 2007). The path forward for reaching a balance between parsimony and complexity for the TPACK model is not clear. However, it is clear that in order for the model to be viable long term, it must lead researchers and practitioners to understand the constructs in more depth without becoming so complicated that it is inaccessible to all but a few elite researchers.

3.1.3. Precise definitions

Precise definitions are essential to a coherent theory. Theory building research should help to shape the definitions of constructs in a theoretical model so that consensus among researchers begins to increase. Without common terms and definitions to work from, researchers may generate a large bulk of findings that don't cohere in any meaningful way (Burkhardt & Schoenfeld, 2003). Evidence from recent research literature points to the fact that TPACK definitions are "fuzzy," lacking sufficient clarity to give a reader confidence in what the constructs represent. Angeli and Valanides (2009) stated, "TPCK's degree of precision needs to be put under scrutiny. The degree of precision of a construct refers to the discriminating value of the construct and has important implications for its development and assessment" (p. 157).

Additionally, in 2008 Cox did a comprehensive conceptual analysis of the TPACK research literature and found 13 distinct definitions for TCK, 10 definitions for TPK, and 89 different definitions for TPACK in the reviewed literature. The differences identified were not minor differences: Many had major implications for understanding and measuring the constructs. The imprecision in defining TPACK constructs has allowed a proliferation of research to be conducted with very few studies making a substantive contribution to the development of the theoretical framework. In many published articles, the term *TPACK* could be substituted with the words *technology integration* without any significant change in meaning. What differentiates the constructs TCK and TPK from other constructs varies widely in articles. For example, pedagogical knowledge considerations are often mentioned in the context of TCK despite the fact that PK does not contribute at all to TCK according to the framework (i.e., there is no overlap between PK and TCK in the model).

3.1.4. Example: definition of technology

Defining what is meant by *technological knowledge* is an example of the current lack of clarity in the TPACK framework. TPACK adds technological knowledge as a third knowledge domain to the PCK framework (see Fig. 1). The definition of technology has failed to clearly delineate the scope of TPACK and designate its meaningful additions to the PCK framework. Koehler and Mishra did not distinguish between the types of technology encompassed within TK (Koehler & Mishra, 2008; Mishra & Koehler, 2006). (They included older technologies like the pencil and chalkboard as well as newer digital technologies). According to this expansive perspective, every teaching situation would require TPACK because one doesn't typically teach without using some kind of tool.

Defining and limiting the scope of how technological knowledge is perceived is important for clarity of the framework. For example, many instructional technologists have very broad conceptions of what technology is and consider technology to be not only physical devices but also processes applied to solving problems (Smaldino, Russell, Heinich, & Molenda, 2005). Thus irrigation is a "technology" used to water dry land far from natural sources, and programmed instruction is a "technology" for teaching. The first *Handbook of Research on Educational Communications and Technology* even had separate sections dedicated to "hard technologies" (e.g., tools, devices, hardware, etc.) and "soft technologies" (e.g., methods, processes, etc.) (Jonassen, 2004).

Because of the lack of definitional clarity, some researchers have attempted to make the definition and scope of the "technological knowledge" under investigation explicit in their research by identifying a particular flavor of TPACK. For example, Angeli and Valanides (2009) used the term ICT-TPCK to represent a focus on the use of information and communication technologies (ICT); Lee and Tsai (2010) used the term TPCK-W to represent a focus on web technologies; and Doering et al. used the term G-TPACK to represent a focus on geospatial (geographic) technologies (Doering, Scharber et al., 2009; Doering & Veletsianos, 2007; Doering, Veletsianos, et al., 2009).

