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Context and Technological Pedagogical Content Knowledge (TPACK): A Systematic Review

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Abstract

Context is an important aspect of educational research and the technological pedagogical content knowledge (TPACK) framework, but is often missing from TPACK research, or its specific meaning is not clear. To provide a systematic and comprehensive view of the extent to which context is included in such research, and to understand the meaning of context when it is included, we conducted a systematic review of publications about TPACK. Context was included in descriptions, explanations, or operationalizations of TPACK among 36% of the 193 empirical journal articles we examined. When context was included, classroom and school factors and those related to teachers were more likely to be included than those related to students and society. The grounds for context being included among around one-third of the articles and why some contextual factors are examined more than others are discussed. Implications for practice and recommendations for future research focus on investigating the complexity of practice, the development of measures that include context, and aligning TPACK and educational technology research with other disciplines through greater attention to context. (Keywords: TPACK, technology integration, teacher knowledge, context).

Context is an essential part of educational research (Berliner, 2002, 2006; Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003; Greeno, Resnick, & Collins, 1996; Tabak, 2004, 2013) but has been the subject of less attention among educational technology research (Garrison, 2003). An important exception to including context less in educational technology than in related fields is research on the technological pedagogical content knowledge (TPACK) framework. TPACK suggests that teachers understand how knowledge of technology, pedagogy, and content interact in their instruction. Context has been described as central to the TPACK framework by its developers (Koehler & Mishra, 2008; Koehler, Mishra, Kereluik, Shin, & Graham, 2014; Mishra & Koehler, 2006) and others (Angeli & Valanides, 2009; Doering, Veletsianos, Scharber, & Miller, 2009; Harris & Hofer, 2014; Kelly, 2007, 2008a, 2008b, 2010; Koh, Chai, & Tay, 2014; Porras-Hernández & Salinas-Amescua, 2013). TPACK is an important exception not only because of the inclusion of context, but also because of its prominence among recent scholarship into the role of technology for teacher education and teacher professional development (Chai, Koh, & Tsai, 2013; Voogt, Fisser, Roblin, Tondeur, & van Braak, 2012).

Despite the importance of context in the TPACK framework, prior research has found that context is frequently missing when researchers describe TPACK in their work (Kelly, 2010). In addition, prior research has found that the meaning of context has differed widely, from teachers' epistemological beliefs to classroom and institutional resources (Porras-Hernández & Salinas-Amescua, 2013). This article, then, contributes to the further understanding of TPACK and its development and enactment in the diverse, complex settings of today's classrooms and schools through an investigation of the nature and role of context in TPACK research.

Color versions of one or more figures in this article can be found online at www.tandfonline.com/ujrt.

Literature Review

We begin with a brief history of prior research on the TPACK framework, and then describe the importance of context in TPACK, a conceptual framework for context in TPACK research, and a systematic review of TPACK in order to establish the need for and purpose of the present study. In a book chapter (Rosenberg & Koehler, in press) we provide a more comprehensive review of the literature on the role of context and importance of context, as well as a detailed unpacking of how context can be considered in TPACK and educational technology research.

The Technological Pedagogical Content Knowledge (TPACK) Framework

Mishra and Koehler (2006) developed TPACK in response to the absence of theory guiding the integration of technology into education. Since then, TPACK has become central to research into technology education and teacher professional development (Chai et al., 2013; Voogt et al., 2012). TPACK represents an extension of Shulman's (1986) characterization of the knowledge needed to teach specific content—namely, pedagogical content knowledge—by characterizing the knowledge needed to teach specific content with technology (Mishra & Koehler, 2006).

The TPACK Framework (see Figure 1) highlights knowledge of technology (TK), about specific tools, software, and hardware, of pedagogy (PK), about how to manage, instruct, and guide students, and of content (CK), about the discipline or subject matter. These coalesce to comprise technological pedagogical knowledge (TPK), about the relationship between technologies and pedagogical practices; pedagogical content knowledge (PCK), about pedagogical practices and learning objectives; and technological content knowledge, about technologies and learning objectives (TCK). TPACK, which comprises the intersection of TPK, PCK, and TCK, is about the complex relationship of all of the constituent areas of knowledge. Importantly, these are all part of the complex context in which teachers act (Koehler & Mishra, 2008).

Research using the TPACK framework has been widespread and growing. Researchers focusing on the theoretical underpinnings of the framework have focused on the whether the overlapping components of knowledge in the framework are best conceptualized as integrative, wherein the areas of knowledge in the TPACK framework are distinct, or transformative, wherein the areas of

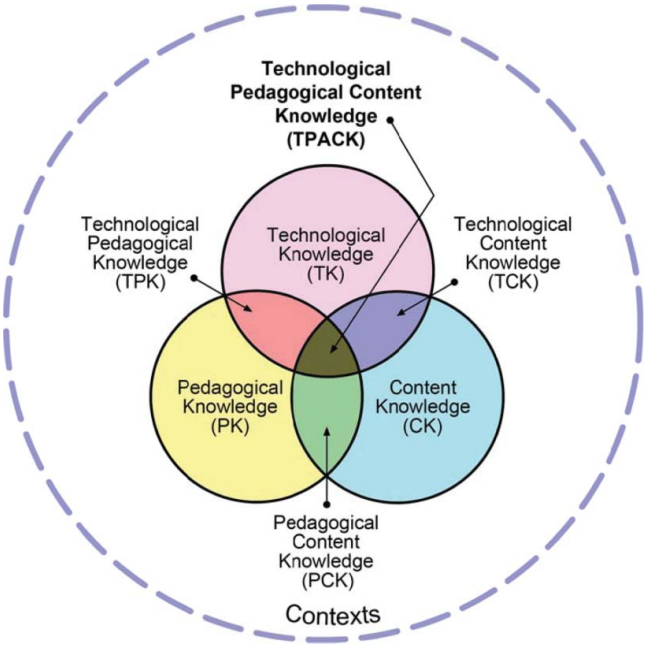

Figure 1. The TPACK framework (used with permission from http://tpack.org).

knowledge in the TPACK framework are indistinguishable and holistic (e.g., Angeli & Valanides, 2009; Graham, 2011). Others have focused on refining the number of components in the framework—some suggesting more components are needed to reflect the complexity of technology integration in classrooms and the complex role of contexts (e.g., Angeli & Valanides, 2009; Porras-Hernandez & Salinas-Amescua, 2013; Yeh, Hsu, Wu, Hwang, & Lin, 2014), and others suggesting that fewer components are needed to reduce the complexity of the framework (see Brantley-Dias & Ertmer, 2013 for a discussion of these issues).

Significant research has also been focused on developing a number of different approaches to developing teachers' TPACK (for a review of these approaches see Koehler, Mishra, Kereluik, Shin, & Graham, 2014). Research has also focused on measures of TPACK (for a review see Abbitt, 2011; Koehler Shin, & Mishra, 2011). These efforts have been met with mixed results, as many of the developed methods to data lack sufficient reliability and validity criteria (Cavanagh & Koehler, 2013). Some researchers have used the measurement of TPACK to corroborate the proposed TPACK framework structure outlined in Figure 1 (e.g., Schmidt, Baran, Thompson, Mishra, Koehler, & Shin, 2009) while others have found support for fewer components (Archambault & Barnett, 2010).

The Importance of Context in TPACK Research

Despite the growing and diverse research into many aspects of TPACK, it is clear that context remains an underdeveloped and underresearched component of the framework. Mishra and Koehler (2006) identified subject matter, grade level, student background, and the types of available technologies as the factors that make TPACK what they earlier referred to as a "context bound" (p. 1032) and situated form of knowledge (Koehler & Mishra, 2005). Although context was described as an important component of the TPACK framework since the introduction, it was not included in a figure representing TPACK until the introductory chapter of the *Handbook of Technological Pedagogical Content Knowledge (TPCK) for Educators* (cf. Koehler & Mishra, 2008).

Kelly (2010) identified context as "one of the most complex, important, and least understood components" (p. 52) of the TPACK framework and wrote extensively on context and TPACK over a series of publications (e.g., 2007, 2008a, 2008b, 2010). In 2007, Kelly argued that the impact of teachers and their knowledge on students depends upon how successfully each teacher adapts to the unique context. The always-changing context includes physical elements, such as the design of the learning environment to characteristics of the school (Kelly, 2008a). As the TPACK literature has developed, Kelly's prior research has been important to other researchers' modifications to the TPACK framework based on the importance of context described in the section.

Angeli and Valanides (2009, 2013) advanced a modification to the TPACK framework wherein TPACK is greater than the sum of its constituent areas of knowledge; it represents a transformative body of knowledge that arises when teachers consider technology, pedagogy, and content in their teaching. Moreover, the transformative perspective considers learners and context to be integral to teachers' TPACK. While Porras-Hernández and Salinas-Amescua (2013) did not explicitly state that their framework for context aligned with the transformative perspective, they included actors (teacher and student), aligning their framework with the inclusion of learners in Angeli and Valanides's transformative perspective. We describe Porras-Hernández and Salinas-Amescua's framework for context in greater detail in the next section.

A Conceptual Framework for Context in TPACK Research

The framework for context advanced by Porras-Hernández and Salinas-Amescua (2013) is based around three levels (micro, meso, and macro), and two actors (teacher and student), as represented in Figure 2. In Porras-Hernández and Salinas-Amescua's framework, teachers' TPACK develops in the contexts categorized through the three levels (micro, meso, and macro) and two actors (teacher and student). These categories can also be considered areas about which teachers develop their knowledge. Thus, the complexity of the social interactions, resources, scaffolds, and supports that

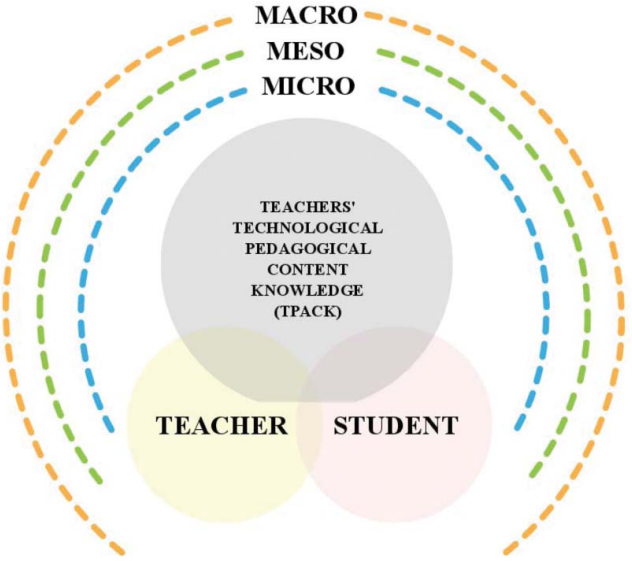

Figure 2. Our representation of the conceptual framework for context as advanced by Porras-Hernandez and Salinas-Amescua (2013). In this conceptual framework for context, teachers' TPACK reciprocally affects each of the parts of the framework, so that changes in teachers' knowledge are a function of teachers' engagement in a rich setting of social interactions, resources, scaffolds, and supports as categorized with the three levels (micro, meso, and macro) and two actors (teacher and student).

affect teaching with technology is included systematically and comprehensively, and in a manner that facilitates better understanding of the context around teachers' TPACK.

