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Contextual Influences in TP(A)CK Research: Bronfenbrenner and Beyond

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Abstract: This critical review examines the past 15 years of scholarship about contextual influences in TP(A)CK to better understand its theoretical bases. While Bronfenbrenner’s ecological systems theory is usually applied in this work, either implicitly or explicitly, its articulation is most often incomplete and/or inaccurate, with some confusion evident about the nature and foci of multiple, intersecting systems of contextual influences. We argue for a more comprehensive way to theorize context in future TP(A)CK research, using Bronfenbrenner’s systemic explanations of the complex and interdependent aspects of contextual influences and actors. We also recommend additional focus upon indirect, intersectional and sociocultural influences upon teachers’ TP(A)CK-based knowledge and action.

Keywords: context, TPACK, TPCK, ecological systems theory, Bronfenbrenner

INTRODUCTION

“Context is everything.” While credited originally to sociologist Alvin Gouldner (1954) in his examination of work relationships during a wildcat strike at a manufacturing company, this assertion has been used to situate inquiry in many fields, including health care (e.g., Bate et al., 2014), neuro design (e.g., Lotto, 2014), research audiology (e.g. Todd, et al., 2021), counseling (e.g., Bright, 2022), art (e.g., Noland, 2020-2021), and education (e.g., Engel, 2000). As Berliner (2004) said when summarizing more than a decade of research about teachers’ expertise, “Knowledge, for the most part, is contextually bound. Cognitions are connected to actions and to places; they are situated” (p. 203). Educational technology research, however, has remained somewhat myopic regarding context in its focus upon the uses of digital tools and resources for learning and teaching, and the professional development necessary for educators to be comfortable and competent with curriculum-based technology integration in praxis.

Moreover, until recently, educational technology inquiry has largely omitted *theorized* explorations of contextual influences upon technology use by teachers and their students. In this paper, we address this rather threadbare patch within the much larger fabric of educational technology literature, critiquing the conceptual bases of extant theoretical and empirical work that has focused on contextual influences upon teachers’ knowledge and educational use of digital tools and resources. We then suggest a more comprehensive way to characterize context in this segment of educational technology research.

We focus the literature examined here on that which describes teachers’ knowledge for technology integration—specifically, teachers’ technological pedagogical content knowledge, abbreviated TPCK or TPACK (Angeli & Valanides, 2005; Koehler & Mishra, 2005; Niess, 2005; Pierson, 2001), combined as TP(A)CK (De Rossi & Trevisan, 2018). Even early versions of this theoretical construct—which describes a now-popular way to conceptualize and study the professional knowledge that teachers use when incorporating the use of educational technologies into their students’ learning—

referenced teachers' contextual knowledge (e.g., Angeli & Valanides, 2005). This is not surprising, given TP(A)CK's roots in Shulman's (1986; 1987) notions of pedagogical content knowledge (PCK), which acknowledged the contextual nature of teachers' expertise (Cox, 2008).

METHODS

Examining the nature of teachers' contextually influenced knowledge and action seems to be burgeoning somewhat in TP(A)CK scholarship at present. Below, we overview the history of theoretical and empirical research about context in TP(A)CK work, tracing the apparent reasons for this uptick in contextually focused publication, identifying conceptual differences and inconsistencies within this nascent work, and suggesting ways to better align theory with conceptual and data-based inquiry in future TP(A)CK-based research about context. Our aim is to examine and clarify the theoretical bases of contextual influences that have been referenced to date, with hopes of assisting TP(A)CK researchers' future inquiry in this important area. In service of these goals, we have chosen to do a constructively *critical review*: a focused form of research synthesis that "aims to critically analyze the extant literature on a broad topic to reveal weaknesses, contradictions, controversies, or inconsistencies" (Paré et al., 2015, p. 189). In offering a critical analysis of the theoretical bases of extant context-focused TP(A)CK literature and recommendations for future work in this area, we hope to help strengthen future understanding of contextual influences in TP(A)CK.