The definition of technology in the framework is important because the rationale for introducing TK as a distinct knowledge domain to be added to PCK hinges on it how it is defined. Mishra and Koehler (2006) stated that "until recently, most technologies used in classrooms had been rendered 'transparent' (Bruce & Hogan, 1998), or in other words, they had become commonplace and were not even regarded as technologies" (p. 1023). For this reason, technology was implicit in researchers' conceptions of PCK. Technology could be considered a part of knowledge of content representations or even curriculum and media. Shulman (1986) explained that the concept of curricular knowledge was included in the larger concept of content knowledge. *Curricular knowledge* was defined as teachers' knowledge of the available educational tools and materials including software, programs, visual materials, and films. Angeli and Valanides (2009) contended that Shulman intended for technology to be included in his PCK framework but "did not *explicitly* 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).

Cox (2008) attempted to address the technology definition issue by making a distinction between *transparent technologies* and *emerging technologies*. She defined transparent technologies as technologies like the pencil, the chalkboard, the book, etc. used ubiquitously in a particular classroom context. In Cox's interpretation of the TPACK framework, the use of these *transparent* technologies is part of the PCK construct. Emerging technologies are defined as new technologies (typically digital technologies) that are being investigated or introduced into a learning environment. The use of these *emerging* technologies is made explicit in the four additional TPACK constructs: TK, TPK, TCK, and TPACK. Cox's elaboration is pragmatic because it allows transparent technologies that are not the focus of a particular analysis to be encompassed within PCK while the emergent technologies are emphasized within the new TPACK constructs. Thus researchers can use similar criteria for distinguishing between TPK, TCK, and TPCK as they do for PK, CK, and PCK with the primary difference being the integration of an emerging technology.

3.2. The how

The second criterion that Whetten (1989) defined as essential to theory development entails articulating *how* the elements of the theory relate to one another. These relationships between variables may or may not be causal. Researchers must address two issues to understand the relationships among constructs in the TPACK model. The first issue is whether the relationship between the elements is integrative or transformative. The second issue has to do with defining boundary conditions between elements in the model to enable clear discrimination between constructs.

3.2.1. Integrative versus transformative models

Gess-Newsome (2002) identified a continuum of positions among researchers on the nature of PCK that also relates to understanding the TPACK model. At one end of the spectrum is what she called the "integrative" perspective, which defines PCK as the combination or mixture of different types of knowledge. She represented this perspective using a Venn diagram which emphasizes areas where different categories of knowledge overlap (see Fig. 2 for an example). The "transformative" perspective, at the other end of the spectrum, considers PCK as a new synthesized form of knowledge that cannot be explained by the sum of its parts. Gess-Newsome (2002) visually represented this perspective using a block diagram with arrows (see Fig. 2 for an example). One area of potential confusion with the current dominant representations

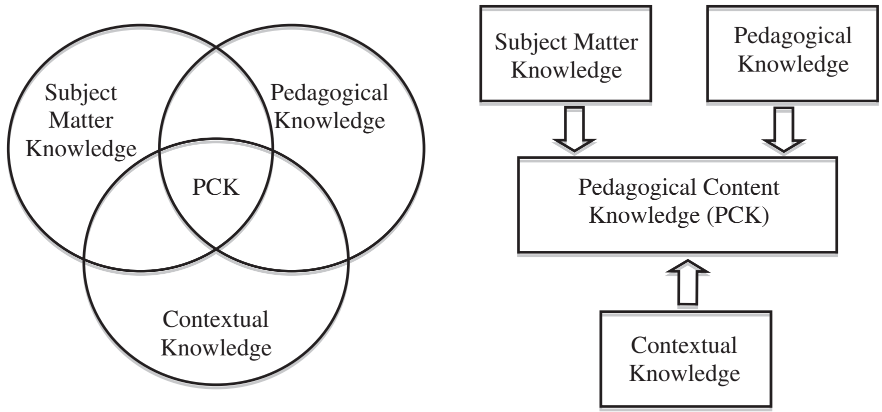

Fig. 2. Visual representations from Gess-Newsome (2002, p. 12) of integrative (left) and transformative (right) models of pedagogical content knowledge (PCK).

of the TPACK framework is use of the Venn diagram (see Fig. 1) representing an integrative model while the language outlined by Mishra and Koehler (2006) implies a more transformative understanding of the constructs.