Porras-Hernández and Salinas-Amescua (2013) described the scope, the differentiated and hierarchical levels, as factors that reciprocally affect teachers' TPACK. The use of levels helps researchers conceptualize the effects of contextual factors, both proximal and distal, in an organized and systematic way. *Micro* factors are those in the classroom or learning environment, such as the design and layout of the room. *Meso* factors are those in the school or other settings in which the classroom or learning environment are found, such as a community center or children's museum, and the availability of support staff. *Macro* factors are the societal conditions that affect teaching, learning, and the development of teachers and learners, such as state and national curricular standards. Porras-Hernández and Salinas-Amescua (2013) described the actors, or individuals, as characteristics that reciprocally affect teachers' TPACK. Their inclusion is helpful for the same reason the author's three levels are helpful: Identifying which individuals (teachers or students) are involved in the context of teaching with technology can resolve the ambiguity about who context affects and who affects the context. *Teacher factors* are all of the characteristics of teachers, such as their motivation and beliefs, except their TPACK. *Student factors* are all of the characteristics of students.

In summary, Porras-Hernández and Salinas-Amescua (2013) identified the widespread variation in meaning for context. However, Porras-Hernández and Salinas-Amescua did not empirically establish this widespread variation in meaning. We address this need by using the conceptual framework Porras-Hernández and Salinas-Amescua described in the present study.

A Content Analysis of TPACK

Kelly (2010) examined whether context was included in the conceptual definition of TPACK and found that context is frequently missing when researchers describe, explain, or operationalize TPACK in their work. Specifically, Kelly reported the "virtual absence of the fourth element of the TPACK model—context—in conceptual analyses and applications of TPACK as well as in research studies" (p. 3887). However, Kelly included a small sample of publications ($n = 16$) that may not

have been representative of all publications about TPACK, and did not codify what counted as context within publications. Due to these limitations, there is a need to extend Kelly's important prior research.

The Present Study

Kelly (2010) and Porras-Hernandez and Salinas-Amescua (2013) made substantial, important contributions to understanding how context has been included, as well as what it means when it is included among TPACK research, and yet opportunities to extend their scholarship in important directions remain. First, the sample of publications Kelly examined was small ($n = 16$) relative to the present number of publications on TPACK. Second, the focus of Kelly's study was not only on the inclusion of context, but also on other characteristics of publications about TPACK, so Kelly did not describe how the inclusion of context was coded and analyzed in sufficient detail. Third, Porras-Hernandez and Salinas-Amescua identified and described the widespread meaning for context and advanced a conceptual framework for thinking about the context component of TPACK, but did not yet use the framework to empirically determine what components of context researchers include, or what researchers mean by context.

There is an urgent need to provide a comprehensive and accurate view into the extent to which context is included in researchers' publications about TPACK, as well as the meaning of context when it is included. We provide this view by extending Kelly's (2010) prior research through an examination of a greater number of recent publications about TPACK as well as a clearer focus on what constitutes the inclusion of context in these publications. We also extend Porras-Hernandez and Salinas-Amescua's (2013) prior research by using their conceptual framework for context to further analyze what aspects of context were mostly likely to be included and excluded in published works. The purpose of this study, then, is to provide a comprehensive and accurate view into the extent to which context is included in researchers' publications, specifically their journal articles, about TPACK, as well as the meaning of context when it is included. Specifically, we seek to answer two research questions:

1. Among journal articles that make use of the TPACK framework, has context been included when authors describe, explain, or operationalize TPACK?
2. For the journal articles in which context was included, what aspects, as understood through a conceptual framework of context with three levels (micro, meso, and macro) and two actors (teacher and student), are included?

Method

This systematic review employs the qualitative coding of data, and the quantitative counting of the frequency of codes. Our search of the literature was guided by standards for systematic reviews of research (e.g., Booth, 2006). To qualitatively code the data, we used a concept-driven coding adopted from Porras-Hernández and Salinas-Amescua's framework for context. We describe the sample, data segmentation, coding, data analysis, and strategies for validating findings and establishing reliability in the remainder of this section.

Sample

Our selection of journal articles about TPACK for this study was guided by Booth's (2006) criteria for systematic reviews of the literature, which he represented with the mnemonic STARLITE, for sampling strategy, type of study, approaches, range of years, limits, inclusion and exclusions, terms used, and electronic sources. We report the steps taken for each of these criteria in Table 1.

One hundred ninety-three journal articles met the criteria. The journals with three or more articles included in the systematic review are reported in Table 2.

The number of journal articles that met the inclusion criteria was much greater than expected, given findings from recent literature reviews. From comprehensive searches of databases, Chai

Table 1. Elements of the Systematic Review for Publications About TPACK

Element	Steps Taken
Sampling strategy	Comprehensive search for all journal articles about TPACK.
Type of study	Empirical in nature.
Approaches	Search of the Education Resources Information Center (ERIC) database, PsychINFO database, and electronic sources (detailed below).
Range of years	From 2005–2013, as 2005 was when the first articles about TPACK were published.
Limits	Published in the English language.
Inclusion criteria	"TPCK," "TPACK," or "technological pedagogical content knowledge" are included in the title, keywords, or abstract (or introduction if an abstract is not included).
Terms used	"Technological pedagogical content knowledge," "TPACK," and "TPCK."
Electronic sources	The citation reference software and website Mendeley and TPACK newsletters published on http://tpack.org between January 2009 and December 2013.

Note. The elements of our systematic review are adapted from Booth's (2006) STARLITE criteria.

et al. (2013) found 74 journal articles, and Voogt et al. (2012) found 61 journal articles. We searched the same databases using similar terms as Chai et al. and Voogt et al., but also searched the group on Mendeley for TPACK, as well as the TPACK newsletters. Our inclusion of the TPACK group on Mendeley, as well as the TPACK newsletters, may be the source of the larger number included in this study. The number of included journal articles included by year illustrated in Figure 3. Additionally, references for all of the journal articles included in the current analysis are presented in the Appendix.

Data Segmentation

For each publication in included in the study, thematic criteria (i.e., changes in topic) were used to identify the beginning and ending of data segments in the publication that explained, described, or operationalized TPACK. These segments were found in the introduction, literature review, methods, and data analysis sections of the journal articles. Typically, these segments provided basic descriptions of TPACK and the conditions (or context) that may impact it. For example, Rienties, Brouwer, and Lygo-Baker (2013), wrote the following in their introduction, which exemplifies a typical data segment in the current study:

> In order to successfully implement ICT in education, a large body of research argues it is important to adjust the content of a module in line with the technology selected and the

Table 2. Journals With Three or More Articles Included in the Systematic Review

Journal	Number of Articles
Australasian Journal of Educational Technology	15
Contemporary Issues in Technology and Teacher Education	13
Computers & Education	10
Journal of Educational Computing Research	10
Journal of Research on Technology in Education	10
Journal of Science Education and Technology	7
Journal of Computers in Mathematics and Science Teaching	6
Journal of Digital Learning in Teacher Education	6
Turkish Online Journal of Educational Technology	5
Computers in the Schools	4
Journal of Computer Assisted Learning	4
Teaching and Teacher Education	4
Australian Educational Computing	3
British Journal of Educational Technology	3
Journal of Technology and Teacher Education	3
Procedia—Social and Behavioral Sciences	3
TechTrends	3
All others	84

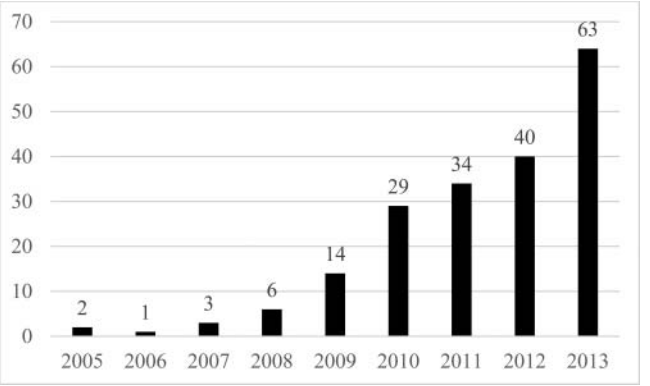

Figure 3. Publications in peer-reviewed journals of empirical studies about TPACK by year. The total number of publications is 193.

pedagogical approach used (Alvarez et al., 2009; Rienties, & Townsend, D., 2012; Lawless & Pellegrino, 2007; Ziegenfuss & Lawler, 2008). Mishra and Koehler (2006) designed the Technological Pedagogical Content Knowledge (TPACK) model with the aim of providing teachers with a conceptual model to effectively design and implement technology-enhanced learning. The TPACK model is based on the pedagogical content knowledge (PCK) model developed by Shulman (1986). In 2008 this was further improved to its current format (Koehler & Mishra, 2008), in which seven components are defined: (1) technological knowledge (TK), (2) content knowledge (CK), (3) pedagogical knowledge (PK), (4) pedagogical content knowledge (PCK), (5) technological content knowledge (TCK), (6) technological pedagogical knowledge (TPK), and (7) Technological Pedagogical Content Knowledge (TPACK). As illustrated in Fig. 1, the TPACK model is framed by the type of knowledge teachers must acquire and develop in order to design a powerful and balanced technology-enhanced learning environment. Contexts such as level, discipline, institutional culture, or financial constraints have an important influence on the choices made by a teacher, which is represented by the circle around the model. (p. 123)

Coding

For each data segment, the first author made six coding decisions about how context was addressed in the data segment, according to a coding scheme summarized in Table 3. For example, in the following text from Lin, Tsai, Chai, and Lee's (2013) publication, the Inclusion of Context category is coded "1": "TPACK is especially referred to as contextualized knowledge." This category is coded "1" only if context was explicitly included in the data segment, and "0" if it was not explicitly included. Thus, only the explicit inclusion of the word "context" was coded. This means that authors who used similar but different terms, such as "situated," were not included, a limitation justified by the explicit inclusion of the word "context" in the TPACK framework (e.g., Angeli & Valanides, 2009; Mishra & Koeler, 2006; Kelly, 2008a, 2010; Porras-Hernández & Salinas-Amescua, 2013).

