PCK and TPCK/TPACK: More than Etiology

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Abstract: In this review of multiple reinterpretations of TPCK/TPACK that have emerged over time, we trace the construct's roots not only to PCK, but more importantly to Shulman's (1987) knowledge base for teaching, within which PCK was originally situated. We suggest that TPACK is a special case of PCK that sits within the considerably broader knowledge base for teaching, basing this assertion upon Cox's (2008) explanation of the differences between teachers' PCK and TPACK. Following Cox, we argue that TPACK references only the specific nature of a teacher's PCK when unfamiliar digital tools are considered and implemented for educational purposes. We recommend that TPACK researchers distinguish among the different categories of teachers' knowledge, reasoning, and action more clearly, bounding TPACK more narrowly in ways that mirror how Shulman delineated PCK with reference to the six other components comprising his knowledge base for teaching.

Teaching is much more than simply telling (Loughran, 2013); close examination of teachers' work reveals that teaching is an "outrageously complex activity" (Shulman, 1987, p. 11). To better understand the work of expert teachers, Shulman (1987) conceptualized a knowledge base for teaching, which comprised content knowledge, general pedagogical knowledge, curriculum knowledge, pedagogical content knowledge, knowledge of learners and their characteristics, knowledge of educational contexts, and knowledge of educational ends, purposes and values. Of the seven categories proposed by Shulman (1986) "subject matter [and pedagogical knowledge] *for teaching*" (pp. 9, 14), or pedagogical content knowledge (PCK), has captured the most attention from educational researchers for more than 30 years. Since Shulman (1987) first described PCK as the type of knowledge "most likely to distinguish the understanding of the content specialist from that of the pedagogue" (p. 8), it has generated more than 17,000 citations. Yet despite Shulman's careful efforts to delineate the knowledge base that underpins "the complexities of the pedagogical process" (p. 20), changes in contextual factors influencing teacher knowledge development and expression challenge the notion of this list of interrelated knowledge types and forms as bounded and finite.

The Changing Knowledge Base for Teaching

Shulman recognised the probable limitations of creating a comprehensive depiction of teachers' knowledge, reminding readers that "a knowledge base for teaching is not fixed and final," predicting that "much, if not most, of the proposed knowledge base remains to be discovered, invented, and refined." He also suggested that "our current 'blueprint' for the knowledge base of teaching has many cells or categories with only the most rudimentary place-holders, much like the chemist's periodic table a century ago" (Shulman, 1986, p. 12). Other depictions of teacher knowledge similar to Shulman's were proposed within three years of his first publication on the topic. Valli and Tom (1988) reported that organisations such as the American Association of Colleges for Teacher Education (Scannell, Corrigan, Denemark, Dieterle, Egbert, & Nielson, 1983), the National Council for Accreditation of Teacher Education (NCATE, 1986), and the National Association of State Directors of Teacher Education and Certification (NASDTEC, 1986) "generated similar but more specific categories" (p. 5) of teacher knowledge, when compared to Shulman's knowledge base. These conceptualizations included categories such as teachers' detecting bias in subject matter, awareness of professional ethics, insight into cultural influences on learning, and—important to the work presented here—familiarity with new technologies.

While Shulman (1986) mentions "software" as a component of curriculum knowledge; that is, one of the "curricular alternatives available for instruction" of content (p. 10), the specific articulation of technological knowledge as part of a knowledge base for teaching is largely absent. We propose that while some researchers recognised the potential influence of emerging digital technologies upon teaching and learning at the time (e.g., Bitter & Camuse, 1988; Papert, 1980; Taylor, 1980), it is reasonable to assume that few in the mid-1980's would have predicted the ubiquity and potential utility of educational technologies in classrooms three decades later. The absence of technological knowledge as a specific category in Shulman's original conceptualisation of a knowledge base for teaching is understandable, yet is also an omission that needed to be addressed.

