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 related to students and society. The grounds for both 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

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

Context is an essential part of educational research (Berliner, 2002, 2006; Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003; Greeno, Collins, & Resnick, 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 than 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; Porras-Hernández & Salinas-Amescua, 2013; Koh, Chai, & Tay, 2014). 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 and Salinas-Amescua, 2013). This paper, 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.

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

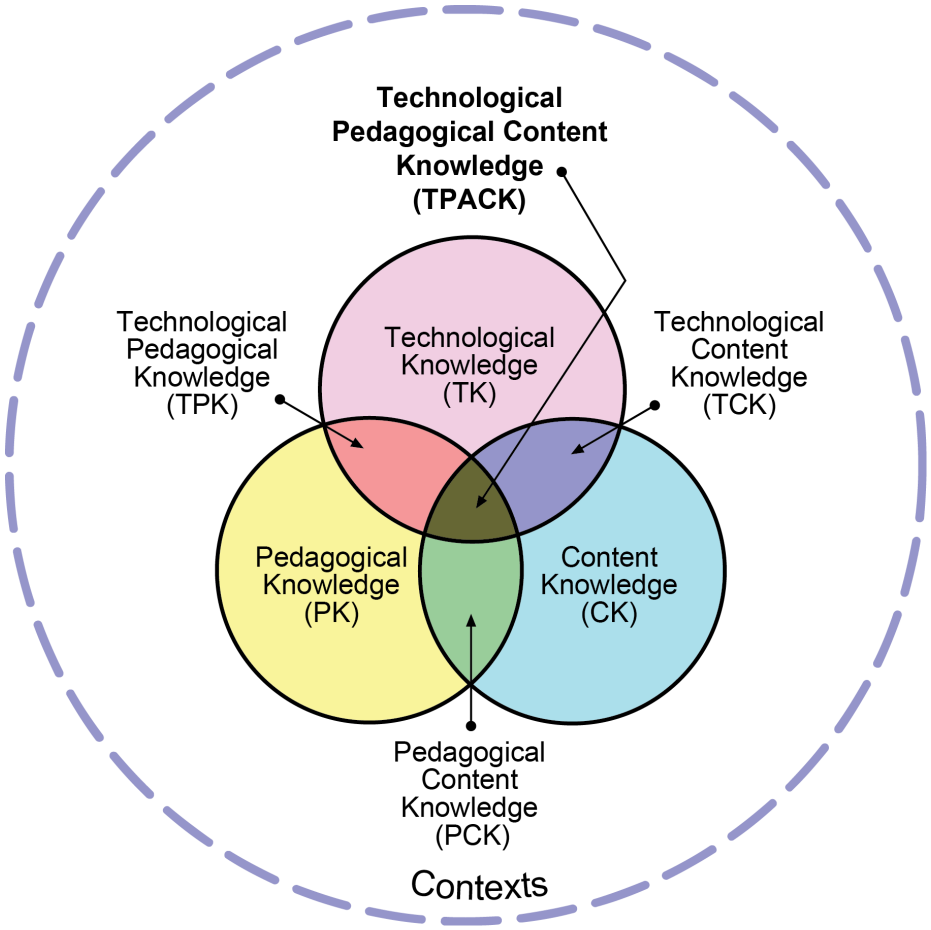
Mishra and Koehler (2006) developed TPACK in response to the absence of theory guiding the integration of technology into education. Since then, TPACK has become central to research into technology education and teacher professional development (Chai et al., 2013; Voogt et al., 2012). TPACK represents 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 (Figure 1) highlights knowledge of technology (TK), about specific tools, software, and hardware, pedagogy (PK), about how to manage, instruct, and guide students, and 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 between all of the constituent areas of knowledge. Importantly, these are all part of the complex context in which teachers act (Koehler & Mishra, 2008).