A wide range of integrative to transformative perspectives exists in the current research literature. The uncertainty about the nature of TPACK derives from the uncertainty in the theoretical model. Angeli and Valanides (2009) articulated this by saying,

> It is not clear from Koehler et al.'s (2007) empirical findings whether TPCK is a distinct form of knowledge or whether growth in TPCK simply means growth in any of the related constructs (i.e., Pedagogical content knowledge, Technological content knowledge, Technological pedagogical knowledge, or even the initial elements of Pedagogy, Content, and Technology). (p. 157)

Many researchers have skirted the transformative versus integrative issue by measuring TPACK as if it were another name for technology integration without making reference to the other elements in the model. Researchers like Guzey and Roehrig (2009), Doering, Scharber, et al. (2009) and Doering, Veletsianos, et al. (2009), and even Koehler, Mishra, and Yahya (2007) have taken an integrative approach by collecting evidence of TK, PK, and CK and using that data to infer existence of TPACK and other constructs. Mouza and Wong (2009) combined the transformative and integrative approaches by first looking for evidence of six TPACK constructs (i.e., PK, CK, PCK, TK, TPK, & TCK) as if they were distinct constructs (transformative approach) and second claiming the combination of the six elements indicate the existence of TPACK.

Understanding whether the constructs in the TPACK model are transformative or integrative is particularly important for those trying to establish construct validity for instruments that measure TPACK. To date, only a few researchers have created surveys and made attempts to use factor analysis to establish the construct validity of their instruments (Archambault & Barnett, 2010; Archambault & Crippen, 2009; Burgoyne, 2010; Lee & Tsai, 2010; Lux, 2010; Schmidt, Baran, & Thompson, 2009). Factor analysis seeks to establish both convergent and discriminant validity of instruments (Hair, Black, Babin, Anderson, & Tatham, 2006). The underlying structural model used for the analysis (including possible second order factors) depends on whether the researcher considers the relationship between constructs to be integrative or transformative. With the exception of a recent confirmatory factor analysis completed by Lux (2010) most instruments to date have not been able to establish an acceptable level of discriminant validity for the TPACK constructs (Archambault & Barnett, 2010; Archambault & Crippen, 2009; Burgoyne, 2010; Schmidt et al., 2009).

3.2.2. Construct boundary issue

> The boundaries between some components of TPCK, such as, for example, what they define as Technological content knowledge and Technological pedagogical knowledge, are fuzzy indicating a weakness in accurate knowledge categorization or discrimination, and, consequently, a lack of precision in the framework. (Angeli & Valanides, 2009, p. 157)

Many researchers who have made serious attempts at measuring TPACK constructs have been challenged by the difficulty the model presents in distinguishing boundaries between the constructs in the model (Angeli & Valanides, 2009; Archambault & Oh-Young, 2009; Archambault & Barnett, 2010; Burgoyne, 2010; Cox, 2008; Cox & Graham, 2009; Graham et al., 2009). While closely related to the issue of precise construct definitions, this issue goes further by indicating that the definitions must allow for discrimination between constructs – especially constructs that share a boundary in the model. Thus researchers should be able to distinguish PCK from TPACK, TPK from TPACK, TCK from TPK, and so on. After extended efforts to develop and validate an instrument to measure all the TPACK constructs, Archambault and Barnett (2010) were successful only in clearly identifying one factor that they identified as knowledge of technology. They concluded,

> Although the TPACK framework is helpful from an organizational standpoint, the data from this study suggest that it faces the same problems as that of pedagogical content knowledge in that it is difficult to separate out each of the domains, calling into question their existence in practice. (p. 1659)

Cox (2008) also found boundary conditions of the TPACK constructs to be unclear. An early phase of her conceptual analysis identified in detail the boundary conditions problematic to distinguishing between adjacent constructs in the TPACK framework. She followed the analysis up by trying to build a conceptual model with clearer definitions and boundary conditions. She attempted to stay true to the "essence" of the constructs while creating "précising definitions" that drew more sharply the boundary conditions for each construct.