This is not to say that educational technologies were not used in the mid-1980's. Indeed, we would argue that virtually every classroom at the time incorporated a variety of technology, such as pens and paper, chalkboards and chalk, books and visual aids. However, these forms of technology were *transparent* (Cox, 2008) to most teachers. That is, the teachers did not have to think much about how to use these technologies in pedagogical ways, or, indeed, how they may integrate with and influence other aspects of their knowledge for teaching. In contrast, we argue that the availability and unfamiliarity of contemporary digital technologies for learning and teaching require teachers to think about these newer tools in different ways than their more transparent predecessors, rendering newer digital tools comparatively opaque until sufficient pedagogical experience and expertise are built with each. The ubiquity of these *emerging* technologies (Cox, 2008) in many educational contexts requires teachers to think specifically about their educational affordances and constraints as part of their active professional knowledge. What, then, are the connections between teachers' emerging technological knowledge and the seven components of Shulman's (1986) knowledge base for teaching?

Connections between Technological and Pedagogical Content Knowledge

Given the rapid development and diffusion of digital hardware and software, the connections between technological knowledge (TK) and pedagogical content knowledge (PCK) have been conceptualised as technological pedagogical content knowledge (TPCK), which is also known as technology, pedagogy, *and* content knowledge (TPACK). While TPCK began to appear in educational technology literature in the early 2000's (Keating & Evans, 2001; Pierson, 2001; Niess, 2005; Angeli & Valanides, 2005), the construct was less well-known until Mishra and Koehler's representation of TPCK was published in *Teachers College Record* in 2006.

In the years following the appearance of the *TCR* article, TPCK, later to be renamed TPACK (Thompson & Mishra, 2007), has been examined extensively. For example, at a recent PCK and TPACK international symposium (Phillips, Harris, van Driel, Berry and Cooper, 2017), it was reported that there were 2658 publications that used the TPCK/TPACK framework between 2007 and 2016. The contributions from this corpus of work have been many and varied, and our understanding of the development and use of TPCK/TPACK in a variety of educational settings is undoubtedly richer as a result. However, it is important to remember that TPACK, like PCK, is just one part of a much broader knowledge base for teaching.

Changing Notions of TPCK/TPACK

Our examination of the extant TPCK/TPACK literature suggests that this particular point has been lost in the flurry of focus upon the nature and development of this construct since 2005. While the components of different models of TPACK are somewhat similar—most incorporate teachers' technological, pedagogical, content/curriculum, and contextual knowledge, and all acknowledge these aspects' interdependence to some extent—the representations can differ markedly. For example, in the same publication year, Angeli & Valanides (2009) depicted TPCK as the central intersection of five distinct components of teachers' knowledge (Figure 1), while Koehler and Mishra (2009) depicted TPACK as four components that all intersect with each other, forming seven interrelated forms of teacher knowledge, all of which are contextually situated (Figure 2).

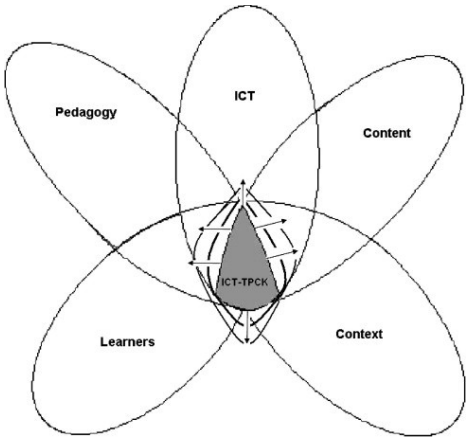

Figure 1. "ICT-TPCK" (Angeli & Valanides, 2009, p. 159)

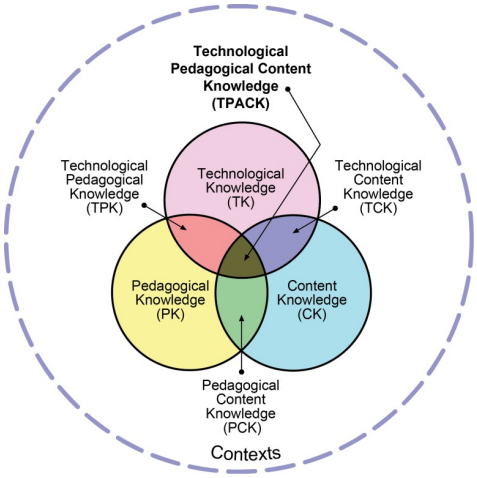

Figure 2. "The TPACK framework and its knowledge components" (Koehler & Mishra, 2009, p. 63)

More importantly to the focus of this paper, as researchers discovered and began to use the earlier depictions of the TPCK/TPACK construct, more than a few proposed sizable changes to the elements included. Several examples that illustrate this trend appear and are described below.