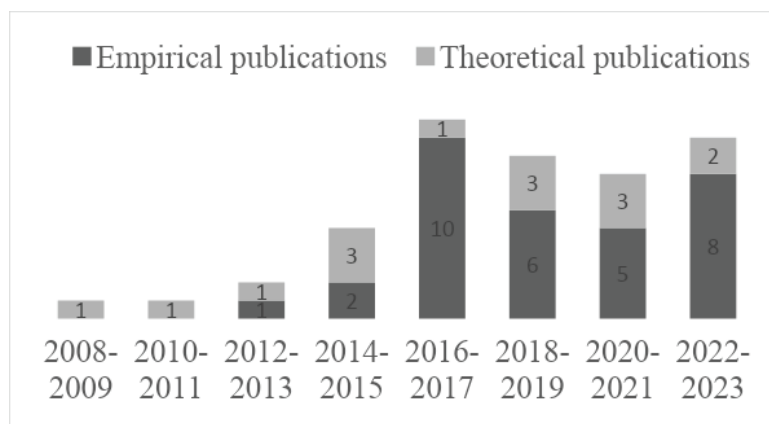
We began this examination of extant literature by determining its parameters: all theoretical and empirical (data-based) peer-reviewed articles and chapters that focus upon context and use TP(A)CK as a primary conceptual framework. Given that our interest is in critically analyzing the theoretical bases of this literature, we limited the selected publications to those that focused upon, rather than merely included, examination of contextual influences, since research that examines multiple TP(A)CK elements would logically not be based in a theory of contextual influence per se. In this, our review differs from three others that have appeared before it, which used either broader literature selection strategies, to include work that examined contextual influences along with other aspects of teachers' TP(A)CK (Brianza et al., 2022; Rosenberg & Koehler, 2015a, 2015b), or TP(A)CK-based research in a particular curriculum area (English language instruction: Greene & Jones, 2020; Greene et al., 2022). We studied these extant literature reviews first and closely. Our analyses of them appear later in this paper.

Then, to locate refereed articles and chapters that focused upon contextual aspects of TP(A)CK, we conducted many searches in Google Scholar, Scopus, and Education Research Complete, using multiple permutations and combinations of the search terms *context*, *contextual*, *ecological*, *bioecological*, *TPCK*, *TPACK*, *technological pedagogical*, *Bronfenbrenner*, *Porras-Hernandez & Salinas-Amescua*, and "*intrapersonal dimension*, *interpersonal dimension*, *cultural/institutional factors*, and *physical/technological provisions*" (Chai et al., 2013, p. 46). We also examined the references cited in all publications located in these searches that addressed our review's specific focus, used Google Scholar to trace other publications that cited these resulting publications, and scoured past issues of the [TPACK eNewsletter](#), which list TP(A)CK publications comprehensively over time. We then winnowed all publications located to those that focused upon context, theoretically and/or empirically.

We organized the results of these comprehensive searches into a set of tables, figures, and reference lists that can be accessed online (<https://tinyurl.com/ContextInTPACK>), given proceedings space considerations. Overall, we found 47 peer-reviewed publications: 32 empirical (data-based research studies) and 15 theoretical examinations of contextual influences in TP(A)CK that were published in peer-reviewed journals and edited books between 2008 and 2023. A graph of these publications appears in Figure 1, which shows how the numbers of context-focused TP(A)CK publications have increased over time, with empirical outnumbering theoretical pieces in most years since 2016.

Figure 1

Frequencies of Context-focused TP(A)CK Publications over Time



CONTEXT IN TP(A)CK

Pierson (2001) was the first to publish research that supported a technology-related extension of Shulman’s PCK (1986; 1987), which she called *technological-pedagogical-content-knowledge* (p. 427). Niess’ (2005) research with pre-service mathematics teachers described their content-focused, *technology-enhanced PCK (TPCK)* (p. 509) as “an overarching conception of their subject matter with respect to technology and what it means to teach with technology” (p. 510).

One month later, the results of Angeli & Valanides’ (2005) early design experiments with preservice teachers were published, in which the authors proposed an instructional design model that was based upon the students’ *ICT-related PCK* (p. 292). It was this conceptualization of teachers’ technology integration knowledge that first included named contextual elements—in this case, “knowledge of the context within which the instruction will take place such as school values, norms, and expectations” (p. 298). The authors made a strong case against teacher educators using then-extant instructional design models, which they saw as “generic and decontextualized” (p. 295).