Similar to the coding for the Inclusion of Context category, the micro, meso, macro, teacher, and student categories were coded "1" if those aspects of context were included in the data segment, and "0" if those aspects of context were not included in the data segment. As an illustration, in the following text from Liu's (2013) publication, micro is coded "1": "Most studies did not identify the perspectives of teachers or explore how teachers develop TPACK in real classrooms." As a final example, in Jang and Tsai's (2012) publication, Student is coded "1": "This context might include students' prior knowledge and learning difficulties."

Table 3. Coding Frame for the Inclusion and Meaning of Context

Variable	Description	Possible Codes
Inclusion of context	The word "context" in in descriptions, explanations, or operationalizations of TPACK	1 (included) 0 (not included)
Micro	Factors at the classroom (or learning environment) level in descriptions, explanations, or operationalizations of TPACK	1 (included) 0 (not included)
Meso	Factors at the school (or community level) in descriptions, explanations, or operationalizations of TPACK	1 (included) 0 (not included)
Macro	Factors at the societal level in in descriptions, explanations, or operationalizations of TPACK	1 (included) 0 (not included)
Teacher	Factors related to the teacher or teachers in descriptions, explanations, or operationalizations of TPACK	1 (included) 0 (not included)
Student	Factors related to one or more students in descriptions, explanations, or operationalizations of TPACK	1 (included) 0 (not included)

Data segments could be coded "1" for multiple categories, and the data segments coded varied from having each category coded "0" to having each category coded "1." Specific parts of data segments—such as words or sentences—could be coded into only one category; for example, the text "the availability of a computer lab could affect teachers' TPACK" would be coded "1" for meso, and could not be coded "1" for micro. A worked example of how the Rienties et al. (2013) article, identified in the data segmentation section, was coded for each variable follows:

- Inclusion of Context is coded "1" because the word context is explicitly included.
- Micro is coded "1" because classroom factors (level" and "discipline") are included.
- Meso is coded "1" because school factors ("institutional culture" and "financial constraint") are included.
- Macro is coded "0" because societal factors are not included.
- Teacher is coded "1" because characteristics of teachers ("the choices made by a teacher") are included.
- Student is coded "0" because characteristics of students are not included.

Data Analysis

To analyze the data needed to determine the inclusion of context in journal articles, we computed frequencies and percentages for the "1" (included) and "0" (not included) codes for Inclusion of Context. To analyze the data needed to determine the meaning of context, we computed frequencies and percentages for the "1" (included) and "0" (not included) codes for the categories micro, meso, macro, teacher, and student.

Strategies for Validating Findings and Establishing Reliability

Construct validity describes the extent to which a variable characterizes the concept or theory it represents; in this study, construct validity describes the extent to which the coding frame characterizes the concept of teachers' context. We adapted the coding frame for the meaning of context from the conceptual framework for context advanced by Porras-Hernández and Salinas-Amescua (2013). This conceptual framework was adapted from prior research, including Bronfenbrenner's (1981) bioecological model of development in order to characterize systematically the nature of teacher's context. Because the coding frame is grounded in prior empirical and theoretical research into the nature of context, it exhibits construct validity. With respect to the inclusion of context in journal articles, we coded for the explicit inclusion of the word "context," and we discuss this decision further in the conclusion.

To establish the reliability of the coding scheme, a second coder coded the data segments concurrently with the first author. The second coder was first trained on the use of the coding frame, after which the first author and second coder coded approximately 20 data segments across three cycles,

Table 4. Percent Agreement and Cohen's Kappa Statistics

Variable	Percentage Agreement	Cohen's Kappa
Inclusion of Context	.80	.61 (substantial)
Micro	.83	.47 (moderate)
Meso	.72	.44 (moderate)
Macro	.89	.00 (poor)
Student	.83	.64 (substantial)
Teacher	.61	.22 (slight)

Note. The interpretation of the value of Cohen's kappa (e.g., "substantial") is from Sim and Wright's (2005) guidelines based upon a review of the literature.

for a total of approximately 60 data segments, or 35% of the total data. After each cycle, the coders met to discuss disagreements and to come to consensus for all of the data segments both coded. Following the final round of coding, we computed the percent agreement statistic between the two coders for all three rounds. We also computed Cohen's kappa, a statistic that takes into account agreement that would happen purely by chance (Sim & Wright, 2005). Table 4 presents percent agreement, Cohen's kappa, and interpretation of Cohen's for each coding category in the study.

Results

Context is included in the descriptions, explanations, or operationalizations of TPACK among 36% ($n = 70$) of the 193 peer-reviewed, empirical journal articles about TPACK published between 2005 and 2013 in English, as in Figure 4. We then subjected these 70 journal articles that included context to further analysis: Among this corpus, 84% of journal articles were coded "1" for micro (classroom factors); 61% for meso (school factors); 57% for teacher (teacher factors); 44% for student (student factors); and 14% for macro (societal factors), as in Figure 5.

Discussion

Context is an essential part of educational research, where its inclusion has impacted the development of theories (Berliner, 2002, 2006) and teaching and learning practices (Putnam & Borko, 2000). The purpose of this study was to provide a comprehensive and accurate view into the extent to which context is included in researchers' journal articles about TPACK, as well as the meaning of context when it is included. We discuss key findings, limitations of the study, implications for practice, and recommendations for future research.

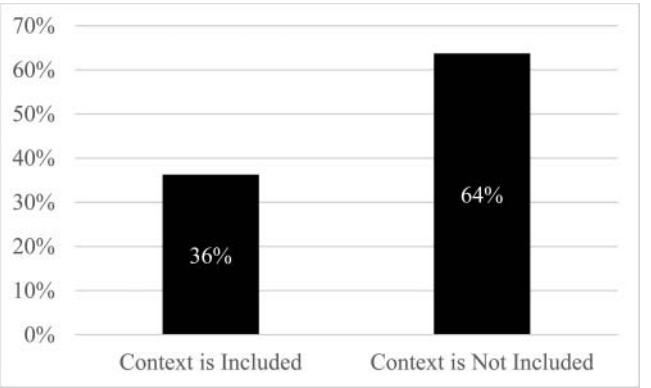

Figure 4. Results for the inclusion of context.

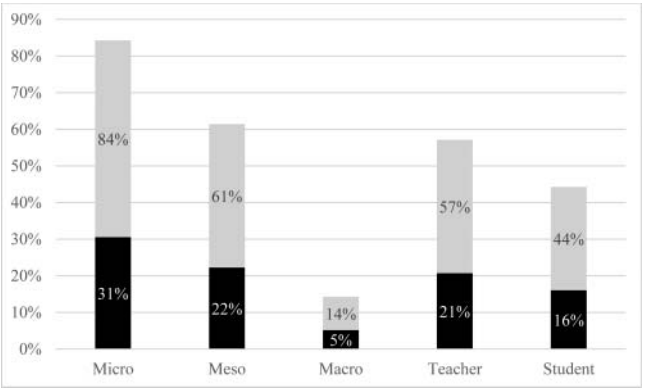

Figure 5. Results for the meaning of context. Only the publications that included context were coded for Micro, Meso, Macro, Teacher, and Student. The black bars represent the percentage of all of the publications ($N = 193$) coded with each of the codes. The grey bars represent the percentage of only the publications that included context ($n = 70$) coded with each of the codes.

Key Findings

First, we found that context is important but often missing from research about TPACK. Context was included among 36% of the 193 peer-reviewed journal articles about TPACK we examined. This percentage was less than would be expected, given the importance of context in educational research as well as in TPACK research. Thus, when included among TPACK research, context is not always considered in a systematic or comprehensive manner. Context is now included to a greater extent than previous work suggested: Kelly (2010) reported that 0% ($n = 16$) of studies included context.

Second, we found that the meaning of context has differed widely. The categories for the meaning of context were included inconsistently among the journal articles that included context in descriptions, explanations, and operationalizations of TPACK. When researchers included context, what they meant differed according to the dimensions of the conceptual framework for context. Researchers included classroom factors (micro) in 84% of journal articles, while other factors were addressed less frequently, including school factors (meso; 61%), teacher factors (teacher; 57%), student factors (student; 44%), and societal factors (macro; 14%). The conceptual framework around which the coding frame was based represents a systematic and comprehensive view of the context around teachers' TPACK. Therefore, the moderate extent to which student-related characteristics were included and the low extent to which societal factors were included suggest that when context is included in journal articles, it may be presented in a way that is neither systematic nor comprehensive. The presentation of context in a way that is neither systematic nor comprehensive has implications for understanding the complexities of TPACK. For example, macro—societal factors, such as the rate and influence of technological innovation—was included in 14% of the journal articles coded for the meaning of context. This means that these conditions, which have been theorized to be important to individual learning and development (e.g., Bronfenbrenner & Morris, 2006; Ratner, 2011), and which comprise part of a systematic and comprehensive account of context, are rarely included in research.

Third, we identified the number of peer-reviewed journal articles about TPACK based on our searches of the elements of the systematic review. This numbered exceeded previous studies by Chai et al. (2013), who found 74 journal articles about TPACK, and Voogt et al. (2012), who found 61. This discrepancy can possibly be attributed to our searches of the group on Mendeley for TPACK, as well as the TPACK newsletters and to our inclusion of more recent journal articles (Figure 3).

Limitations of the Study

This study exhibited limitations that warrant discussion. First, with concern to the inclusion of context, we coded for only the explicit inclusion of the word "context." This means that authors who

used similar but different terms, such as "situated," were not included. However, as discussed earlier, the term *context* is an explicit part of the TPACK framework. Therefore it is unclear what findings may result if future researchers include studies that use *situated* as a synonym for context.

Second, with concern to reliability, reliability statistics for Teacher exhibited moderate percent agreement (61%) but low Cohen's kappa (.22; slight agreement), which represents some systematic disagreement with regard to the use of the coding frame. Also, reliability statistics for macro exhibited high percent agreement (89%) but low Cohen's kappa (0; poor agreement). According to the formula for Cohen's kappa, all the agreement (89%) was due to random chance.

