Educational Technology, Teacher Knowledge, and Classroom Impact:

A Research Handbook on Frameworks and Approaches

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Chapter 2
How Do We Measure TPACK? Let Me Count the Ways

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ABSTRACT

In this chapter we reviewed a wide range of approaches to measure Technological Pedagogical Content Knowledge (TPACK). We identified recent empirical studies that utilized TPACK assessments and determined whether they should be included in our analysis using a set of criteria. We then conducted a study-level analysis focusing on empirical studies that met our initial search criteria. In addition, we conducted a measurement-level analysis focusing on individual measures. Based on our measurement-level analysis, we categorized a total of 141 instruments into five types (i.e., self-report measures, open-end questionnaires, performance assessments, interviews, and observations) and investigated how each measure addressed the issues of validity and reliability. We concluded our review by discussing limitations and implications of our study.

INTRODUCTION

I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind.— William Thompson Kelvin (Popular Lectures, Vol. I, "Electrical Units of Measurement," p. 73, 1883).

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In this chapter we review a wide range of approaches to measure Technological Pedagogical Content Knowledge (TPACK). In the first section we provide a brief overview of the TPACK framework and discuss the need for the current review. In the second section, we identify recent empirical studies that utilized TPACK assessments. We categorize these approaches into five types, and investigate how the researchers address issues of validity and reliability. We end the chapter with a set of summary conclusions, a discussion on limitations and implications of our review for future research on TPACK assessment.

Research on the role and impact of technology in education has often been criticized for being a-theoretical in nature, driven more by the possibilities of the technology than broader or deeper theoretical constructs and frameworks. Accordingly, the preponderance of work in educational technology has consisted of case studies and examples of best practices and implementation of new tools. Though such case studies can be informative, the lack of broader theoretical or explanatory conceptual frameworks prevents us from identifying and developing themes and constructs that would apply across cases and examples of practice. Over the past few years there has been a considerable interest in the Technological Pedagogical Content Knowledge (originally TPCK, now known as TPACK, or Technology, Pedagogy, and Content Knowledge) Framework for effective technology integration (American Association of Colleges for Teacher Education (AACTE), 2008; Koehler & Mishra (2009); Mishra & Koehler, 2006; Niess, 2007). The TPACK framework connects technology to curriculum content and specific pedagogical approaches and describes how teachers' understandings of these three knowledge bases can interact with one another to produce effective discipline-based teaching with educational technologies. The TPACK framework has had a significant impact on both research and practice in the area of educational technology.

Theoretical frameworks, such as TPACK, play an important role in guiding observation. Quoting Chalmers, a philosopher of science, Mishra and Koehler (2006) write:

… "Precise, clearly formulated theories are a prerequisite for precise observation statements." (p.27) In other words, observation statements cannot be made without using the language of some theory and in turn, these theories determine what is investigated. Thus, frameworks play an important role by guiding the kinds of questions we can ask, the nature of evidence that is to be collected, the methodologies that are appropriate for collecting this evidence, the strategies available for analyzing the data and finally interpretations we make from this analysis. (p.1039)

The TPACK framework functions as a "conceptual lens" through which one views educational technology by drawing attention to specific aspects of the phenomena, highlighting relevant issues, and ignoring irrelevant ones. In this view, the framework functions as a classification scheme providing insight into the nature and relationships of the objects (and ideas and actions) under scrutiny.

Providing a framework, however, is not enough. Frameworks have to be examined within the real world, where it becomes critical to develop sensitive instruments and measures that are both consistent with the theory *and* measure what they set out to measure. Since the TPACK framework was first published in *Teacher College Record* (Mishra & Koehler, 2006), researchers have been developing a wide range of TPACK instruments to measure whether their TPACK-based interventions and professional developments efforts have developed teachers' TPACK (Graham et al., 2009; Guzey & Roehrig, 2009). The move towards measuring TPACK is notable as a shift from the conceptual to the empirical. As researchers began to focus on empirically testing the effect of their TPACK-based treatments, the issue of how to accurately capture their subjects' levels of understanding in TPACK became more important.

Despite the abundance in studies involving the use of TPACK measures in recent years (Graham, Cox, & Velasquez, 2009; Jamieson-Proctor et al., 2007; Mueller, 2010; Robertshaw, 2010; Schmidt et al., 2009), little effort has been made to provide a comprehensive account of TPACK measures in a systematic manner. This situation is somewhat understandable given the infancy of the field. Without a full understanding of the repertoire of TPACK assessments and the strengths and weaknesses of each, there is a danger of an overreliance on one measure over the others. This state, in turn, can lead to missed opportunities in accurately assessing and measuring the multiple components of TPACK.