In 2008, Koehler and Mishra added contextual knowledge to their TPCK conceptualization and depiction, although they had described contextual influences generally in earlier publications (e.g., Mishra & Koehler, 2006). They explained teachers’ contextual knowledge by saying, in part:

Because teaching is a complex and ill-structured problem, there are few—perhaps no—general principles that apply in every situation. In short, context matters. Solutions to “wicked problems” require nuanced understanding that goes beyond the general principles of content, technology, and pedagogy. A deep understanding of the interactions among these bodies of knowledge, and how they are bound in particular contexts (including knowledge of particular students, school social networks, parental concerns, etc.) imparts the kind of flexibility teachers need in order to succeed. (2008, pp. 22–23)

In the same year, Kelly (2008a; 2008b) published the first two pieces to focus directly on contextual influences in the TP(A)CK model, framed and instantiated with definitions and discussion of digital equity. He explained that context “is one of the most complex, important, and least tangible components” of TP(A)CK “and of any teaching-learning situation” (2008a, p. 52). It is much more than a setting for teaching and learning with technology; “it is an integral part of the process.” To Kelly, context comprises physical settings and objects, plus students’ demographic, “ethnic, socio-economic, cultural, social, psychological, and experiential characteristics,” teachers’ “knowledge, skills and dispositions,” and the “explicit and implicit expectations” (2008a, p. 52) of all who are involved in schooling: students, parents, teachers, and administrators. Moreover, Kelly said, contextual elements interact with and influence each other, forming both opportunities and challenges for learning and teaching.

Five years would then elapse before published explanations of the nature of teachers' contextual knowledge within TP(A)CK would be challenged directly, saying that it was too narrowly defined and generally described (Porrás-Hernández & Salinas-Amescua, 2013). (More on this seminal publication below.) Our analysis seeks to extend this important work conceptually, as its authors urged, and as others (e.g., Brianza et al., 2022) are also doing at present. First, however, we examine contextual aspects of educational technology research that predated even the earliest published depictions of TP(A)CK.

CONTEXT IN EDUCATIONAL TECHNOLOGY RESEARCH

While early educational technology inquiry was decidedly *technocentric*—that is, centered or focused upon the technologies in use, attempting to discover their decontextualized effects (Papert, 1987)—several researchers noted the contextual situatedness of educational technology use and argued for its importance. Speaking about the children's programming language LOGO, for example, Papert described the sociocultural nature of its implementation, explaining that "... children encounter LOGO in a particular way, in a particular relationship to other people, teachers, peer mentors, and friends. They don't encounter a thing, they encounter a culture" (1987, p. 27). He urged educators to consider both the "microculture" of the classroom and/or school in which computers are used and the "larger microculture" (p. 29) of societal (mis)perceptions and attitudes about computer use.

About a decade later, the influential Vanderbilt University Cognition and Technology Group (1996) developed the LTC Framework to assist educational technology researchers with examining *learning technologies in context*. The framework was designed to encourage scholars to examine educational technology-related pedagogical practices within three different types of educational research contexts: *in vitro* (in laboratories), *in vivo* (in individual classrooms and sometimes in schools), and in sets of "connected" (via telecommunications technologies) classes, schools, and communities (p. 810). In sharing this framework, the Vanderbilt Group—like Papert—strongly encouraged other researchers to examine educational technology use systemically; to "study entire systems rather than look only at piecemeal effects" (1996, p. 825).

In the more than 25 years since this call for systemic ways of understanding educational integrations of digital tools and resources was published, comparatively few have appeared in educational technology literature. One of the most promising, however, conceptualizes technology use within an ecological framework, which sees individual teachers' technology-related decisions "... as a consequence of contextual conditions as much as individual choice" (Hammond, 2020, p. 855). Ecological systems regard individuals' decisions and actions as directly and indirectly shaped by the nature of the multiple, interrelated physical and sociocultural systems in which they live and interact. Such interconnected environmental systems are highly integrated and interdependent (Hammond, 2020).

The most-cited ecological systems perspective in educational technology research was conceptualized in successive versions by Urie Bronfenbrenner and colleagues (Hammond, 2020). It focused on systems of nested contextual influences upon individual children's development. Similarly, ecological ways to understand ICT adoption (and lack thereof) in school environments have been asserted by several researchers who conceptualize technologies metaphorically as newer "species" (p. 139) within institutional ecosystems (Zhao et al., 2006), focusing more upon systems than individuals.