Implications for Practice

The results of this study do not have a direct impact upon practice; however, greater attention to context will affect teaching and learning in important ways. Attending to context can place researchers into contact with diverse teachers and learners in diverse settings, strengthening our understanding of teaching with technology across contexts, as well as contributing support and guidance in settings that we know little about, such as educational technology use in high-poverty urban settings. More generally, taking context seriously asks researchers to spend time in the complex settings of classrooms and schools and other settings to understand the conditions under which teaching with technology is most effective. At the same time that researchers can better understand these contextual conditions, they can contribute their expertise to teachers, parents, administrators, and other stakeholders to change practice. Investigating the complexity and "messiness" of classrooms and schools may also challenge researchers to develop measures of TPACK that include context that better assess practice, as the widely used TPACK survey (e.g., Schmidt et al., 2009) and many other measures do not include context.

Recommendations for Future Research

Context may not have been included to a great extent among prior TPACK research, and when included, different aspects of context may have been included more than others due to a number of possible reasons. First, context may have not been sufficiently theorized so that researchers can understand and apply in in their work. Context may also not have been the area of focus because researchers chose to focus on other areas of TPACK research and development. It may have not been included because of methodological shortcomings and challenges with respect to including context in already-complex surveys (e.g., Schmidt et al., 2009) and other measures (cf. Koehler, Shin, & Mishra, 2011). Finally, there are the ways in which some contextual factors may be due to researchers' focus on the parts of context that are easier or more desirable to examine, such as those related to classrooms, schools, and teachers. The framework for context introduced by Porras-Hernandez and Salinas-Amescua makes a contribution toward addressing the conceptual challenges facing the understanding and application of context, but greater attention to context and the development of measures that include context are also needed.

In addressing to improve TPACK research, greater attention to context can align TPACK and educational technology research with other disciplines, such as teacher education, the learning sciences, and educational and developmental psychology, which honor its role. The framework for context advanced by Porras-Hernández and Salinas-Amescua (2013) is an important theoretical contribution that allows us to think about the role of context in our research. In addition to drawing from the work of Porras-Hernández and Salinas-Amescua, we can draw from other frameworks for context or frameworks that include context (e.g., Angeli & Valanides, 2009; Doering, Veletsianos, Scharber, & Miller, 2009; Kelly, 2008a, 2008b) with respect to TPACK, and from frameworks from other disciplines. We recommend that researchers draw from prior research to consider context even more incisively and critically in order to further advance our understanding of teaching and learning across contexts. Especially, scholarship on the bioecological model of development (e.g., Bronfenbrenner, 1981; Bronfenbrenner & Morris, 2006), from which Porras-Hernández and Salinas-Amescua drew inspiration for their micro, meso, and macro levels, can inform further theoretical

development. In addition to further refining our understanding of context, we recommend that researchers move beyond identifying the contextual factors that may affect teaching and learning, to investigating how and why they have an impact.

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Angeli, C., & Valanides, N. (2013). Technology mapping: An approach for developing technological pedagogical content knowledge. *Journal of Educational Computing Research*, *48*, 199–221. doi:10.2190/ec.48.2.e

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

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Voogt, J., Fisser, P., Roblin, N. P., Tondeur, J., & van Braak, J. (2012). Technological pedagogical content knowledge – A review of the literature. *Journal of Computer Assisted Learning*, *29*, 109–121. doi:10.1111/j.1365-2729.2012.00487.x

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

Appendix: References and Codes for the Publications Included in the Systematic Review

Reference	Micro	Meso	Macro	Teacher	Student
Abbitt, Jason T. (2011). An investigation of the relationship between self-efficacy beliefs about technology integration and technological pedagogical content knowledge (TPACK) among preservice teachers. *Journal of Digital Learning in Teacher Education, 27*, 134–143. doi:10.1080/21532974.2011.10784670	0	n/a	n/a	n/a	n/a
Agyei, D. D., & Voogt, J. (2012). Developing technological pedagogical content knowledge in pre-service mathematics teachers through collaborative design. *Australasian Journal of Educational Technology, 28*, 547–564. Retrieved from http://ascilite.org.au/ajet/	0	n/a	n/a	n/a	n/a
Akkoc, H. (2011). Investigating the development of prospective mathematics teachers' technological pedagogical content knowledge with regard to student difficulties: The case of radian concept. *Research in Mathematics Education, 13*, 75–76. doi:10.1080/14794802.2011.550729	0	n/a	n/a	n/a	n/a
Akkoc, H., & Ozmantar, M. F. (2013). Use of multiple representations in technology rich environments. *Research in Mathematics Education, 15*, 189–190. doi:10.1080/14794802.2013.797750	0	n/a	n/a	n/a	n/a
Alayyar, G.H., Fisser, P., & Voogt, J.M. (2011). ICT integration through design teams in science teacher preparation. *International Journal of Learning Technology, 6*, 125–145. doi:10.1504/ijlt.2011.042645	1	1	1	0	1
Alayyar, G. M., Fisser, P., & Voogt, J. (2012). Developing technological pedagogical content knowledge in pre-service science teachers: Support from blended learning. *Australasian Journal of Educational Technology, 28*, 1298–1316.	0	n/a	n/a	n/a	n/a
Allan, W. C., Erickson, J. L., Brookhouse, P., & Johnson, J. L. (2010). Teacher professional development through a collaborative curriculum project – an example of TPACK in Maine. *TechTrends*, *54*(6), 36–43. doi:10.1007/s11528-010-0452-x	0	n/a	n/a	n/a	n/a
Almås, A. G., & Krumsvik, R. (2008). Teaching in technology-rich classrooms: is there a gap between teachers' intentions and ICT practices? *Research in Comparative and International Education, 3*, 103–121. doi:10.2304/rcie.2008.3.2.103	1	1	1	0	1
Alsofyani, M. M., bin Aris, B., Eynon, R., & Majid, N. A. (2012). A preliminary evaluation of short blended online training workshop for TPACK development using Technology Acceptance Model. *The Turkish Online Journal of Educational Technology, 11*, 20–32. Retrieved from http://www.tojet.net/	1	1	1	0	1
An, H., & Shin, S. (2010). The impact of urban district field experiences on four elementary preservice teachers' learning regarding technology integration. *Journal of Technology Integration in the Classroom, 2(*3), 101–107. Retrieved from http://www.joti.us/	0	n/a	n/a	n/a	n/a
An, H., Wilder, H., & Lim, K. (2011). Preparing elementary pre-service teachers from a non-traditional student population to teach with technology. *Computers in the Schools, 28*, 170–193. doi:10.1080/07380569.2011.577888	0	n/a	n/a	n/a	n/a

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Reference	Micro	Meso	Macro	Teacher	Student
Anderson, A., Barham, N., & Northcote, M. (2013). Using the TPACK framework to unite disciplines in online learning. *Australasian Journal of Educational Technology, 29*, 549–565. Retrieved from http://ascilite.org.au/ajet/	1	1	1	0	0
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*, 154–168. doi:10.1016/j.compedu.2008.07.006	1	1	1	0	1
Angeli, C., & Valanides, N. (2013). Technology mapping: An approach for developing Technological Pedagogical Content Knowledge. *Journal of Educational Computing Research, 48*, 199–221. doi:10.2190/ec.48.2.e	1	1	1	0	1
Annetta, L. A., Frazier, W. M., Folta, E., Holmes, S., Lamb, R., & Cheng, M. T. (2013). Science teacher efficacy and extrinsic factors toward professional development using video games in a design-based research model: the next generation of STEM learning. *Journal of Science Education and Technology, 22*, 47–61. doi:10.1007/s10956-012-9375-y	1	1	0	0	0
Antonenko, P. D. (2013). Two heads are better than one: Inservice teachers engaging in instructional design 2.0. *Journal of Digital Learning in Teacher Education*, *29*(3), 72–81. doi:10.1080/21532974.2013.10784708	0	n/a	n/a	n/a	n/a
Archambault, L. (2011). The practitioner's perspective on teacher education: Preparing for the K-12 online classroom. *Journal of Technology and Teacher Education, 19*, 73–91. Retrieved from http://www.editlib.org/j/JTATE/	0	n/a	n/a	n/a	n/a
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	0	n/a	n/a	n/a	n/a
Archambault, L., & Crippen, K. (2009). Examining TPACK among K-12 online distance educators in the United States. *Contemporary Issues in Technology and Teacher Education, 9*, 71–88. Retrieved from http://www.citejournal.org/vol15/iss1/	0	n/a	n/a	n/a	n/a
Banister, S., & Reinhart, R. V. (2011). TPCK for impact: Classroom teaching practices that promote social justice and narrow the digital divide in an urban middle school. *Computers in the Schools, 28*, 5–26. doi:10.1080/07380569.2011.551086	0	n/a	n/a	n/a	n/a
Baran, E., Chuang, H-H., Thompson, A. (2011). TPACK: An emerging research and development tool for teacher educators. *The Turkish Online Journal of Educational Technology, 10*, 370–377. Retrieved from http://www.tojet.net/	1	1	0	0	0
Bassi, J., Kushniruk, A. W., & Borycki, E. M. (2013). Application of the Technological Pedagogical Content Knowledge framework in integrating an educational EMR into health informatics education. *Studies in Health Technology and Informatics, 183*, 49–53. Retrieved from http://www.iospress.nl/book/enabling-health-and-healthcare-through-ict/	0	n/a	n/a	n/a	n/a
Bauer, W. I. (2012). The acquisition of musical Technological Pedagogical and Content Knowledge. *Journal of Music Teacher Education*, *22*(2), 51–64. doi:10.1177/1057083712457881	0	n/a	n/a	n/a	n/a
Benson, S. N. K., & Ward, C. L. (2013). Teaching with Technology: Using TPACK to understand teaching expertise in online higher education. *Journal of Educational Computing Research, 48*, 153–172. doi:10.2190/ec.48.2.c	1	1	0	0	0
Blonder, R., Jonatan, M., Bar-Dov, Z., Benny, N., Rap, S., & Sakhnini, S. (2013). Can You Tube it? Providing chemistry teachers with technological tools and enhancing their self-efficacy beliefs. *Chemistry Education Research and Practice*, *14*, 269–285. doi:10.1039/c3rp00001j	0	n/a	n/a	n/a	n/a
Bos, B. (2011). Professional development for elementary teachers using TPACK. *Contemporary Issues in Technology and Teacher Education*, 11, 167–183. Retrieved from http://www.citejournal.org/vol15/iss1/	1	0	0	0	1
Bowers, J. S., & Stephens, B. (2011). Using technology to explore mathematical relationships: A framework for orienting mathematics courses for prospective teachers. *Journal of Mathematics Teacher Education*, *14*(4), 285–304. doi:10.1007/s10857-011-9168-x	0	n/a	n/a	n/a	n/a
Bustamante, C., & Moeller, A. J. (2013). The convergence of content, pedagogy, and technology in online professional development for teachers of German: An intrinsic case study. *CALICO Journal, 30*, 82–104. doi:10.1007/s10857-011-9168-x	0	n/a	n/a	n/a	n/a
Çalik, M., Özsevgeç, T., Ebenezer, J., Artun, H., & Küçük, Z. (2013). Effects of 'environmental chemistry' elective course via technology-embedded scientific inquiry model on some variables. *Journal of Science Education and Technology, 23*, 412–430. doi:10.1007/s10956-013-9473-5	0	n/a	n/a	n/a	n/a