Our goal is not only to identify a wide range of TPACK measures, but also scrutinize each TPACK measure in terms of its *reliability* and *validity*. Reliability refers to the extent to which a measure yields stable and consistent results when repeated over time (Gall et al., 2007). A reliable measure should address the question of "Does the measure yield the same result if we follow the same measurement process?" Validity, on the other hand, refers to the extent to which a measure accurately reflects or assesses the specific concept that the researcher is set out to measure. A valid measure should address the question of "Does the instrument measure what it is supposed to measure?" Whether it is a self-report survey or an interview, a good measure needs to be reliable *and* valid.

PURPOSE OF THIS REVIEW

In this chapter, we present a review of various techniques of measuring TPACK, specifically addressing the following two questions: (1) What kinds of measures are used in the TPACK literature? (2) Are those measures reliable and valid?

We begin with a detailed review of existing measures of TPACK, focusing on five commonly used techniques: self-report measures, open-ended questionnaires, performance assessments, interviews, and observations (Duke & Mallette, 2004; Gall et al., 2007). Then, we examine the reliability and validity of each instrument. Specifically, we look for evidence that the instrument developers address the issues of reliability and validity in an appropriate manner.

Method

Search Strategies and Procedure

To ensure that this literature review provided a comprehensive overview of a wide range of TPACK measures, we conducted literature searches (Cooper, Hedges, & Valentine, 2009), in the PsychINFO, Education & Information Technology Digital Library (EdITLib), and Education Resources Information Center (ERIC) online databases using the keywords "technological pedagogical content knowledge," "TPACK," and "TPCK." We also sought to include grey literature in our search (i.e., documents other than journal articles in widely known, accessible electronic databases) to reduce the impact of a potential publication bias with well known, indexed journal articles (Rothstein & Hopewell, 2009). We also reviewed other types of publications, including existing conference papers, dissertations, and unpublished manuscripts that were listed on the reference list of www.tpack.org. After cross-checking the reference lists in these data sources, we created a master reference list of articles on TPACK. A total of 303 articles were identified through our initial search process.

Inclusion Criteria

Once we collected all the manuscripts using the sampling procedures described above, we then evaluated each research study against the following criteria:

a. The study used TPACK measures
b. The study was of empirical nature
c. The study was published between 2006 and 2010
d. The study was written in English

Out of 303 articles we identified, a total of 66 studies met our inclusion criteria. A total of 237

Table 1. Categories and descriptions for coding articles in the review

Category	Description	% Agreement
Authors	We listed the author(s) of the publication.	100%
Publication Type	We listed the type of publication (Journal article, Conference proceeding, Dissertation, Conference presentation)	100%
Type of TPACK Measure	Gall, Gall, and Borg (2007) identified five different ways of collecting research data: self-report measures, open-ended questionnaires, performance assessments, interviews, and observations. We used their categorization of measures in our coding as it was deemed comprehensive and commonly used in educational research. All measures fit into our categorization.	96.92%
Target Audience	Each measure was developed for a specific population. Some instruments targeted pre-service teachers while others were specifically designed for online educators. We listed who the primary target was for each measure.	84.62%
Evidence of Reliability	We checked whether the particular TPACK measure addressed the issue of reliability. We then reported how the study tested the reliability of its TPACK measure.	100%
Evidence of Validity	We checked whether the particular TPACK measure addressed the issue of validity. We then reported what kind of validation process the TPACK measure underwent.	100%

studies were excluded from our analysis for the following reasons:

a. The study was a conceptual piece with no empirical data
b. The study was not directly related to TPACK
c. The study provided insufficient information on the TPACK measures
d. The study was grounded within the TPACK framework but did not measure participants' TPACK
e. The study was a literature review
f. The study was a conference paper or dissertation that was later published in a refereed journal

Data Coding Scheme

We entered the information about each publication into our database: author(s), publication type, type of TPACK measure, target audience, evidence of reliability, and evidence of validity. See Table 1 for a description of these categories and possible values for each.

Coding was done by one of the authors who had experience in meta-analysis. When there was an ambiguous case, the other authors participated in an extensive discussion until a final decision was made on whether to include the particular case or not. Rationale for each decision were documented and entered into our master database. A total of 66 studies were identified for inclusion.

For the purposes of determining the robustness of the coding scheme, a random sample of 19 studies (of the 66 total) were coded independently by another author. Percentage agreement for each of the coding categories is presented in Table 1. Disagreement was resolved in all cases by consensus.

Many of the studies we reviewed implemented multiple measures to assess TPACK. Therefore, we allowed each study to be coded multiple times when two or more types of TPACK measures were used. For instance, Niess et al. (2006) used a performance assessment, an interview, and an observation to accurately document changes in their subjects' level of TPACK. In this case, the study was coded three times even though the three measures were used in the same study.