TPACK-deep

Yurdakul, Odabasi, Kilicer, Coklar, Birinci and Kurt (2012) used exploratory and confirmatory factor analyses of 995 Turkish preservice teachers' self-reported knowledge to develop a scale that redefined the teachers' TPACK to comprise *design:* "creating and developing curriculum plans [for] teaching and learning environments as well as combining appropriate technological tools and resources to maximize learning in content," *exertion:* "implementing design plans and facilitating a variety of effective assessments and evaluations by applying appropriate technologies," *ethics:* "exhibiting legal and ethical behavior in the use of technology in teaching and learning environments," and *proficiency:* "improv[ing] and exhibit[ing] teacher leadership ability to integrate technology into the teaching and learning process by promoting and demonstrating the effective use of technological resources" (p. 973). They named this construct "TPACK-deep" (Figure 3, p. 973).

Figure 3. "The framework and factors of TPACK-deep scale" (p. 973)

TPACK-XL

Saad, Barbar and Abourjeili (2012) expanded Angeli & Valanides' (2005) TPCK to include "thirty-one constituent knowledge constructs" that represent "*the amalgamation of contributing disciplines* to building preservice teacher knowledge base" (emphasis added, p. 51). Their TPACK-XL construct, illustrated in Figure 4, comprises preservice teachers' intersecting knowledge of "educational technology," "pedagogy & didactics," "educational psychology," "educational sociology," and the teachers' "academic discipline" knowledge (p. 50).

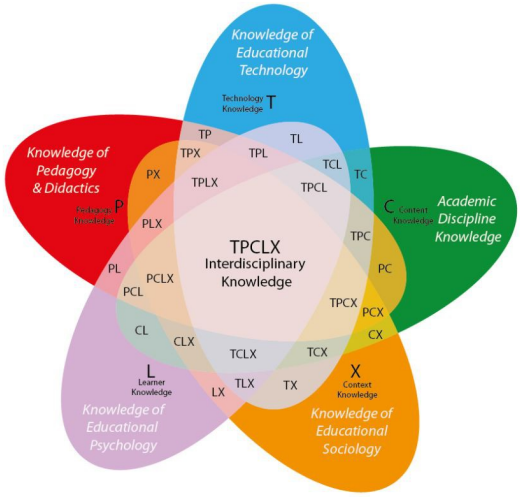

Figure 4. "The Proposed TPACK-XL Theoretical Framework Model" (p. 50)

TPACK-practical

Yeh, Hsu, Wu, Hwang and Lin (2014) used a Delphi technique with six researchers and 54 science educators to develop and validate an eight-dimension model of inservice teachers' knowledge that they called "TPACK-Practical." This depiction is "knowledge- and experience-based, delineating the *practical TPACK* that experienced teachers have developed from years of teaching practice" (emphasis added, p. 711). The eight knowledge dimensions encompassed "knowing one's learners, comprehending subject content, designing a curriculum, engaging [in] practical instruction and evaluating students' progress," viewing "TPACK not only as a coherently woven body of knowledge, but also something further because it incorporates rounds of knowledge transformation" (pp. 716, 718), as depicted in Figure 5.