Figure 1

The TPACK Framework (Used with Permission from http://tpack.org)



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 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 et al., 2013*), while others suggesting fewer componentts 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 (see Koehler, Mishra, Kereluik, Shin, & Graham, 2014 for a review of these approaches). Research has also focused on measures of TPACK (see Abbitt, 2011; Koehler Shin, & Mishra, 2011 for a review). 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 under-developed and under-researched 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 and 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 depend 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 (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' transformative perspective. We describe Porras-Hernández and Salinas-Amescua's framework for context in greater detail in the next section.

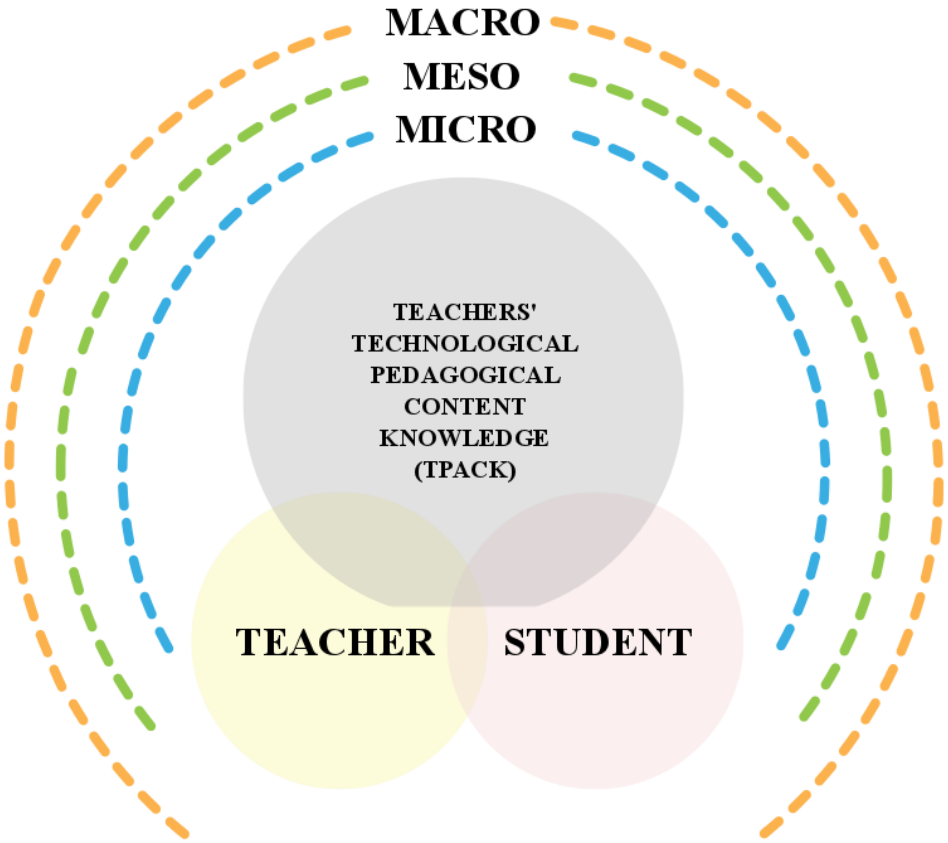
A Conceptual Framework for Context in TPACK Research

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

Figure 2

Our Representation of the Conceptual Framework for Context as Advanced by Porras-

Hernandez and Salinas-Amescua (2013)



Note. In this conceptual framework for context, teachers' TPACK reciprocally affects each of the parts of the framework, so that changes in teachers' knowledge is 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).

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, such as 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 (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 exists 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.

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.

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

Table 2.

