Investigating contextual knowledge within TPACK: How has it been done empirically so far?

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Abstract: The technological pedagogical content knowledge (TPACK) framework traditionally describes seven domains of knowledge which teachers rely on for effectively combining technology, pedagogy and content within their teaching contexts. To date, the context construct has been acknowledged interchangeably as both the settings within which teachers operate as well as teachers' knowledge of their teaching environments. The need to distinguish between the two has been emphasized by Mishra (2019) by explicitly upgrading context as an eighth domain of knowledge of TPACK. To support future research on contextual knowledge, based on a systematic review of the TPACK literature published between 2005 and 2020, this study offers an overview of the current empirical methods, instruments, and findings surrounding this construct. Findings reveal a range of approaches (i.e., self-report, interviews, artifacts, observations, vignettes, and multimethods) for investigating contextual knowledge and the comparison of these approaches and their related findings are discussed.

Introduction: Emphasizing context as a domain of knowledge in the TPACK framework

Currently, the technological pedagogical content knowledge (TPACK) framework (Koehler & Mishra, 2009; Mishra & Koehler, 2006) is one of the most cited frameworks for describing the various domains of knowledge teachers rely on for teaching in technological educational settings. As an extension of Shulman's (1986, 1987) pedagogical content knowledge framework, it presents teachers' knowledge as consisting of seven distinct domains: pedagogical knowledge (PK), content knowledge (CK), technological knowledge (TK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPCK). In addition, to acknowledge the highly situated nature of teaching and learning, in 2009 Koehler and Mishra officially incorporated an out circle labeled "context" (see Fig. 1) for representing the fact that teachers' knowledge "does not exist in a vacuum" (Mishra & Warr, 2021, p. 2) but rather is dynamically related to the unique contextual factors of each educational environment.

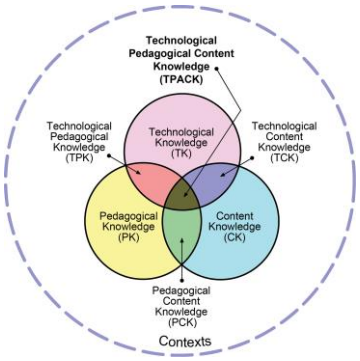

Figure 1. Technological pedagogical content knowledge framework (Koehler & Mishra, 2009)

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Since then, context has been associated with perceptions of the "wicked problems" surrounding TPACK, as it presents itself as a complex, multifaceted, situation-specific, and ill-structured construct (Kelly, 2008, p. 55). In 2015, Rosenberg and Koehler conducted a systematic review to investigate the state of research on context in the TPACK framework. Their findings revealed context to be considered in only a minority (~36%) of the records retrieved focusing on TPACK research and when included, this construct was diversely and inconsistently defined across records: referencing aspects ranging from factors related to classrooms (micro level), schools or local communities (meso level), national/global and societal factors (macro level), as well as mentioning teacher- or student-related factors (categories derived from the representation of context by Porras-Hernández & Salinas-Amescua, 2013). Further complicating matters, within the sample considered by Rosenberg and Koehler (2015) context also appeared to be subject to a certain degree of conceptual confoundment, being across studies interchangeably regarded as describing the environments within which teachers operate (objective settings) or as a domain of teachers' knowledge (teacher-centered construct) without acknowledgement of the conceptual differences between these two constructs. This fact was explicitly addressed by Mishra in 2019, calling for the need to view context specifically as a domain of knowledge in the TPACK framework. Mishra (2019) suggested that "upgrading" context to contextual knowledge (XK) not only promotes conceptual consistency within the framework but also emphasizes the importance of teachers' integration of situation-specific knowledge (including aspects such as the opportunities and constraints of the organizational settings of their educational institutions) for effectively developing TPACK.

Based on this invitation for a more specialized view of context, the authors (in preparation) conducted a systematic literature review of the literature published between 2005-2020, mirroring that of Rosenberg and Koehler (2015) but with a selective focus on context as a domain of knowledge. The review aimed to provide a conceptual overview of how XK has been included and defined in current literature and revealed similar patterns as those reported by Rosenberg and Koehler (2015), showing XK to be underrepresented and inconsistently included and diversely defined across the TPACK literature, thus requiring future research (Authors, in preparation).