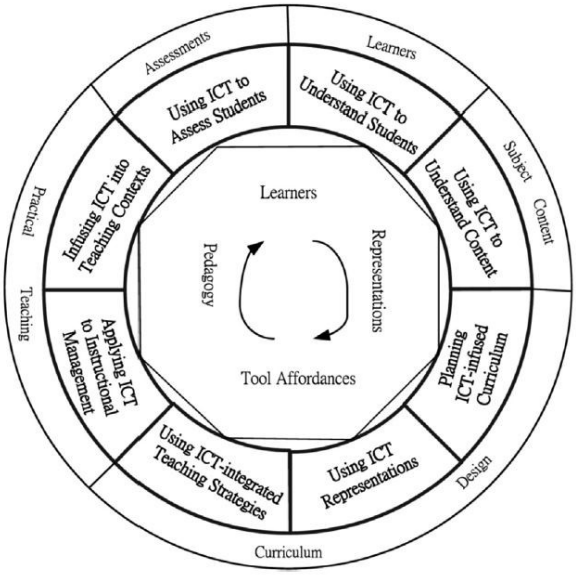

Figure 5. "The framework of the TPACK-Practical model" (p. 99)

Other Additions to TPACK

Still other researchers have proposed modified or expanded definitions of TPACK that differ by discipline (e.g., TPSK, or technological pedagogical statistical knowledge; Lee & Hollenbrands, 2011), by type of learning design (e.g., TPACK-DBL for design-based learning; Baran & Uygun, 2016), by learning goals (e.g., TPACK + CAPb for 21st-century general capabilities; Groenewald, Carey, Lloyd, & Trinca, 2016), and by technologies used (e.g., TPACK-Web; Lee & Tsai, 2010).

We have selected all of these examples purposefully. Note that these depictions of TPACK stretch well beyond the simple addition of technology knowledge to Shulman's definition of PCK as "that special amalgam of content and pedagogy that is uniquely the province of teachers" (1987, p. 8). These TPACK variants incorporate aspects of teachers' "knowledge of learners and their characteristics," "knowledge of educational contexts," and "knowledge of educational ends, purposes and values," all of which were part of Shulman's (1987, p. 8) conceptualization of the broader knowledge base for teaching, but not dimensions of PCK itself. They also include aspects of Shulman's (1987) notions of pedagogical reasoning and action, within which teachers' knowledge, including their PCK, is used. To Shulman, pedagogical reasoning and action comprises 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 (Harris & Phillips, 2018). In redefining TPACK repeatedly to encompass ever-increasing numbers of components, it appears that the construct is being reshaped over time in an attempt to represent all of teachers' knowledge, reasoning, and action. This does not reflect what Shulman (1986; 1987) envisioned when he proposed a seven-part knowledge base for teaching, of which PCK was only one component.

The overlapping, ever-expanding concepts reflected in the multiple versions of TPACK described above contribute to the often-referenced imprecision of the TPACK construct (e.g., Archambault & Barnett, 2010; Graham, 2011). If we can distinguish among the different categories of teachers' knowledge, reasoning, and action more clearly, bounding TPACK more precisely in the way that Shulman did when describing PCK, perhaps we can re-contextualize, re-center, and invigorate future TPCK/TPACK-based inquiry in ways that will help to clarify this fuzzy construct.

Transparent (PCK) vs. Emerging (TPACK) Knowledge

To this end, we suggest that *TPACK is a special case of the PCK that sits within the considerably broader knowledge base for teaching.* We base this assertion upon Cox's (2008) explanation of the differences between PCK and TPACK. Cox introduced the "perception of TPACK as a sliding framework." Her detailed construct analysis found that TPACK functions as a "temporary framework" when teachers consider using unfamiliar, or "emerging" technologies (p. 99) as part of their classroom practice. Emerging technologies in this conceptualization are defined as those that are new to the teacher considering them for pedagogical use, but not necessarily new to other teachers who have more experience using the same technologies.