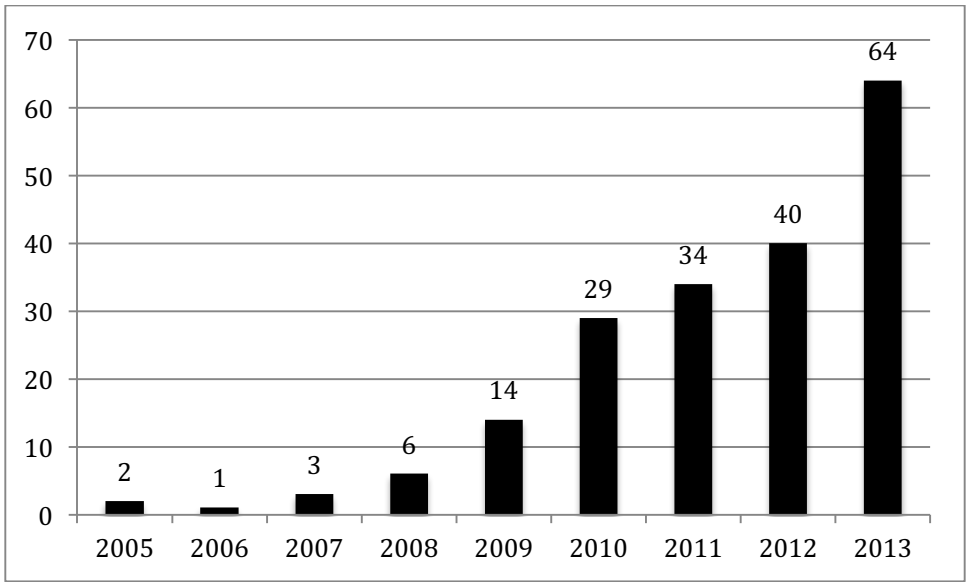
Journals with Three or More Articles Included in the Systematic Review

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

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 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 are included in Appendix A.

Figure 3

Publications in Peer-reviewed Journals of Empirical Studies about TPACK by Year



Note. The total number of publications is 193.**Data Segmentation**

For each publication in included in the study, thematic criteria (i.e., changes in topic) where used to identify the beginning and ending of data segments in the publication that explained, described, or operationalized TPACK (Schreier, 2012). 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, viz., Rienties, Brouwer, and Lygo-Baker (2013), wrote the following in their introduction , and exemplies 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 pedagogical approach used (Alvarez et al., 2009; Rienties, B., & Townsend, D., 2012 [*sic*]; 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, 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	1 (included)

	descriptions, explanations, or operationalizations of TPACK	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, Brouwer, and Lygo-Baker's (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, 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.

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)

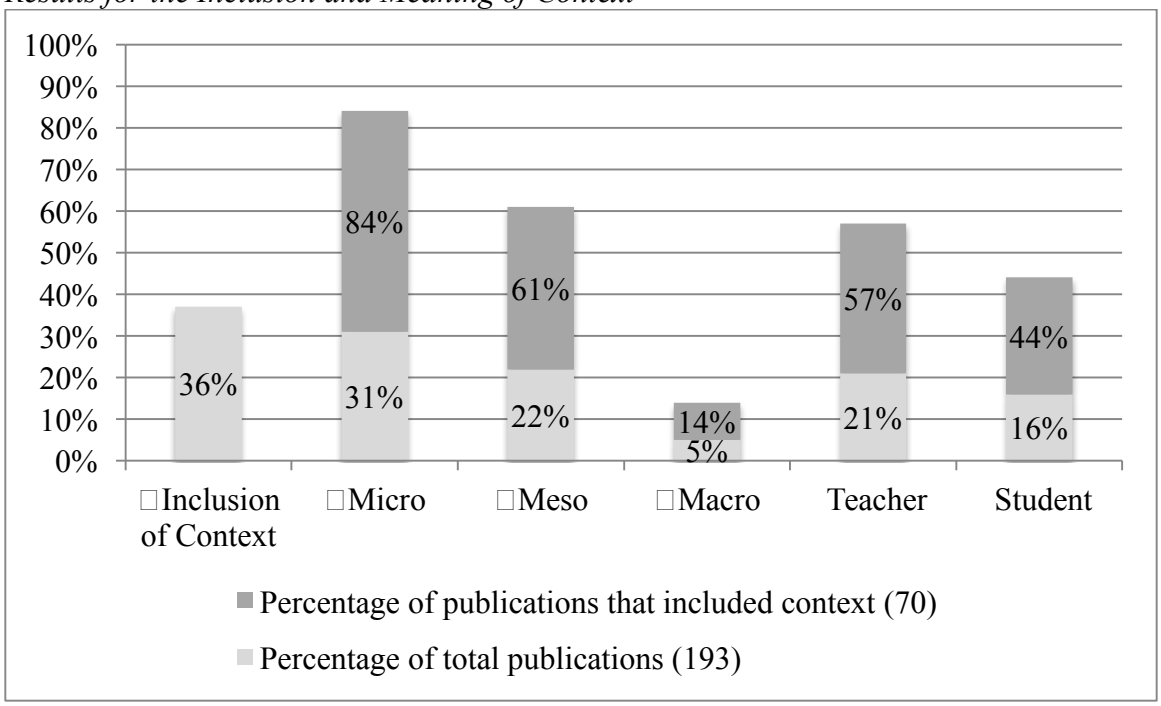
Note. The interpretation of the value of Cohen's kappa (e.g., "substantial") is from Sim and Wright's (2005) guidelines based upon a review of the literature.