Research question and model

Nevertheless, addressing XK on a conceptual level is only a first step in investigating XK and empirical research is needed to provide further evidence and validity for this construct. Thus, this study aimed to complement the conceptual overview of XK (Authors, in preparation) by presenting an overview of the current stand of empirical research on XK and contribute by setting to the methodological groundwork for conducting future research on this underrepresented construct. Considering the sample identified and analyzed conceptually by the authors (in preparation), the following research questions were addressed:

RQ1. Which methods have been used to investigate XK empirically?
RQ2. Which aspects of XK have been considered in the current empirical literature?
RQ3. What is the stand of the empirical XK-related findings reported in the current literature?

Sample and Methods

The sample of records analyzed in this study was directly derived from the systematic review previously conducted by the authors (in preparation) by investigating the TPACK literature published between 2005 and 2020. Records published between 2005 and 2013 were adopted from the sample identified by Rosenberg and Koehler (2015), whereas for the subsequent years (i.e. 2013-2020) the sample was retrieved through searches over the five databases Education Resource Information Center (ERIC), Google scholar, PsycInfo, Scopus, and Web of Science, as well as in the TPACK Newsletter (retrieved from https://www.punyamishra.com/research/tpack/tpack-newsletter-archive/). The initial searches retrieved 743 records, of which 58 met eligibility criteria for focusing on TPACK and substantially referencing context as a domain of knowledge within the TPACK framework. Of these, we additionally screened for studies addressing XK empirically and excluded dissertations, resulting in a final sample of $N = 24$. These records were analyzed and grouped based on their adopted research methods and the aspects of XK addressed by the different research approaches along the three levels of context micro, meso, and macro (Porras-Hernández & Salinas-Amescua, 2013; Rosenberg & Koehler, 2015). In a final step, we summarized each study's XK-related findings.

Results

Exploring our first research question, we found a range of methods for investigating XK and studies employing both mono- ($n = 21$) as well as multimethod approaches ($n = 3$). Table 1 presents an overview of the different methods identified as well as the specifics of the instruments. As presented in Table 1, self-report surveys were the most frequently employed instruments and was the only approach for which (versions of) two instruments were found to be repeatedly used across different studies (i.e. IWB-TPACK, Jang & Tsai, 2012; TPACK-SES, Bilici et al., 2013).

Our second research question aimed to investigate how the various approaches addressed the different levels of XK. As depicted by Table 1, there appeared to be a degree of overlap between the different methods, with self-reports and multimethod approaches showing the most comprehensive coverage of XK. Interviews tended to focus on the meso level and other monomethods (i.e. artifacts, observations, and vignettes) did not address the macro-level. With the exception of the multimethod study by Cirit and Canopolat (2019), we did not find other studies that addressed all three levels of XK systematically.

Considering our third research question, we found evidence for XK-related findings of methodological (i.e. scale development, validation, and knowledge level) and conceptual nature (i.e. evidence for XK as a construct, construct content and structure), as well as findings related to the development of XK and its effects and relations with both other TPACK domains and external constructs (e.g. teacher experience, gender, resilience, etc; see Tab. 1). In addition to the diverse array of contextual factors and XK-related findings summarized in Table 1, we found this construct to have two different structural representations: Some studies depicted XK as an independent domain of knowledge (e.g. knowledge of restrictions of curricular materials and preparation time, as in Jimoyiannis, 2010; knowledge of students' and their daily lives, as in Lewthwaite, 2015; school values and collaboration, as in Hsu & Chen, 2019; classroom physical characteristics, as in Önal, 2016), while others presented it as a contextualizing factor, integrated within other TPACK domains (e.g. PCKCx, TPCKCx, Jang & Tsai, 2012; context-specific TK for educational settings, as in Hsu, 2012; situational TPK, as in Lachner et al., 2019; contextualized knowledge, as in Chai et al., 2020).