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Reference	Micro	Meso	Macro	Teacher	Student
Campbell, T., & Abd-Hamid, N. (2013). Technology use in science instruction (TUSI): Aligning the integration of technology in science instruction in ways supportive of science education reform. *Journal of Science Education and Technology, 22*, 572–588. doi:10.1007/s10956-012-9415-7	0	n/a	n/a	n/a	n/a
Carlson, D. L., & Archambault, L. (2013). Technological pedagogical content knowledge and teaching poetry: Preparing preservice teachers to integrate content with VoiceThread technology. *Teacher Education and Practice*, *26*(1), 117–142. Retrieved from https://rowman.com/page/TEP	0	n/a	n/a	n/a	n/a
Chai, C S, Hwee, J., Koh, L., & Tsai, C.-C. (2010). Facilitating preservice teachers' development of Technological, Pedagogical, and Content Knowledge (TPACK). *Educational Technology & Society*, *13*(1), 63–73. Retrieved from http://www.ifets.info/	0	n/a	n/a	n/a	n/a
Chai, C. S., Koh, J. H. L., Ho, H. N. J., & Tsai, C. C. (2012). Examining preservice teachers' perceived knowledge of TPACK and cyberwellness through structural equation modeling. *Australasian Journal of Educational Technology, 28*, 1000–1019. Retrieved from http://ascilite.org.au/ajet/	1	0	0	0	1
Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2011). Exploring the factor structure of the constructs of Technological, Pedagogical, Content Knowledge (TPACK). *The Asian-Pacific Education Researcher, 20*, 595–603. doi:10.1080/1359866x.2014.941280	1	0	1	1	1
Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2013). A Review of Technological Pedagogical Content Knowledge. *Educational Technology & Society*, *16*(2), 31–51. Retrieved from http://www.ifets.info/	1	0	0	0	1
Chai, C. S., Koh, J. H. L., Tsai, C.-C., & Tan, L. L. W. (2011). Modeling primary school pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) for meaningful learning with Information and Communication Technology (ICT). *Computers & Education, 57*, 1184–1193. doi:10.1016/j.compedu.2011.01.007	1	1	1	0	1
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Chen, H.-Y., & Syh-Jong, J. (2013). Exploring the resasons for using electric books and technological pedagogical and content knowledge of Taiwanese elementary mathematics and science teachers. *Turkish Online Journal of Educational Technology, 12*, 131–141. Retrieved from http://www.tojet.net/	1	1	0	0	1
Chuang, H. (2013). A case study of e-tutors' teaching practice: Does technology drive pedagogy? *International Journal of Education in Mathematics, Science and Technology*, *1*, 75–82. Retrieved from http://ijemst.com/home.html	0	n/a	n/a	n/a	n/a
Ciampa, K., & Gallagher, T. L. (2013). Professional learning to support elementary teachers' use of the iPod Touch in the classroom. *Professional Development in Education, 39*, 201–221. doi:10.1080/19415257.2012.749802	0	n/a	n/a	n/a	n/a
Cook, D. (2013). Infusing music technology in music education: A descriptive analysis of the status of high school music technology and professional development in large Suffolk County, NY school districts. *Long Island Educational Review*, *12*(1), 16–26.	0	n/a	n/a	n/a	n/a
Dawson, K., Ritzhaupt, A., Liu, F., Rodriguez, P., & Frey, C. (2013). Using TPCK as a lens to study the practices of math and science teachers involved in a year-long technology integration initiative. *Journal of Computers in Mathematics and Science Teaching, 32*, 395–422. Retrieved from http://www.aace.org/pubs/jcmst/	0	n/a	n/a	n/a	n/a
De Olviera, J. M. (2010). Pre-service teacher education enriched by technology-supported learning environments: A learning technology by design approach. *Journal of Literacy and Technology*, *11*(1), 89–109. Retrieved from http://www.literacyandtechnology.org/	0	n/a	n/a	n/a	n/a
Debele, M., & Plevyak, L. (2012). Conditions for successful use of technology in social studies classrooms. *Computers in the Schools, 29*, 285–299. doi:10.1080/07380569.2012.703602	1	1	1	0	1
Doering, A., & Veletsianos, G. (2007). An investigation of the use of real-time, authentic geospatial data in the K-12 classroom. *Journal of Geography, 106*, 217–225. doi:10.1080/00221340701845219	0	n/a	n/a	n/a	n/a
Doering, A., Veletsianos, G., Scharber, C., & Miller, C. (2009). Using the technological, pedagogical, and content knowledge framework to design online learning environments and professional development. *Journal of Educational Computing Research*, *41*(3), 319–346. doi:10.2190/ec.41.3.d	0	n/a	n/a	n/a	n/a
Doğan, M. (2012). Prospective Turkish primary teachers' views about the use of computers in mathematics education. *Journal of Mathematics Teacher Education, 15*, 329–341. doi:10.1007/s10857-012-9214-3	0	n/a	n/a	n/a	n/a

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Reference	Micro	Meso	Macro	Teacher	Student
Doukakis, S., Koilias, C., & Chionidou-Moskofoglou, M. (2010). Students' satisfaction with an undergraduate primary education teaching practicum design on developing Technological, Pedagogical and Mathematical Knowledge. *Journal of Higher Education Policy and Management*, *73*, 661–666. doi:10.1007/978-3-642-13166-0_92	0	n/a	n/a	n/a	n/a
Doukakis, S., Koilas, C., & Chionidou-Moskofoglou, M. (2011). An undergraduate primary education teaching practicum design and undergraduate primary teachers' satisfaction on developing technological, pedagogical and mathematical knowledge. *International Journal of Teaching and Case Studies, 3*, 180–195. doi:10.1504/ijtcs.2011.039557	0	n/a	n/a	n/a	n/a
Doukakis, S., Moskofoglou, M. C., Phelan, E. M., & Roussos, P. (2010). Researching technological and mathematical knowledge (TCK) of undergraduate primary teachers. *International Journal of Technology Enhanced Learning, 2*, 372–382. doi:10.1504/ijtel.2010.035739	0	n/a	n/a	n/a	n/a
Drijvers, P., Tacoma, S., Besamusca, A., Doorman, M., & Boon, P. (2013). Digital resources inviting changes in mid-adopting teachers' practices and orchestrations. *ZDM, 45*, 987–1001. doi:10.1007/s11858-013-0535-1	0	n/a	n/a	n/a	n/a
Erdogan, A., & Sahin, I. (2010). Relationship between math teacher candidates' Technological Pedagogical and Content Knowledge (TPACK) and achievement levels. *Procedia – Social and Behavioral Sciences*, *2*, 2707–2711. doi:10.1016/j.sbspro.2010.03.400	0	n/a	n/a	n/a	n/a
Figg, C. & McCartney, R. (2010). Impacting academic achievement with student learners teaching digital storytelling to others: The ATTTCSE digital video project. *Contemporary Issues in Technology and Teacher Education*, *10*(1), 38–79. Retrieved from http://www.citejournal.org/vol15/iss1/	0	n/a	n/a	n/a	n/a
Fransson, G., & Holmberg, J. (2012). Understanding the theoretical framework of technological pedagogical content knowledge: A collaborative self-study to understand teaching practice and aspects of knowledge. *Studying Teacher Education, 8(*2), 193–204. doi:10.1080/17425964.2012.692994	1	1	1	1	0
Gao, P., & Mager, G. M. (2013). Constructing embodied understanding of technological pedagogical content knowledge: Preservice teachers learning to teach with information technology. *International Journal of Social Media and Interactive Learning Environments, 1*, 74–92. doi:10.1504/ijsmile.2013.051654	1	0	1	0	0
Gao, P., Tan, S. C., Wang, L., Wong, A., & Choy, D. (2011). Self reflection and preservice teachers' technological pedagogical knowledge: Promoting earlier adoption of student-centred pedagogies. *Australasian Journal of Educational Technology, 27*, 997–1013. Retrieved from http://ascilite.org.au/ajet/submission/index.php/AJET/index	0	n/a	n/a	n/a	n/a
Graham, C. R., Borup, J., & Smith, N. B. (2012). Using TPACK as a framework to understand teacher candidates' technology integration decisions. *Journal of Computer Assisted Learning*, *28*, 530–546. doi:10.1111/j.1365-2729.2011.00472.x	0	n/a	n/a	n/a	n/a
Graham, C. R., Burgoyne, N., Cantrell, P., Smith, L., St. Clair, L., & Harris, R. (2009). Measuring the TPACK Confidence of Inservice Science Teachers. *TechTrends, 53*, 70–79.	0	n/a	n/a	n/a	n/a
Groth, R., Spickler, D., Bergner, J., & Bardzell, M. (2009). A qualitative approach to assessing technological pedagogical content knowledge. *Contemporary Issues in Technology and Teacher Education, 9*, 392–411. Retrieved from http://www.citejournal.org/vol15/iss1/	0	n/a	n/a	n/a	n/a
Guzey, S. S., & Roehrig, G. H. (2009). Teaching science with technology: Case studies of science teachers' development of technology, pedagogy, and content knowledge. *Contemporary Issues in Technology and Teacher Education, 9*, 25–45. Retrieved from http://www.citejournal.org/vol15/iss1/	0	n/a	n/a	n/a	n/a
Guzey, S. S., & Roehrig, G. H. (2012). Integrating educational technology into the secondary science teaching. *Contemporary Issues in Technology and Teacher Education, 12*, 162–183. Retrieved from http://www.citejournal.org/vol15/iss1/	0	n/a	n/a	n/a	n/a
Haciomeroglu, E. S., Bu, L., Schoen, R. C., & Hohenwarter, M. (2011). Prospective teachers' experiences in developing lessons with dynamic mathematics software. *International Journal for Technology in Mathematics Education, 18*, 71–82. Retrieved from http://www.researchinformation.co.uk/time.php	0	n/a	n/a	n/a	n/a
Han, I., Eom, M., & Shin, W. W. (2013). Multimedia case-based learning to enhance pre-service teachers' knowledge integration for teaching with technologies. *Teaching & Teacher Education, 34*, 122–129. doi:10.1016/j.tate.2013.03.006	0	n/a	n/a	n/a	n/a