Results

Context is included in the descriptions, explanations, or operationalizations of TPACK among 36%, or 70, of the 193 peer-reviewed, empirical journal articles about TPACK published between 2005 and 2013 in English. We then subjected these 70 journal articles that included context to further analysis: among those 70 journal articles, 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). Results are presented in Figure 4.

Figure 4

Results for the Inclusion and Meaning of Context



Note. Only the 36% (70) publications that were coded "1" for "Inclusion of Context" were coded for Micro, Meso, Macro, Teacher, and Student.

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.

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 included to a greater extent than previous work suggested: Kelly (2010) reported that 0% (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 suggests 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 differed from other comprehensive searches of databases 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.

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 concern 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, 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 & 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, 2008) 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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(TPACK). *Computers & Education*, *78*, 20-29. http://dx.doi.org/10.1016/j.compedu.2014.04.022

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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. http://dx.doi.org/10.1111/j.1365-2729.2012.00487.x

Appendix A

References and Codes for the Publications Included in the Systematic Review

Reference	Micro	Meso	Macro	Teacher	Student
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. http://dx.doi.org/10.1504/ijlt.2011.042645	1	1	1	0	1
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. http://dx.doi.org/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. http://dx.doi.org/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. http://dx.doi.org/10.1080/14794802.2013.797750	0	n/a	n/a	n/a	n/a
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. http://dx.doi.org/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. http://dx.doi.org/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. http://dx.doi.org/10.1080/07380569.2011.577888	0	n/a	n/a	n/a	n/a
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	1	1	1	0	0

http://ascilite.org.au/ajet/					
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. http://dx.doi.org/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. http://dx.doi.org/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. http://dx.doi.org/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. http://dx.doi.org/10.1080/21532974.2013.10784708	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
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. http://dx.doi.org/10.1016/j.compedu.2010.07.009	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. http://dx.doi.org/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
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. http://dx.doi.org/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. http://dx.doi.org/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).	0	n/a	n/a	n/a	n/a

Can You Tube it? Providing chemistry teachers with technological tools and enhancing their self-efficacy beliefs. *Chemistry Education Research and Practice*, *14*, 269-285. http://dx.doi.org/10.1039/c3rp00001j					
Bos, Beth. (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–	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. http://dx.doi.org/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. http://dx.doi.org/10.1007/s10956-013-9473-5	0	n/a	n/a	n/a	n/a
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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., & 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., 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
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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. http://dx.doi.org/10.1080/1359866x.2014.941280					
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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*	1	1	0	0	1

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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
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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
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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. http://dx.doi.org/10.1080/07380569.2012.703602	1	1	1	0	1
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Doğan, M. (2012). Prospective Turkish primary teachers' views about the use of computers in mathematics education. *Journal of Mathematics Teacher Education, 15*, 329-341. http://dx.doi.org/10.1007/s10857-012-9214-3	0	n/a	n/a	n/a	n/a
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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.