For example, when first introduced to a database program, a teacher needs to consider how asking her students to use this form of technology may influence her pedagogical approaches and assumptions. How, for example, might using (and perhaps populating) a database help students to encounter curriculum content in different forms and ways than what they have experienced before? What opportunities might it provide for them to work collaboratively with other students, sharing differing topic-related information? How might it assist student-centered learning? How can specific curriculum standards be met when the information that different students encounter when working with entries in a database varies? In considering these types of questions and their implications for professional practice with an unfamiliar educational technology, we argue that this teacher is developing and using TPACK. If the same teacher were planning or using a tool or resource with which she had considerable prior instructional experience, she would be using her PCK, rather than her TPACK. If PCK encompasses knowledge that informs the educational use of familiar, or transparent (Cox, 2008) pedagogical materials and tools, then *TPACK references the specific nature of a teacher's PCK when unfamiliar tools are considered and implemented for educational purposes.*

Over time, this teacher will become more familiar with the affordances and constraints of the technology (TK), the particular curriculum content learning that the technology can best facilitate (TCK), and the pedagogical methods and approaches that are effective when helping students to learn with this particular tool (TPK). She will come to understand different methods that she can use with database software to help her students learn in different ways. As this occurs, the teacher's awareness of this new technological (TK), technological content (TC), and technological pedagogical (TP) knowledge will diminish, with her thinking about her practice becoming less focused upon the implications of using this new tool over time. At this point, the teacher's knowledge is arguably better represented in the way Shulman (1986) first defined PCK; as Cox said, "thus, TPACK becomes PCK as the technology becomes transparent" (2008, p. 99).

Recommendations

The temporal continuum between emerging and transparent technologies—that is, between TPACK and PCK as they change for each teacher as professional learning and experience build over time—is a powerful idea that can help us to position TPACK more precisely in the broader knowledge base for teaching as a special case of PCK. Given the continuing emergence of new digital tools and resources, PCK and TPCK/TPACK will probably be aspects of the knowledge base for teaching for the foreseeable future, because, as Cox (2008) asserts, "there will always be a need for TPACK as long as there are new emerging technologies that have not yet become a transparent, ubiquitous part of the teaching profession's repertoire of tools" (pp.78-79).

As such, it is arguably helpful for teacher educators to determine the comparative transparent or nascent nature of *specific* teachers' use of *particular* technologies in *particular* educational contexts at the distinct times when they are used and studied. This situated approach can help us to more fully understand the nature of the teachers' TPACK, both alone and in relation to the other aspects of the professional knowledge base, and therefore the ways in which TPACK (and related knowledge) can develop as a result of professional learning and experience. Learning to use a familiar/transparent technology as a pedagogical tool is probably a much different knowledge-building process than learning to use an unfamiliar/emerging technology in regular educational practice. Similarly, using a technology pedagogically is quite different from using it in preparation for teaching, so corresponding knowledge development processes may differ markedly between inservice and preservice teachers. If these differences are not considered when the nature and development of teachers' TPACK is researched, studies' findings could easily overgeneralize both, leading to incomplete understanding of how best to assist the TPACK development process.

These ideas suggest several intriguing foci for future research. How might the differences between transparent and emerging technologies be discerned for individual teachers? What is the nature of the developmental trajectories for each, and are they similar or different across teachers? If the conceptualization of TPACK is constrained in the ways suggested above, which, if any, of the other components of the knowledge base for teachers also need to be redefined in light of teachers' emerging technology knowledge? If TPACK is redefined more narrowly within the larger notion of a knowledge base for teaching, as recommended here, what would it now encompass? Might the measurement of teachers' TPACK according to this new definition be more consistently reliable and valid across studies? Might the strategies best used to develop preservice and/or inservice teachers' technology-related professional knowledge change?

We urge our readers to consider using the ideas shared in this paper, with hopes that our suggested reconceptualizations will help future TPACK-based research to manifest increased clarity and coalescence.

References

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. doi:10.1016/j.compedu.2008.07.006

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

Archambault, L. M., & Barnett, J. H. (2010). Revisiting technological pedagogical content knowledge: Exploring the TPACK framework. *Computers & Education, 55*(4), 1656– 1662. doi:10.1016/j.compedu.2010.07.009

Baran, E., & Uygun, E. (2016). Putting technological, pedagogical, and content knowledge (TPACK) in action: An integrated TPACK-design-based learning (DBL) approach. *Australasian Journal of Educational Technology, 32*(2), 47-63. doi:10.14742/ajet.2551

Bitter, G.G., & Camuse, R. A. (1988). *Using a microcomputer in the classroom.* Upper Saddle River, NJ: Prentice Hall.