A decade ago, an interpretation of part of an earlier version of Bronfenbrenner's ecological systems theory was applied in the influential TP(A)CK publication mentioned earlier (Porrás-Hernández & Salinas-Amescua, 2013), and consequently, TP(A)CK research has begun to take a contextual turn (cf. Burke, 2002, p. 164), with successive publications often echoing aspects of Bronfenbrenner's bioecological theories, even when his work is not cited directly. In the following two sections, we first take a closer look at Bronfenbrenner's ecological systems models, given that current TP(A)CK research about contextual elements and influences often invokes his theoretical work, either directly or indirectly. Then we describe how contextual factors have been theorized in TP(A)CK research.

Bronfenbrenner's Conceptualizations of Context

The study of human development has been strongly influenced by Bronfenbrenner's *ecological systems theory*, which was published in successive versions from the mid-1970s through the early 2000s, ending soon after his death in 2005. Bronfenbrenner (1977; 2005) saw children as active participants within multiple interconnected social systems that influence and shape their development, and that are, in turn, influenced and shaped by the participants who comprise the systems. These include:

- The *microsystem*, which includes all that interacts directly with children in their immediate environments, such as their immediate family members and their school-based relationships.
- The *mesosystem*, which encompasses direct interactions (and resulting influences) between the different aspects of children’s multiple microsystems, such as parent-teacher communication.
- The *exosystem*, which incorporates social structures that indirectly influence children’s development by affecting one or more of the developing child’s microsystems, such as parents’ workplace schedules, school funding allocations, and state achievement testing requirements.
- The *macrosystem*, which comprises the myriad intersectional sociocultural influences upon children’s development, such as socioeconomic status, culture, gender, and race. Macrosystem influences envelop those of micro-, meso- and exosystems.
- The *chronosystem*, which references the changes that occur in all of the bioecological systems that shape children’s development during their lifetimes. These include changes such as primary life transitions (e.g., divorce; adolescence) and national/global events (e.g., war; pandemic illness) that impact children’s experiences and development over time.

Bronfenbrenner’s earlier conceptualizations of his developmental theory—published in the 1970s and 1980s—focused more (but not exclusively) on the contextual factors that influence children’s development. His later work, beginning in 1989, emphasized the person-based processes of human development within systems of direct and indirect interactions, which he termed *proximal processes* (Tudge et al., 2009). These are “...processes of progressively more complex reciprocal interaction between an active, evolving biopsychological human organism and the persons, objects, and symbols in its immediate external environment...over extended periods of time” (Bronfenbrenner & Morris, 1998, p. 996). The nature of these reciprocal processes varies by individual and according to present and past contextual influences, which Bronfenbrenner emphasized by naming the core of his (now) *bioecological theory* as the *Process-Person-Context-Time model* (Tudge et al., 2009). This revision was, in part, a reflection of his concern that context had been over-emphasized in other researchers’ use of earlier versions of his theory (Darling, 2007).

Given the recommendations presented later in this paper, is important to note that Bronfenbrenner’s theoretical work has never focused exclusively on contextual factors in children’s development, even in its earliest versions (Tudge et al., 2009). Unfortunately, multiple citations of his work—including in some TP(A)CK research—misapply his theories. To date, two critical analyses of empirical applications of Bronfenbrenner’s theoretical work have been published, both addressing research about families (Tudge et al., 2009; Tudge et al., 2016). In both examinations, the authors found either incomplete or misapplied aspects of Bronfenbrenner’s ideas. We have noted similar patterns in much TP(A)CK literature, which we will explain below.

DESCRIBING AND DEPICTING CONTEXT IN TP(A)CK LITERATURE

Porras-Hernandez and Salinas-Amescua’s influential 2013 publication addressed TP(A)CK researchers directly, saying that “...the notion of context [in TP(A)CK inquiry] requires further theoretical development to understand its complexity, expand its several dimensions, and make the teacher’s own subjective variables visible as part of the TPACK model” (p. 224), and urging us to consider contextual influences in terms of both scope (“macro, meso, and micro level contexts”) and actor (“students’ and teachers’ contexts”) (p. 228). The authors mention Bronfenbrenner (1999), saying that “some models use concentric spheres to represent context, such as Bronfenbrenner’s ecological developmental model” (p. 228). They later add three such concentric circles to two different models of TP(A)CK, having defined and explained three aspects of scope-related context as:

- *macro*, or “social, political, technological, and economic conditions” (p. 229)
- *meso*, or “the social, cultural, political, organizational, and economic conditions established in the local community and the educational institution” (p. 229) and
- *micro*, or “concerned with in-class conditions for learning. These conditions may involve available resources for learning activities, norms, and policies, as well as the expectations, beliefs, preferences, and goals of teachers and students as they interact.” (p. 230)

Comparing these three definitions with Bronfenbrenner’s five bioecological systems explained earlier suggests that Porras-Hernandez and Salinas-Amescua (2013) were selecting among and narrowing several of Bronfenbrenner’s no-

tions of contextual influences within systems, omitting exo- and chronosystems and redefining micro- and mesosystems. A preponderance of later TP(A)CK researchers then based their context-focused work upon Porras-Hernandez and Salinas-Amescua's selective redefinitions. More on this to follow.

Also, in some ways similar to Bronfenbrenner's emphasis upon the developing child within a series of nested bioecological systems, Porras-Hernandez and Salinas-Amescua (2013) named students and teachers as important *actors* in learning environments and processes, who therefore "should be taken into consideration and become objects of knowledge with their unique inner and external contexts" (p. 231). They argued for a contextually informed understanding of teachers' TPACK that is based less upon "predominantly cognitive," "prescriptive elements" (p. 236) that are delineated separately, and more upon teachers' holistic, biographically and pedagogically influenced, strategic, and contextually developed praxis.

By contrast, the multiple versions of Bronfenbrenner's (bio)ecological systems framework published between 1977 and 2005 continued to focus upon the developing child as the primary actor; the "biopsychosocial person" who is the "center of gravity" (Bronfenbrenner & Morris, 1998, p. 1013) in this model of human development. Teachers, parents, administrators, and others—along with additional contextual elements, such as objects, symbols, and language—were seen by Bronfenbrenner as having influence upon the child, but his framework remained child- and development-centered, rather than contextually focused.

Our review located 18 peer-reviewed publications (11 empirical and seven theoretical) of 47 total pieces published between 2008 and early 2023 that used Porras-Hernandez and Salinas-Amescua's abridged and redefined interpretation of Bronfenbrenner's bioecological systems. This represents 38% of the peer-reviewed literature published to date that focuses specifically upon contextual influences in TP(A)CK. By contrast, only three of the 47 publications (two theoretical and one empirical), or 6%, actively used Bronfenbrenner's conceptualizations of contextual influence.

Uses of Porras-Hernandez and Salinas-Amescua's (2013) Adapted Framework

Three published literature reviews to date have reported on TP(A)CK research that addressed contextual influences. All used Porras-Hernandez and Salinas-Amescua's (2013) conceptualizations of micro-, meso/mezzo-, and macro-systems of contextual influence, though in somewhat different ways. We overview these reviews next, chronologically.

In a systematic review of TP(A)CK research published between 2005 and 2013, Rosenberg and Koehler (2015a; 2015b) used Porras-Hernandez and Salinas-Amescua's adapted framework to identify how, and in what ways, context was examined and interpreted. They found that it was "included in the descriptions, explanations, or operationalizations of TPACK among only 36% (n = 70) of the 193 peer-reviewed, empirical journal articles" examined, and that in those depictions, 84% addressed micro (defined as "classroom") factors, 61% explored meso (defined as "school") factors, 57% examined "teacher" factors, 44% reported "student" factors, and 14% included macro (defined as "societal") factors (2015b, p. 194). They concluded that context was underrepresented in the TP(A)CK work that was examined for the review, despite its importance, and that how context was defined in the work in which it was included was inconsistent. They recommended further, more explicitly and consistently theorized exploration of contextual influences in future TP(A)CK research, and specifically suggested that TP(A)CK researchers might consider drawing upon Bronfenbrenner's bioecological models to support future work.

In a second systematic review of TP(A)CK research published between 2009 and 2019, Greene and Jones (2020) and Greene et al. (2022) examined only empirical research that focused on contextual aspects of English language instruction. Their searches of ERIC, EBSCOhost, JSTOR, and Web of Science yielded 365 publications, of which 24 met all of the STARLITE (Booth, 2006) criteria that they had established. Of those resulting publications, 46.93% addressed "classroom factors (micro)," 22.44% described "school factors (meso)," and 30.16% reported "societal factors (macro)" (Green et al., 2022, p. 90), paralleling Porras-Hernandez and Salinas-Amescua's (2013) definitions. The authors noted that the contextual influences examined in the 24 studies were defined and described quite differently and were more often related to teachers than students. They called for additional critical TP(A)CK work, saying that "...not all grand and universal solutions to technology integration using TPACK are synchronous with local linguistic, educational, social, cultural, and political needs" (p. 92). We agree with this point, as we will explain in the final section of this paper.