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Reference	Micro	Meso	Macro	Teacher	Student
Handal, B., Campbell, C., Cavanagh, M., Petocz, P., & Kelly, N. (2012). Integrating technology, pedagogy and content in mathematics education. *Journal of Computers in Mathematics and Science Teaching, 31*, 387–413. Retrieved from http://www.aace.org/pubs/jcmst/	0	n/a	n/a	n/a	n/a
Handal, B., Campbell, C., Cavanagh, M., Petocz, P., & Kelly, N. (2013). Technological Pedagogical Content Knowledge of secondary mathematics teachers. *Contemporary Issues in Technology and Teacher Education, 13*, 22–40. Retrieved from http://www.citejournal.org/vol15/iss1/	0	n/a	n/a	n/a	n/a
Hardy, M. (2010). Enhancing preservice mathematics teachers' TPCK. *Journal of Computers in Mathematics and Science Teaching, 29*, 73–86. Retrieved from http://www.aace.org/pubs/jcmst/	0	n/a	n/a	n/a	n/a
Hardy, M. D. (2010). Facilitating growth in preservice mathematics teachers' TPCK. *National Teacher Education Journal, 3*, 121–138. Retrieved from http://www.ntejournal.com/	0	n/a	n/a	n/a	n/a
Harris, J. B., & Hofer, M. J. (2011). Technological pedagogical content knowledge (TPACK) in action: A descriptive study of secondary teachers' curriculum-based, technology-related instructional planning. *Journal of Research on Technology in Education, 43*, 211. doi:10.1080/15391523.2011.10782570	1	0	1	0	0
He, W., Zhang, S., Strudler, N., & Means, T. (2012). Integrating a case library with blogs for lesson planning activities. *International Journal of Learning Technology, 7*, 133–153. doi:10.1504/ijlt.2012.047979	1	1	1	0	1
Hechter, R. P. (2012). Pre-service teachers' maturing perceptions of a TPACK-framed signature pedagogy in science education. *Computers in the Schools, 29*, 53–69. doi:10.1080/07380569.2012.657999	0	n/a	n/a	n/a	n/a
Hechter, R. P., & Vermette, L. A. (2013). Technology integration in K-12 science classrooms: An analysis of barriers and implications. *Themes in Science and Technology Education*, *6*(2), 73–90. Retrieved from http://earthlab.uoi.gr/theste/	0	n/a	n/a	n/a	n/a
Hofer, M., & Grandgenett, N. (2012). TPACK development in teacher education: A longitudinal study of preservice teachers in a secondary M.A.Ed. program. *Journal of Research on Technology in Education, 45*, 83–106. doi:10.1080/15391523.2012.10782598	0	n/a	n/a	n/a	n/a
Hofer, M., & Swan, K. O. (2008). Technological pedagogical content knowledge in action: A case study of a middle school digital documentary project. *Journal of Research on Computing in Education, 41*, 179–200. doi:10.1080/15391523.2008.10782528	1	1	0	0	1
Holmes, K. (2009). Planning to teach with digital tools: Introducing the interactive whiteboard to pre-service secondary mathematics teachers. *Australasian Journal of Educational Technology, 25*, 351–365. Retrieved from http://ascilite.org.au/ajet/submission/index.php/AJET/index	0	n/a	n/a	n/a	n/a
Horzum, M. B. (2013). An investigation of the technological pedagogical content knowledge of pre-service teachers. *Technology, Pedagogy and Education, 22*, 303–317. doi:10.1080/1475939x.2013.795079	0	n/a	n/a	n/a	n/a
Hosseini, Z., & Kamal, A. (2012). Developing an instrument to measures perceived technology integration knowledge of teachers. *International Magazine on Advances in Computer Science and Telecommunications*, *3*, 79–89. Retrieved from http://imacst.com/author/index.php/IMACST/index	0	n/a	n/a	n/a	n/a
Hosseini, Z., & Kamal, A. (2013). A survey on pre-service and in-service teachers' perceptions of technological pedagogical content knowledge (TPCK). *Malaysian Online Journal of Educational Technology, 1*, 1–7. Retrieved from http://www.mojet.net/	1	1	1	0	1
Hosseini, Z., & Tee, M. Y. (2012). Conditions influencing development of teachers' knowledge for technology integration in teaching. *International Magazine on Advances in Computer Science and Telecommunications, 3*, 91–101. Retrieved from http://imacst.com/author/index.php/IMACST/index	0	n/a	n/a	n/a	n/a
Hsu, P. (2012). Examining the impact of educational technology courses on pre-service teachers' development of technological pedagogical content knowledge. *Teaching Education, 23*, 195–213. doi:10.1080/10476210.2011.622041	1	1	1	0	0
Hu, H-W., Walker, K., & Hsiao, W-Y. (2013). Developing elementary pre-service teachers' technological, pedagogical, and content knowledge for learning and teaching division of fractions. *International Journal of Technology, Knowledge and Society, 9*, 185–204. http://techandsoc.com/publications/journal	0	n/a	n/a	n/a	n/a

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Hubbard, J. D., & Price, G. (2013). Cross-culture and technology integration: Examining the impact of a TPACK-focused collaborative project on pre-service teachers and teacher education faculty. *Journal of the Research Center for Educational Technology: Annual Review, 9*, 131–155.	0	n/a	n/a	n/a	n/a
Hughes, J. E. (2013). Descriptive indicators of future teachers' technology integration in the PK-12 classroom: Trends from a laptop-infused teacher education program. *Journal of Educational Computing Research, 48*, 491–516. doi:10.2190/ec.48.4.e	0	n/a	n/a	n/a	n/a
Jaipal, K., & Figg, C. (2010). Unpacking the "Total PACKage": Emergent TPACK characteristics from a study of preservice teachers teaching with technology. *Journal of Technology and Teacher Education, 18*, 415–441. Retrieved from http://www.editlib.org/j/JTATE/	1	1	1	0	0
Jamieson-Proctor, R., Finger, G., & Albion, P. (2010). Auditing the TK and TPACK confidence of pre-service teachers: are they ready for the profession? *Australian Educational Computing, 25(*1), 8–17. Retrieved from http://acce.edu.au/journal/	0	n/a	n/a	n/a	n/a
Jang, S.-J. (2010). Integrating the interactive whiteboard and peer coaching to develop the TPACK of secondary science teachers. *Computers & Education, 55*, 1744–1751. doi:10.1016/j.compedu.2010.07.020	1	1	0	0	0
Jang, S.-J., & Chen, K.-C. (2010). From PCK to TPACK: Developing a transformative model for pre-service science teachers. *Journal of Science Education and Technology, 19*, 553–564. doi:10.1007/s10956-010-9222-y	1	0	1	1	1
Jang, S.-J., & Tsai, M.-F. (2012). Exploring the TPACK of Taiwanese elementary mathematics and science teachers with respect to use of interactive whiteboards. *Computers & Education, 59*, 327–338. doi:10.1016/j.compedu.2012.02.003	1	1	0	0	1
Jang, S-J., & Tsai, M-F. (2013). Exploring the TPACK of Taiwanese secondary school science teachers using a new contextualized TPACK model. *Australasian Journal of Educational Technology, 29*, 566–580. Retrieved from http://ascilite.org.au/ajet/submission/index.php/AJET/index	1	1	0	1	1
Jeong-so, H., & Kim, B. (2009). Learning about problem based learning: Student teachers integrating technology, pedagogy, and content knowledge. *Australiasian Journal of Educational Technology*, *25*(1), 101–116. Retrieved from http://ascilite.org.au/ajet/	1	1	1	0	1
Jimoyiannis, A. (2010). Designing and implementing an integrated technological pedagogical science knowledge framework for science teachers professional development. *Computers & Education*, *55*(3), 1259–1269. doi:10.1016/j.compedu.2010.05.022	1	1	1	0	1
Jordan, K. (2011). Beginning teacher knowledge: Results from a self-assessed TPACK survey. *Australian Educational Computing*, *26*(1), 16–26. Retrieved from http://acce.edu.au/journal/	0	n/a	n/a	n/a	n/a
Kadijevich, D. M. (2012). TPCK framework: Assessing teachers' knowledge and designing courses for their professional development. *British Journal of Educational Technology*, *43*, 28–30. doi:10.1111/j.1467-8535.2011.01246.x	0	n/a	n/a	n/a	n/a
Kaya, S., & Dag, F. (2013). Turkish adaptation of Technological Pedagogical Content Knowledge Survey for elementary teachers. *Educational Sciences: Theory and Practices, 13*, 302–306. Retrieved from http://www.estp.com.tr/	0	n/a	n/a	n/a	n/a
Keeler, C. G. (2008). When curriculum and technology meet: Technology integration in methods courses. *Journal of Computing in Teacher Education, 25*, 23–30. doi:10.1080/10402454.2008.10784605	0	n/a	n/a	n/a	n/a
Khan, S. (2011). New pedagogies on teaching science with computer simulations. *Journal of Science Education and Technology, 20*, 215–232. doi:10.1007/s10956-010-9247-2	0	n/a	n/a	n/a	n/a
Koçoğlu, Z. (2009). Exploring the technological pedagogical content knowledge of pre-service teachers in language education. *Procedia - Social and Behavioral Sciences, 1*, 2734–2737. doi:10.1016/j.sbspro.2009.01.485	0	n/a	n/a	n/a	n/a
Koehler, M. J., & Mishra, P. (2005). What happens when teachers design educational technology? The development of technological pedagogical content knowledge. *Journal of Educational Computing Research, 32*, 131–152. doi:10.2190/0ew7-01wb-bkhl-qdyv	1	1	1	0	1
Koehler, M. J., Mishra, P., Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology. *Computers & Education, 49*, 740–762. doi:10.1016/j.compedu.2005.11.012	1	1	0	0	1
Koh, J. H. L., Chai, C. S., & Tsai, C. C. (2010). Examining the technological pedagogical content knowledge of Singapore pre-service teachers with a large-scale survey. *Journal of Computer Assisted Learning, 26*, 563–573. doi:10.1111/j.1365-2729.2010.00372.x	0	n/a	n/a	n/a	n/a