However, there is very little evidence that her attempt to clarify TPACK construct boundaries have influenced the precision with which other researchers have tried to define their constructs.

3.3. *The why*

The third critical aspect of theory development is to clearly articulate the rationale for the theory and the underlying assumptions that give credence to it. For the TPACK framework, one must ask what additional value TPACK adds to the previously existing PCK framework and what contribution the TPACK framework purports to contribute to the body of technology integration research. Mishra and Koehler (2006) have effectively started the conversation. One of their more important rationales is articulated as follows:

> One of the most frequent criticisms of educational technology is that it is driven more by the imperatives of the technology than by sound pedagogical reasons…. The TPCK framework, we argue, has given us a language to talk about the connections that are present (or absent) in conceptualizations of educational technology. In addition, our framework places this component, the relationship between content and technology, within a broader context of using technology for pedagogy. (p. 1044)

Having a common language to talk about issues of technology integration is an important start that has been discussed at length in the previous sections of this paper. This section will highlight two issues related to the value of the framework that need to be addressed more closely by researchers. First, the construct value issue has to do with establishing the theoretical value for all constructs in the model. Second, researchers need to better articulate the prescriptive value or potential of the framework.

3.3.1. *Construct value*

The essence of the construct value issue is the need to clearly establish the value of each construct in the TPACK framework and to articulate how the TPACK constructs relate to other widely used terms such as *technology integration*. If these questions are unanswered, TPACK could become another generic term for technology integration, with perhaps some added emphasis on content knowledge. Many of the currently published articles that cite TPACK as a research framework do not emphasize the unique and distinguishing characteristics of the framework, but rather conflate TPACK with the term *technology integration*.

To help in understanding this issue, consider the two possible representations of TPACK in Fig. 3. Both of these models represent TPACK as the combination of PK, CK, and TK. However, the model on the right adds three constructs (TPK, TCK, and PCK) and nine boundary conditions to the model on the left. It is up to researchers to show that the added complexity of the model actually contributes theoretical value to the understandings and propositions that can be developed from the model. Perhaps one of the reasons that most researchers do not even mention the added constructs is because this difficult theoretical work has not been adequately articulated.

One example of how the added constructs can increase value is in distinguishing TPACK from technology integration in a more clear, robust way. The TK, TPK, and TPCK constructs are of particular importance to researchers of educational technology. These boundaries highlight the evolution of the educational technology field and the growing importance of content-specific applications of technology. Earlier, educational technology research was mostly TK focused: The emphasis was on technical skills independent of pedagogy or content (Graham, Culatta, Pratt, & West, 2004; Hargrave & Hsu, 2000; Willis & Mehlinger, 1996). The focus soon shifted to technology integration, which emphasized knowing how to use technology in a teaching context, a perspective that included aspects of TPK and TPCK. However, TPK was typically the primary focus because technology integration courses tended to be taught by generalists, and skills were not integrated with content-specific methods courses. The emergence of the TPACK framework emphasizes the distinction between technology integration focused on general pedagogy (TPK) and technology integrated with content-specific pedagogy (TPCK) in the way that the PCK framework distinguished between PK and PCK (see Fig. 4).

Understanding the different dimensions of technology integration (from general to content-specific) allows programs and instructors to begin thinking about different instructional interventions and paths for reaching their goals (Niess, 2008; Niess & Scholz, 1999; Suharwoto, 2006). Researchers must do a better job of articulating the value of the constructs TPK, TCK, and PCK, including their theoretical value, so that they are not routinely ignored in the research.