In a third systematic review of TP(A)CK research published between 2005 and 2020, Brianza et al. (2022) also used Porras-Hernandez and Salinas-Amescua's micro-meso/mezzo-macro contexts/teacher-student actors framework (2013) initially but distinguished between teachers' "knowledge *in* context" and their "knowledge *of* context" (p. 9), favoring

the latter in line with Mishra's (2019) recent redefinition of contextual knowledge (XK) in TPACK. The researchers asserted the importance of this "shift from approaching teaching and learning environments objectively to addressing teachers' subjective views and understanding of their environments" (p. 10), therefore focusing their more detailed analysis of 58 sources (from a total of 210 located) that both described and defined XK as it relates to TPACK in terms of teachers' personal/professional knowledge of context. Their results showed that "the microlevel was most frequently mentioned (91.7%), followed by knowledge of students (41.6%), the mesolevel (33.3%), and finally the macrolevel and teacher domain (both 25.0%)" (p. 23).

Overall, and similarly to Rosenberg and Koehler (2015), Brianza et al. (2022) found that XK is "underrepresented" in TP(A)CK literature, in that it was "substantially included" in only about 20% of the publications that could be found (p. 28). (This proportion aligns well with our review's results, which yielded 47 context-focused publications.) They also noted many inconsistencies in how context was defined and operationalized, interpreting these inconsistencies as reflecting the nature of XK as a "broad, complex, multifaceted, yet structured construct" (p. 28); with each "educational context [as] its own unique constellation of contextual factors, leading teachers to develop specialized knowledge for each educational setting" (p. 33) and, by implication, also for each student. In this view, XK is understood in terms of teachers' agency and level of potential influence: *immediate, proximal, and/or distal*, across multiple dimensions: social (pedagogy-related), resource (technology-related), and/or curriculum/content, forming networks of contextual influences upon teachers' knowledge that change over space and time.

Other Depictions of Contextual Influences in TP(A)CK Scholarship

Three calls for a fundamental redefinition of context in TP(A)CK have been published to date. Cherner and Smith (2017) strongly recommended that content knowledge within the TP(A)CK construct be reframed as contextual knowledge since effective content-based instruction is based upon teachers' accurate and comprehensive knowledge of students. They explain:

Meaning is contextual, not discipline based. The implication of [our recommended] revision, from content knowledge to contextual knowledge, is that teachers must know both the content knowledge associated with their discipline(s) and they must understand the ecology of the student to whom the content will be delivered. With this knowledge, teachers will have an understanding of who their students are, inclusive of students' prior knowledge, understandings, misconceptions, and cultural values among other indicators. Teachers must also be able to relate the content knowledge to all their learners based upon the construction of both their own and their learners' personal contexts. (p. 337)

In a systematic review of publications in which TP(A)CK was used or discussed, Chai et al. (2013) identified "four interdependent contextual factors that are [somewhat] distinctive." (p. 46) They named these factors the *intrapersonal dimension, interpersonal dimension, cultural/institutional factors, and physical/technological provisions* in schools. The authors explained that intrapersonal dimensions of teaching/learning contexts refer to teachers' epistemological and pedagogical beliefs, and interpersonal dimensions concern teachers' interactions and collaborations with each other in designing instruction. Koh et al. (2014) then developed and empirically tested *TPACK-in-Action*, a framework that helps researchers to understand the "interplay" (p. 27) between TPACK and Chai et al.'s (2013) four interwoven contextual factors that influence teachers' design of instruction that integrates educational technologies.

Soon after these four types of contextual factors were proposed, and in response to Porras-Hernandez and Salinas-Amescua's (2013) critique of how contextual knowledge was conceptualized within TP(A)CK at the time, Chai et al. (2014) argued for an expanded version of the TP(A)CK construct that includes all actors within educational systems: "the student, the curriculum designer, the head of department, the school principal, [governmental] officers, software designers, parents, and industry partners," explaining that "these other actors need to understand TPACK so that they can contribute to the design of curriculum guidelines, policies, infrastructure and physical space allocation, etc. in order to achieve [educational technology] integration." (p. 8) To frame this much-expanded notion of TP(A)CK, Chai et al. (2014) strongly recommended incorporating all five levels of Bronfenbrenner's (1994) ecological systems theory, using his definitions. The authors also provided examples from extant educational technology literature of how these contextual systems were already beginning to be addressed, offering specific ideas for future TP(A)CK-focused research at each system level.