Method	Study	Instrument specification	Micro	Meso	Macro	Findings
Artifacts	Koh (2020)		X		X	**XK construct**: XK included knowledge of participants/learners (e.g. learners' life situations). **Effects of XK**: XK was the 4th most frequently mentioned element and emerged as a relevant aspect in all three instructional coaching settings (i.e. technology modeling; pedagogical realignment; deepening practice).
Interview	Jimoyiannis (2010)			X	X	**Effects of XK**: Meso and macro-level XK factors (e.g. school status and educational system, respectively) influenced teachers' perspectives.
	Lewthwaite et al. (2015)	O	X	X		**Effects of XK**: Lecturers' knowledge of students influenced their adoption of instructional roles and technology use.
	Harris & Hofer (2017)	SS		X		**Effects of XK**: Contextual factors and professional culture emphasized as important elements for developing and shaping TPACK.
	Chai et al. (2020)			X		**Effects of XK**: Creating contextualized knowledge for student learning-focused designs requires effortful consideration of "many contextual uncertainties" (e.g. characteristics of students and their prior knowledge as well as interdisciplinary links).
Observation	Bibi & Khan (2017)		X	X		**Effects of XK**: Evidence for both contextual categories as defined by Markauskaite et al. (2011) "technological educational contexts knowledge" (TECK) and "technological learner characteristics knowledge" (TLCK) emerged and were referenced in all three stages of lesson development (content selection, review of teaching methods, assessment design).
	Ogan-Bekiroglu & Karabuz (2017)	SCOR	X			**Knowledge levels**: Preservice teachers scored highest on the XK category "relationship between teacher and students", whereas they had the lowest scores on the two other XK categories (i.e. "dissolution of misconceptions" and "change in teaching methods in order to facilitate understanding").
Self-report	Jang & Tsai (2012)	IWB TPACK*	X	X		**Instrument development and validation**: Four factor structure (CK, TK, PCKCx, TPCKCx) and evidence for contextualized knowledge.
	Chen & Syh-Jong (2013)	IWB TPACK*	X	X		**Effects of experience (years) and teaching subject**: Positive relations between contextualized domains and years of teaching experience. Differences between subjects for TPCKCx.
	Jang & Tsai (2013)	IWB TPACK*	X	X		**Factor structure replication and effects of experience (level)**: Preservice teachers report higher scores than inservice teachers on T-related domains (including TPCKCx), whereas inservice teachers score higher P-related domains (including PCKCx).
	Koh & Chai (2015)	Web 2.0 TPACK**	X		X	**Instrument development**: Contextualization of TPK and TCK by Web 2.0 improved factor structure.
	Önal (2016)		X	X		**Instrument development and validation**: Validation of 9 factor structure among preservice mathematics teachers. Evidence for XK.

	Ünal Çoban et al. (2016)	TPACK-SES	X	X		**Development of XK**: XK increased after TPACK-based argumentation practice.
	Wright & Akgunduz (2018)	TPACK-SES	X	X		**Relations of XK with gender**: Female preservice teachers reported significantly higher XK scores than male counterparts.
	Hsu & Chen (2019)		X	X		**Instrument development and validation**: Identification of 5 factors (TK, PK, Academic Discipline Content Knowledge, XK, and learner knowledge). General reports of subscale reliabilities > .7.
	Ortega-Sánchez & Gómez-Trigueros (2019)			[X]$^{+}$	[X]$^{+}$	**Instrument development**: Unclear which items relate to XK; only conceptualized, not validated.
	Sadaf et al. (2019)	TPACK-SES	X	X		**Relations of XK with resilience**: XK significant weak positive relation with resilience.
	Xu & Sun (2019)		X	X	X	**Instrument development and validation**: Single XK item loaded onto PCK factor.
	Kapici & Akcay (2020)	TPACK-SES	X	X		**Development of XK**: XK increased significantly over time.
	Sen (2020)	IWB TPACK*	X	X		**Relations between domains**: Significant positive effects of CK on TPCKCx and PCKCx, as well as of PCKCx on TPCKCx, and TK on TPCKCx. TK had an indirect, significant effect on "efficacy for classroom management" mediated by TPCKCx, but no direct effect.
Vignettes	Lachner et al. (2019)		[X]^{a}			**Evidence for contextualized knowledge**: Conceptual TPK and situational TPK were related, but yet distinct qualities of teachers' TPK.
Multimethods	Cirit & Canpolat (2019)	Art, Int-SS, Vig	X	X	X	**Knowledge levels**: Similar trends among preservice teachers across years of study level: mostly disregarded the macro and meso contexts, partial acknowledgement of teacher context, micro (incl. resources), and student contexts.
	Hsu (2012)	Art, Int, Obs	X	X		**Evidence for contextualized knowledge**: Context-specific TK (i.e. knowledge of available and subject-specific use of technology in schools) identified as another type of TK critical in the development of preservice teachers' knowledge.
	Bergeson & Beschorner (2020)	Art, Int, Obs	X			**Development of XK**: Technology Integration Planning Cycle (Hutchison & Woodward, 2014) led to increases in preservice teachers' "knowledge of digital tools used in elementary school classrooms".