3.3.2. *Prescriptive value*

To date, researcher energy has been devoted more to the descriptive value than to the prescriptive value of the TPACK framework. A theoretical model has value not only in its power to help describe a phenomenon, but also in the way it facilitates one's ability to develop

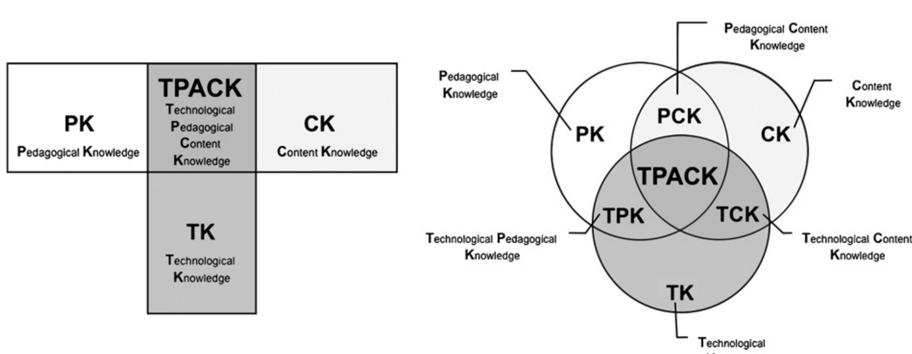

Fig. 3. Two different models combining PK, CK, and TK.

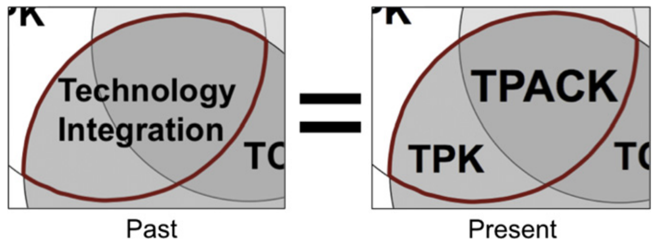

Fig. 4. Using the TPACK framework to understand the term *technology integration*.

interventions that will predictably influence the phenomenon. Archambault and Barnett (2010) expressed some frustration with the model's potential to yield predictive knowledge,

> In addition to weaknesses in TPACK's precision and heuristic value, the framework is also limited in its ability to assist researchers in predicting outcomes or revealing new knowledge. While it focuses on three major areas of teaching, namely content, pedagogy, and technology, it does not represent the causative interaction or the direction of the relationship between and among these domains. This makes it difficult for TPACK to be a fruitful model, as it does not suggest problems for solving or hypotheses for testing within the field of educational technology. (pp. 1660–1661)

While the relationship between constructs in the framework is really more descriptive, hypotheses could be developed that predict the relative value of different approaches to developing TPACK, as well as the impact of teachers with strong TPACK, PCK, or TPK on measures of student learning.

For example, university instructors and inservice trainers would benefit from knowing whether it is more or less effective to move from TPK to TPCK or just to begin with TPCK (Koehler, Mishra, Kereluik, Shin, & Graham, in press). Additionally, the path to reaching TPCK might depend on the audience. Some might hypothesize that it is more effective to learn content-specific pedagogies and supporting technologies simultaneously. Others might hypothesize that it is best for preservice teachers to begin with TPK and move to TPCK because of the cognitive overload associated with learning new technologies and content-specific pedagogies all at once. Similarly, some might hypothesize that the most effective process for inservice teachers would be to move from PCK to TPCK because of their prior experience with content-specific pedagogies.

4. Conclusions

The technological pedagogical content knowledge (TPACK) framework has the potential to provide a strong foundation for future technology integration research. A strong TPACK framework can also provide theoretical guidance for how teacher education programs might approach training candidates who can use technology in content-specific as well as general ways. However, in order for that potential to be realized, researchers must work together to shore up weaknesses in the clarity of TPACK construct definitions and in articulating ways that the constructs are related to each other. In particular, researchers must clarify the boundary conditions that enable one element in the framework to be distinguished from adjacent elements. Additionally, researchers must establish clearer rationales for why each construct in the framework is essential and how they all contribute to a better understanding of issues faced by practitioners. This article has identified several specific areas where theoretical development and clarity are imperative. If the theoretical issues in this article can be adequately addressed, research around the TPACK framework will be strengthened and the likelihood for long-term viability of the theoretical framework will be increased.

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