Unfortunately, although this article has been cited in more than 50 different TP(A)CK publications, we have not located any empirical studies to date that incorporate all of Chai et al.'s (2014) recommendations for broadening the definitions of actors and scope/system for contextual influences upon educators' TP(A)CK. While our review did locate three TP(A)CK publications that addressed all five of Bronfenbrenner's bioecological systems—one data-based study and two theoretical works, or 6% of the total number of publications that focused upon TP(A)CK contextual influences—we wonder whether the recommendation to expand the types of actors included within educational systems so dramatically is beyond what is feasible within single, or even multiple, coordinated empirical studies.

Conceptual Revisions Needed

As explained above, almost all of the peer-reviewed empirical and theoretical publications that have focused upon the nature of TP(A)CK's contextual influences have limited consideration of actors to teachers, and 38% (18 of 47 total) have constrained scope (contextual systems) to micro-, meso- and macro-levels, defined most often according to Porras-Hernandez and Salinas-Amescua's (2013) depictions, rather than Bronfenbrenner's (1977; 1994; 2005). We agree with Brianza et al. (2022), Chai et al. (2014), and Rosenberg and Koehler (2015a, 2015b) that these ways of representing TP(A)CK's contextual influences need conceptual reconsideration, if future TP(A)CK scholarship is to be of maximal utility in both research and practice. In the next section, we offer our recommendations to improve both the academic rigor and the utility of future TP(A)CK-based inquiry into contextual influences.

RECOMMENDATIONS

As we hope that we have demonstrated above, researching contextual influences upon learning and teaching with technological tools and resources is quite complex. However, this fact does not justify oversimplifying how contextual factors are defined and explored in either empirical or theoretical research. For example, reducing microsystems, which Bronfenbrenner (1977; 2005) defined as all influences within children's immediate environments at home, in school, and elsewhere to "in-class conditions for learning" (Porras-Hernandez & Salinas-Amescua, 2013, p. 230), or ignoring time-based/historical (chronosystem) contextual factors (Bronfenbrenner, 2005), will yield unnecessarily constrained results in this important and burgeoning area of research.

Given that our review found that approximately one-third of the 47 context-focused pieces published since 2008 did not specify completely the theoretical bases for the conceptions of context that were used, we recommend that TP(A)CK researchers select among or build upon the available frameworks described above, clearly stating their arguments for their selections. If both comprehensiveness and maximal specificity regarding contextual influences examined is desired, we recommend using Bronfenbrenner's (2005) five interconnected bioecological social systems (as Chai et al. (2014) also recommend), which shape and are shaped by all of the actors within those systems. If another framework that is more limited in scope is selected, such as Brianza et al. (2022), Chai et al. (2013), Cherner and Smith (2017), or Porras-Hernandez and Salinas-Amescua (2013), a clear argument for the smaller scope of the selected theoretical conceptualization of context, relative to the focus of the study, should be made. More frequent use of a particular contextual framework in previous TP(A)CK literature is probably *not* sufficient reason for selecting it, however, since doing so could continue to limit unnecessarily the contextual influences explored.

Finally, and perhaps most importantly, the results of our review illustrated how very little published TP(A)CK inquiry to date has focused upon historical, identity-related and sociocultural contextual influences, albeit with notable exceptions (e.g., Adam, 2017; Adams et al., 2022; Gumbo, 2020; Lewthwaite, 2015; Novita et al., 2022; Phillips, 2016; Van Vaerenwyck, 2017). This suggests that TP(A)CK scholarship may be out-of-step with much of other recent educational research, since "...there is now wide recognition that learning is a complex cognitive and emotional phenomenon that is situated in specific social and cultural contexts." (National Academies of Sciences, Engineering, and Medicine, 2022, p. 19). Many such research foci are, by their nature, equity-aware and contextual at the exo-, macro- and chronosystem levels. Future research in these areas could be quite important to both forward TP(A)CK scholarship within the educational technology community and to align it more completely with the research paradigms and foci of current academic inquiry in other educational subdisciplines.

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