Table 1. Overview of XK-related findings by research method

Note. SS = semi-structured interview; O = open-ended questions. SCOR = Science Classroom Observation Rubric (based on Burry-Stock & Oxford, 1994). *Contextualized PCK and TPCK; **Contextualized of TPK and TCK for Web 2.0; $^{+}$ not validated, only conceptualized. ^{a} Situational TPK focusing on students.

Discussion

In this study we aimed to complement the conceptual systematic review on XK (Authors, in preparation) by investigating the literature through an empirical lens and thus offer insight into the validity of this construct also from this latter perspective. Results showed that to date, XK has been investigated using a range of methodological approaches (including artifacts, interviews, observations, self-report surveys, and vignettes; RQ1). Self-report surveys emerge as the most frequently adopted instruments, with a couple of surveys (or their adaptations) being used in multiple studies (i.e. IWB TPACK, Jang & Tsai 2012; TPACK-SES, Bilici et al., 2013). Interestingly though, self-report surveys were not found to be used in combination with other methods. Future research might consider multimethod studies including self-reports for data triangulation.

Our findings also indicate that the conceptualization of XK as a three-level construct appears to be supported by the empirical literature yet there remains a lack of systematic assessment of XK, leading these three levels to be inconsistently and diversely acknowledged across studies (RQ2). With regards to the various assessment approaches, we found a substantial degree of overlap across methodologies for covering the levels of XK, with the micro level being addressed by at least one instrument of each method. In addition, method-specific tendencies also emerged: Self-reports and multimethod approaches appeared to be the most comprehensive, whereas interviews revealed a greater focus on the meso-level, and other monomethods (i.e. artifacts, observations, and vignettes) did not appear to address the macro-level. In general, we found that even in studies adopting more comprehensive approaches (i.e. self-report or multimethod), empirical XK research, for the most part, yet lacks a systematic approach to this construct. In fact, in our sample we found only one study (multimethod study by Cirit & Canopolat, 2019) to be exemplary for systematically investigating XK levels (micro, sub-micro [students' context], meso, sub-meso [teachers' context], and macro). Although the study showed that preservice teachers have "less-than-ideal" levels of knowledge in these domains, their study is unique in providing clearly structured evidence for XK along multiple levels.

Finally, analyzing findings reported in the literature, we found both conceptual (including findings related to the content and effects of this domain of knowledge) and methodological evidence (including development and validation of assessment tools) for XK as a construct as well as findings of relations of XK with other constructs (RQ3). Across methods, a number of different approaches indicated compatible findings (e.g. XK as construct which can be developed over time/intervention, Bergeson & Beschorner, 2020; Kapici & Akcay, 2020; Ünal Çoban et al., 2016). Such patterns of evidence across methods strengthen construct validity of XK (Piedmont, 2014).

Overall, this review of the empirical literature further supports the relevance of XK as a domain of knowledge in the TPACK framework. Nevertheless, in line with previous findings, within the empirical literature XK still appears to be an under- and unsystematically represented and assessed domain of TPACK. Our investigation of the empirical literature reveals findings to not only be compatible with viewing XK as a multi-level construct but also suggests that research would benefit from greater systematization for investigating this construct.

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