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Reference	Micro	Meso	Macro	Teacher	Student
Koh, J., Chai, C., & Tsai, C.-C. (2013). Examining practicing teachers' perceptions of technological pedagogical content knowledge (TPACK) pathways: A structural equation modeling approach. *Instructional Science, 41*, 793–809. doi:10.1007/s11251-012-9249-y	0	n/a	n/a	n/a	n/a
Koh, J. H., & Divaharan, S. (2011). Developing pre-service teachers' technology integration expertise through the TPACK-developing instructional model. *Journal of Educational Computing Research, 44*, 35–58. doi:10.2190/ec.44.1.c	1	1	0	0	0
Koh, J. H. L., & Divaharan, S. (2013). Towards a TPACK-fostering ICT instructional process for teachers: Lessons from the implementation of interactive whiteboard instruction. *Australasian Journal of Educational Technology, 29*, 233–247. Retrieved from http://ascilite.org.au/ajet/submission/index.php/AJET/index	0	n/a	n/a	n/a	n/a
Koh, J. H. L., Woo, H. L., & Lim, W. Y. (2013). Understanding the relationship between Singapore preservice teachers' ICT course experiences and technological pedagogical content knowledge (TPACK) through ICT course evaluation. *Educational Assessment, Evaluation and Accountability*, *24*(4), 321–339. doi:10.1007/s11092-013-9165-y	1	0	1	0	1
Kohen, Z., & Kramarski, B. (2012). Developing a TPCK-SRL assessment scheme for conceptually advancing technology in education. *Studies in Educational Evaluation, 38*, 1–8. doi:10.1016/j.stueduc.2012.03.001	1	0	1	0	1
Kramarski, B., & Michalsky, T. (2009). Three metacognitive approaches to training pre-service teachers in different learning phases of technological pedagogical content knowledge. *Educational Research and Evaluation, 15*, 465–485. doi:10.1080/13803610903444550	0	n/a	n/a	n/a	n/a
Kramarski, B., & Michalsky, T. (2010). Preparing preservice teachers for self-regulated learning in the context of technological pedagogical content knowledge. *Learning and Instruction, 20*, 434–447. doi:10.1016/j.learninstruc.2009.05.003	0	n/a	n/a	n/a	n/a
Krauskopf, K., Zahn, C., & Hesse, F. W. (2012). Leveraging the affordances of Youtube: The role of pedagogical knowledge and mental models of technology functions for lesson planning with technology. *Computers & Education, 58*, 1194–1206. doi:10.1016/j.compedu.2011.12.010	0	n/a	n/a	n/a	n/a
Kukkonen, J., Kärkkäinen, S., Valtonen, T., & Keinonen, T. (2011). Blogging to support inquiry-based learning and reflection in teacher students' science education. *Problems of Education in the 21st Century, 31*, 73–84. Retrieved from http://www.jbse.webinfo.lt/Problems_of_Education.htm	0	n/a	n/a	n/a	n/a
Larkin, K., Jamieson-Proctor, R., & Finger, G. (2012). TPACK and pre-service teacher mathematics education: Defining a signature pedagogy for mathematics education using ICT and based on the metaphor "mathematics is a language." *Computers in the Schools, 29*, 207–226. doi:10.1080/07380569.2012.651424	0	n/a	n/a	n/a	n/a
Lee, H., & Hollebrands, K. (2008). Preparing to teach mathematics with technology: An integrated approach to developing technological pedagogical content knowledge. *Contemporary Issues in Technology and Teacher Education*, *8*(4), 326–341. Retrieved from http://www.citejournal.org/vol15/iss1/	0	n/a	n/a	n/a	n/a
Lee, M.-H., & Tsai, C.-C. (2008). 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	0	n/a	n/a	n/a	n/a
Liang, J-C., Chai, C. S., Koh, J. H. L., Yang, C-J., & Tsai, C-C. (2013). Surveying in-service preschool teachers' technological pedagogical content knowledge. *Australasian Journal of Educational Technology, 29*, 581–594. Retrieved from http://ascilite.org.au/ajet/submission/index.php/AJET/index	1	1	1	1	1
Lin, T.-C., Tsai, C.-C., Chai, C., & Lee, M.-H. (2013). Identifying science teachers' perceptions of technological pedagogical and content knowledge. *Journal of Science Education and Technology, 22*, 325–336. doi:10.1007/s10956-012-9396-6	1	1	1	0	1
Liu, S-H. (2013). Exploring the instructional strategies of elementary school teachers when developing technological, pedagogical, and content knowledge via a collaborative professional development program. *International Education Studies*, *6* (11), 58–68. doi:10.5539/ies.v6n11p58	1	1	1	0	0
Lu, L., & Lei, J. (2012). Using live dual modeling to help preservice teachers develop TPACK. *Journal of Digital Learning in Teacher Education*, *29*(1), 14–22.	1	1	1	0	1
Lux, N. J., Bangert, A. W., & Whittier, D. B. (2011). The development of an instrument to assess preservice teacher's technological pedagogical content knowledge. *Journal of Educational Computing Research, 45*, 415–431. doi:10.1080/21532974.2012.10784699	1	1	1	0	0

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Reference	Micro	Meso	Macro	Teacher	Student
Maddin, E. (2011). Using TPCK with digital storytelling to investigate contemporary issues in educational technology. *Journal of Instructional Pedagogies*, 7(2), 1–11. Retrieved from http://www.aabri.com/jip.html	1	1	1	0	0
Maeng, J. L., Mulvey, B. K., Smetana, L. K., & Bell, R. L. (2013). Preservice teachers' TPACK: Using technology to support inquiry instruction. *Journal of Science Education and Technology, 22*, 838–857. doi:10.1007/s10956-013-9434-z	0	n/a	n/a	n/a	n/a
Magana, A. J., Brophy, S. P., & Bodner, G. M. (2012). Student views of engineering professors' technological pedagogical content knowledge for integrating computational simulation tools in nanoscale science and engineering. *International Journal of Engineering Education, 28*, 1033–1045. Retrieved from http://www.ijee.ie/	0	n/a	n/a	n/a	n/a
Magen-Nagar, N., & Peled, B. (2013). Characteristics of Israeli school teachers in computer-based learning ennvironments. *Journal of Educators Online*, *10*(1), 1–34. Retrieved from http://www.thejeo.com/	0	n/a	n/a	n/a	n/a
Maher, D. (2013). Pre-service primary teachers' use of iPads to support teaching: Implications for teacher education. *Educational Research for Social Change*, *2*(1), 48–63. Retrieved from http://ersc.nmmu.ac.za/	0	n/a	n/a	n/a	n/a
Manfra, M. M., & Hammond, T. C. (2007). Teachers' instructional choices with student-created digital documentaries: Case studies. *Journal of Research on Technology in Education, 41*, 223–245. doi:10.1080/15391523.2008.10782530	1	1	0	0	1
Meng, C. C., & Sam, L. C. (2013). Developing pre-service teachers' Technological Pedagogical Content Knowledge for teaching mathematics with the Geometer's Sketchpad through lesson study. *Journal of Education and Learning*, *2*(1), 1–8. Retrieved from http://www.ccsenet.org/journal/index.php/jel/index	0	n/a	n/a	n/a	n/a
Morsink, P. M., Hagerman, M. S., Heintz, A., Boyer, D. M., Harris, R. Kereluik, K., & Hartman, D. K. (2010/2011). Professional development to support TPACK technology integration: The initial learning trajectories of thirteen fifth- and sixth-grade educators. *Journal of Education*, *191*(2), 3–18. Retrieved from http://www.bu.edu/journalofeducation/	1	0	1	0	1
Mouza, C. (2011). Promoting urban teachers' understanding of technology, content, and pedagogy in the context of case development. *Journal of Research on Technology in Education, 44*, 1–29. doi:10.1080/15391523.2011.10782577	1	1	1	0	1
Mouza, C., & Karchmer-Klein, R. (2013). Promoting and Assessing pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) in the context of case development. *Journal of Educational Computing Research, 48*, 127–152. doi:10.2190/ec.48.2.b	1	1	1	0	1
Nicholas, H., & Ng, W. (2012). Factors influencing the uptake of a mechatronics curriculum initiative in five Australian secondary schools. *International Journal of Technology and Design Education, 22*, 65–90. doi:10.1007/s10798-010-9138-0	1	1	1	0	1
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.	0	n/a	n/a	n/a	n/a
Niess, M. L. (2013). Central Component Descriptors for Levels of Technological Pedagogical Content Knowledge. *Journal of Educational Computing Research, 48*, 173–198. doi:10.1016/j.tate.2005.03.006	1	1	1	0	0
Niess, M., & Gillow-Wiles, H. (2013). Advancing K-8 teachers' STEM education for teaching interdisciplinary science and mathematics with technologies. *Journal of Computers in Mathematics and Science Teaching, 32*, 219–245. Retrieved from http://www.aace.org/pubs/jcmst/	0	n/a	n/a	n/a	n/a
Niess, M. L., van Zee, E. H., & Gillow-Wiles, H. (2011). Knowledge growth in teaching mathematics/science with spreadsheets: Moving PCK to TPACK through online professional development. *Journal of Digital Learning in Teacher Education, 27*, 42–52. doi:10.1080/21532974.2010.10784657	0	n/a	n/a	n/a	n/a
Oakley, G., Howitt, C., Garwood, R., Durack, A-R. (2013). Becoming multimodal authors: Pre-service teachers' interventions to support young children with autism. *Australasian Journal of Early Childhood*, *38*(3), 86–96. Retrieved from http://www.earlychildhoodaustralia.org.au/our-publications/australasian-journal-early-childhood/	0	n/a	n/a	n/a	n/a
Oster-Levinz, A., & Klieger, A. (2010). Online tasks as a tool to promote teachers' expertise within the Technological Pedagogical Content Knowledge (TPACK). *Procedia – Social and Behavioral Sciences, 2*, 354–358. doi:10.1016/j.sbspro.2010.03.024	0	n/a	n/a	n/a	n/a