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

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

Groenewald, D., Carey, P., Lloyd, M., & Trinca, G. (2016, May 17). *Revitalising our methods for teaching effectively with technology* [Community contribution]. Retrieved from https://au.educationhq.com/news/34725/revitalising-our-methods-for-teaching-effectively-with-technology/#

Harris, J., & Phillips, M. (2018, March). *If there's TPACK, is there technological pedagogical reasoning and action?* Paper presented at the Society for Information Technology & Teacher Education International Conference 2018, Washington, D.C.

Keating, T. & Evans, E. (2001). Three computers in the back of the classroom: Preservice teachers' conceptions of technology integration. In J. Price, D. Willis, N. Davis & J. Willis (Eds.*), Proceedings of SITE 2001--Society for Information Technology & Teacher Education International Conference* (pp. 1671-1676). Retrieved from https://www.learntechlib.org/p/17023/

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education, 9*(1), 60-70. Retrieved from https://citejournal.s3.amazonaws.com/wp-content/uploads/2016/04/v9i1general1.pdf

Lee, H. S. & Hollebrands, K. F., (2011). Characterising teachers' knowledge for teaching statistics with technology. In C. Batanero, G. Burrill, & C. Reading (Eds.), *Teaching statistics in school mathematics: Challenges for teaching and teacher education* (pp. 359–369). New York: Springer Science + Business Media.

Lee, M., & Tsai, C. (2010). Exploring teachers' perceived self-efficacy and technological pedagogical content knowledge with respect to educational use of the World Wide Web. *Instructional Science, 38*(1), 1–21. doi:10.1007/s11251-008-9075-4

Loughran, J. (2013). Pedagogy: Making sense of the complex relationship between teaching and learning. *Curriculum Inquiry, 43*(1), 118-141. doi: doi:10.1111/curi.12003

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

National Association of State Directors of Teacher Education & Certification. (1986*). Standards for state approval of teacher education.* Salt Lake City, UT: NASDTEC.

National Council for Accreditation of Teacher Education. (1986). *Standards, procedures, and policies for the accreditation of professional teacher education units*. Washington DC: NCATE.

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

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

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

Phillips, M. (Chair), Harris, J., van Driel, J., Berry, A., & Cooper, R. (2017, November). *Unpacking teacher knowledge*, Symposium conducted at Monash University, Melbourne, Australia.

Saad, M., Barbar, A. M. & Abourjeili, S. (2012). Introduction of TPACK-XL, a transformative view of ICT-TPCK for building pre-service teacher knowledge base. *Turkish Journal of Teacher Education, 1*(2): 41-60.

Scannell, D., Corrigan, D., Denemark, G., Dieterle, L., Egbert, R., & Nielson, R. (1983). *Educating a profession: Profile of a beginning teacher.* Washington, DC: American Association of Colleges for Teacher Education.

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

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

Taylor, R. P. (Ed.). (1980). *The computer in school: Tutor, tool, tutee.* New York: Teachers College Press.

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

Valli, L., & Tom, A. R. (1988). How adequate are the knowledge base frameworks in teacher education?.*Journal of Teacher Education, 39*(5), 5-12. doi:10.1177/002248718803900503

Yeh, Hsu, Wu, Hwang, & Lin (2014). Developing and validating technological pedagogical content knowledge-practical (TPACK-practical) through the Delphi survey technique. *British Journal of Educational Technology, 45*(4), 707-722. doi:10.1111/bjet.12078

Yurdakul, I. K., Odabasi, H. F., Kilicer, K., Coklar, A. N., Birinci, G., & Kurt, A. A. (2012). The development, validity and reliability of TPACK-deep: A technological pedagogical content knowledge scale. *Computers & Education, 58*(2012), 964-977. doi:10.1016/j.compedu.2011.10.012