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Reference	Micro	Meso	Macro	Teacher	Student
Oster–Levinz, A., & Klieger, A. (2012). How do we know they can do it? Developing TPACK in a pre–service course. *International Journal of Learning Technology, 7*, 400–418. doi:10.1504/ijlt.2012.052213	0	n/a	n/a	n/a	n/a
Otrel-Cass, K., Khoo, E., & Cowie, B. (2012). Scaffolding with and through videos: An example of ICT-TPACK. *Contemporary Issues in Technology and Teacher Education, 12*(4), 369–390. Retrieved from Retrieved from http://www.citejournal.org/vol15/iss1/	1	1	0	0	1
Özgün-Koca, S. A. (2009). The views of preservice teachers about the strengths and limitations of the use of graphing calculators in mathematics instruction. *Journal of Technology and Teacher Education, 17*, 203–227. Retrieved from http://www.editlib.org/j/JTATE/	0	n/a	n/a	n/a	n/a
Özgün-Koca, S. A., Meagher, M., & Edwards, M. T. (2010). Preservice teachers ' emerging TPACK in a technology-rich methods class. *Mathematics Educator, 19*, 10–20. Retrieved from http://math.coe.uga.edu/tme/tmeonline.html	0	n/a	n/a	n/a	n/a
Özgün-Koca, S. A., Meagher, M., & Edwards, M. T. (2011). A teacher's journey with a new generation handheld: Decisions, struggles, and accomplishments. *School Science and Mathematics, 111*, 209–224. doi:10.1111/j.1949-8594.2011.00080.x	0	n/a	n/a	n/a	n/a
Özmantar, M. F., Akkoç, H., Bingölbali, E., Demir, S., & Ergene, B. (2010). Pre-service mathematics teachers' use of multiple representations in technology-rich environments. *Eurasia Journal of Mathematics, Science & Technology Education, 6*, 19–36. Retrieved from http://www.ejmste.com/	0	n/a	n/a	n/a	n/a
Öztürk, İ. H. (2012). Wikipedia as a teaching tool for technological pedagogical content knowledge (TPCK) development in pre-service history teacher education. *Educational Research and Review*, *7*(7), 182–191. Retrieved from http://www.journals.elsevier.com/educational-research-review/	1	1	1	0	0
Pamuk, S. (2011). Understanding preservice teachers' technology use through TPACK framework. *Journal of Computer Assisted Learning, 28*, 425–439. doi:10.1111/j.1365-2729.2011.00447.x	1	0	1	0	0
Pamuk, S., Ergun, M., Cakir, R., Yilmas, H. B., & Ayas, C. (2013). Exploring relationships among TPACK components and development of the TPACK instrument. *Education and Information Technologies*, *20*, 241–263. doi:10.1007/s10639-013-9278-4	1	0	0	0	0
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Parkes, K. A., Dredger, K. S., & Hicks, D. (2013). ePortfolio as a measure of reflective practice. *International Journal of ePortfolio, 3*, 99–115. Retrieved from http://www.theijep.com/	0	n/a	n/a	n/a	n/a
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Reference	Micro	Meso	Macro	Teacher	Student
Porras-Hernández, L. H., & Salinas-Amescua, B. (2013). Strengthening TPACK: A broader notion of context and the use of teacher's narratives to reveal knowledge construction. *Journal of Educational Computing Research, 48*, 223–244. doi:10.2190/ec.48.2.f	1	1	1	1	1
Richardson, S. (2009). Mathematics teachers' development, exploration, and advancement of technological pedagogical content knowledge in the teaching and learning of algebra. *Contemporary Issues in Technology and Teacher Education, 9*, 117–130.	1	1	0	0	0
Rienties, B., Brouwer, N., Bohle Carbonell, K., Townsend, D., Rozendal, A-P., van der Loo, J.,. . .Lygo-Baker, S. (2013). Online training of TPACK skills of higher education scholars: A cross-institutional impact study. *European Journal of Teacher Education*, *36*(4), 480–495. doi:10.1016/j.tate.2012.09.002	0	n/a	n/a	n/a	n/a
Rienties, B., Brouwer, N., & Lygo-Baker, S. (2013). The effects of online professional development on higher education teachers' beliefs and intentions towards learning facilitation and technology. *Teaching and Teacher Education, 29*, 122–131.	1	1	1	0	0
Saad, M., Barbar, A.M., & Abourjelli, S.A.R. (2012). Introduction of TPACK-XL for building pre-service teacher knowledge base. *Turkish Journal of Teacher Education*, *1*(2), 41–60.	0	n/a	n/a	n/a	n/a
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Shafer, K. (2010). The proof is in the screencast. *Contemporary Issues in Technology and Teacher Education*, *10*(4), 383–410. Retrieved from http://www.citejournal.org/vol15/iss1/	0	n/a	n/a	n/a	n/a
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Reference	Micro	Meso	Macro	Teacher	Student
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Stewart, J., Antonenko, P. D., Robinson, J. S., & Mwavita, M. (2013). Intrapersonal factors affecting technological pedagogical content knowledge of agricultural education teachers. *Journal of Agricultural Education*, *54*(3), 157–170. doi:10.5032/jae.2013.03157	0	n/a	n/a	n/a	n/a
Swan, K., & Hofer, M. (2011). In search of technological pedagogical content knowledge: Teachers' initial foray into podcasting in economics. *Journal of Research on Technology in Education, 44*, 75–98. doi:10.1080/15391523.2011.10782580	0	n/a	n/a	n/a	n/a
Tabach, M. (2011). A mathematics teacher's practice in a technological environment: A case study analysis using two complementary theories. *Technology, Knowledge and Learning, 16*, 247–265. doi:10.1007/s10758-011-9186-x	1	1	0	0	0
Tantarunrgoj, P., & Suwannatthachote, P. (2012). Enhancing pre-service teacher's self-efficacy and Technological Pedagogical Content Knowledge in designing digital media with self-regulated learning instructional support in online project-based learning. *Creative Education, 3*, 77–81. doi:10.4236/ce.2012.38b017	0	n/a	n/a	n/a	n/a
Tee, M. Y., & Lee, S. S. (2011). From socialisation to internalisation: Cultivating technological pedagogical content knowledge through problem-based learning. *Australasian Journal of Educational Technology, 27*, 89–104. Retrieved from http://ascilite.org.au/ajet/submission/index.php/AJET/index	1	1	0	0	1
Tokmak, H. S. (2013). Changing preschool teacher candidates' perceptions about technology integration in a TPACK-based material design course. *Education as Change, 17*, 115–129. doi:10.1080/16823206.2013.773927	0	n/a	n/a	n/a	n/a
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Valtonen, T., Pontinen, S., Kukkonen, J., Dillon, P., Vaisanen, P., & Hacklin, S. (2011). Confronting the technological pedagogical knowledge of Finnish net generation student teachers. *Technology, Pedagogy and Education, 20*, 3–18. doi:10.1080/1475939x.2010.534867	0	n/a	n/a	n/a	n/a
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Voogt, J., Fisser, P., Roblin, N. P., Tondeur, J., & van Braak, J. (2012). Technological pedagogical content knowledge - a review of the literature. *Journal of Computer Assisted Learning, 29*, 109–121. doi:10.1111/j.1365-2729.2012.00487.x	0	n/a	n/a	n/a	n/a
Wetzel, K., Foulger, T. S., & Williams, M. K. (2009). The evolution of the required educational technology course. *Journal of Computing in Teacher Education, 25*, 67–71. doi:10.1080/10402454.2008.10784611	0	n/a	n/a	n/a	n/a
Wetzel, K., & Marshall, S. (2012). TPACK goes to sixth grade: Lessons from a middle school teacher in a high-technology-access classroom. *Journal of Digital Learning in Teacher Education, 28*, 73–81. doi:10.1080/21532974.2011.10784683	0	n/a	n/a	n/a	n/a
White, B., & Geer, R. (2013). Preservice teachers experience with online modules about TPACK. *Australian Educational Computing*, *27*(3), 124–132. Retrieved from http://acce.edu.au/journal/	0	n/a	n/a	n/a	n/a
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Reference	Micro	Meso	Macro	Teacher	Student
Wu, Y. T. (2013). Research trends in technological pedagogical content knowledge (TPACK) research: A review of empirical studies published in selected journals from 2002 to 2011. *British Journal of Educational Technology, 44*, 73–76. doi:10.1111/j.1467-8535.2012.01349.x	0	n/a	n/a	n/a	n/a
Yeh, Y-F., Hsu, Y-S, Wu, H-K. (2014). Developing and validating technological pedagogical content knowledge-practical (TPACK-practical) through the Delphi survey technique. *British Journal of Educational Technology, 45*, 707–722. doi:10.1111/bjet.12078	1	1	1	0	1
Young, J.R., Young, J.L., & Hamilton, C. (2013). The use of confidence intervals as a meta-analytic lens to summarize the effects of teacher education technology courses on preservice teacher TPACK. *Journal of Research on Technology in Education, 46*, 149–172. doi:10.1080/15391523.2013.10782617	1	1	1	0	0
Young, J. R., Young, J. L., & Shaker, Z. (2012). Technological pedagogical content knowledge (TPACK) literature using confidence intervals. *TechTrends*, *56*(5), 25–33. doi:10.1007/s11528-012-0600-6	1	1	0	1	0
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*, 964–977. doi:10.1016/j.compedu.2011.10.012	1	1	1	0	0
Zelkowski, J., Gleason, J., Cox, D.C., & Bismarck, S. (2013). Developing and validating a reliable TPACK instrument for secondary mathematics preservice teachers. *Journal of Research on Technology in Education, 46*, 173–206. doi:10.1080/15391523.2013.10782618	0	n/a	n/a	n/a	n/a
Zhan, Y., Quan, J., & Ren, Y. (2013). An empirical study on the technological pedagogical content knowledge development of pre-service mathematics teachers in China. *International Journal of Social Media and Interactive Learning Environments, 1*, 199–212. doi:10.1504/ijsmile.2013.053600	0	n/a	n/a	n/a	n/a

Note. "n/a," not applicable, indicates that the referenced publication was not coded for that category because it was coded "0" for Inclusion of Context.