Analysis

We conducted two levels of analysis: study- and measurement-levels. First, we examined the char-

Table 2. Characteristics of the (N=66) studies in the review

Category	Number of studies	Percentage
Source of the studies		
Journal articles	30	46%
Conference proceedings	32	48%
Doctoral dissertation	3	5%
Conference presentation	1	1%
Year of publication		
2010*	22	33%
2009	28	42%
2008	7	11%
2007	6	9%
2006	3	5%
Number of TPACK measures used in a study		
1	25	38%
2	14	21%
3	19	29%
4	8	12%

* Only studies published prior to June 2010 were included in our analysis.

acteristics of each study by reporting the source, year of publication, and a total number of TPACK measures used in the study. The study-level analysis was necessary as it gave a broader picture of various measures implemented in TPACK studies.

Once the study-level analysis was completed, the foci of our analysis shifted to the measurement-level. Here we focused on individual TPACK measures rather than on the studies themselves. Specifically, we were interested in who the target population of the measure was and whether the measure provided evidence of reliability and validity.

Study-level analysis. A majority of the studies we investigated were published in journals and conference proceedings (a total of 62 out of 66 studies). The other four publications were unpublished doctoral dissertations and conference presentations. As shown in Table 2, the number of publications implementing TPACK assessments has increased each year, mirroring the extent to which the TPACK framework has become an integral part of the educational technology research literature. We also counted the number and type of TPACK measurements used in individual research studies. The results show that a total of 41 out of 66 studies used more than two different types of TPACK instruments (see Table 2).

Measurement-level analysis. Once the study-level analysis was done, our analysis focused on the individual TPACK measures. First we counted the number of TPACK instruments by the type of measure. Notably, all five types of measures were used fairly evenly across studies. Self-report measures (31 out of 141) and performance assessments (31 out of 143) were most frequently used while open-ended questionnaires (20 out of 141) were the least popular TPACK instruments (see Table 3). Note that the number of measures does not total to 66 because a majority of research studies involved the use of multiple measures.

Self-Report Measures

Self-report measures, which ask participants to rate the degree to which they agree to a given statement regarding the use of technology in teaching, are one of the most frequently used methods to measure participants' TPACK. A total of 31 studies implemented self-report measures to assess the level of their participants' TPACK. Most self-report measures were aimed at measuring pre- or in-service teachers (29 out of 31 measures). The other two instruments were developed for K-12 online educators (Archambault & Crippen, 2009) and faculty instructors (Koehler, Mishra, & Yahya, 2007) (see Table 3).

In most cases, self-report measures included multiple sub-scales of TPACK. For instance, Lee and Tsai (2010) used the Technological Pedagogical Content Knowledge-Web (TPCK-W) Survey

Table 3. Frequency and Percentage Summary of TPACK measures for Intended Audience, Evidence of Reliability, and Evidence of Validity

Category	Self Report-Measures N=31, 23%		Open-Ended Questionnaires N=20, 13%		Performance Assessments N=31, 23%		Interviews N=30, 21%		Observations N=29, 20%	
	N	%	N	%	N	%	N	%	N	%
Target Audience										
Pre-service only	14	44%	9	45%	17	55%	13	43%	10	34%
In-service only	13	42%	10	50%	12	39%	15	50%	17	58%
Pre- and In-service	2	7%	1	5%	1	3%	0	0%	1	4%
Other	2	7%	0	0%	1	3%	2	7%	1	4%
Evidence of Reliability										
Clearly provided	12	39%	3	15%	6	19%	0	0%	3	10%
Vaguely provided	0	0%	3	15%	5	16%	5	17%	7	24%
Not provided	19	61%	14	70%	20	65%	25	83%	19	66%
Evidence of Validity										
Clearly provided	11	35%	1	5%	1	3%	0	0%	0	0%
Vaguely provided	0	0%	0	0%	0	0%	0	0%	0	0%
Not provided	20	65%	19	95%	30	97%	30	100%	29	100%

to assess teachers' self-efficacy regarding the use of Web in teaching. Although the TPCK-W Survey consists of the six sub-scales, only the following five sub-scales were based on the TPACK framework: (1) Web-general: Teachers' confidence in their general use of Web, (2) Web-communicative: Teachers' confidence in their general knowledge about the Web, (3) Web-Pedagogical Knowledge (WPK): Teachers' confidence in their knowledge about the Web specifically related to educational settings, (4) Web-Content Knowledge (WCK): Teachers' confidence in their knowledge about the use of Web in enhancing content knowledge, and (5) Web-Pedagogical Content Knowledge (WPCK): Teachers' confidence in using the Web to fit the needs of a particular course and the practice of appropriate pedagogies to enhance student learning.

For reliability, out of 31 self-report measures, a total of 12 studies presented evidence of reliability. Except for one study that reported Raykov's reliability rho (Burgoyne, Graham, & Sudweeks, 2010), all eleven studies reported Cronbach's Alpha as their reliability index. For example, Lee and Tsai (2010) reported the reliability coefficient (Cronbach's Alpha) for each of the five sub-scales ranging from.92 to.99.

For validity, only 11 studies presented evidence that they addressed the issue of validity. The most frequent way to establish validity of a self-report measure was to conduct either an exploratory or confirmatory factor analysis. For instance, Jamieson-Proctor et al. (2007) developed 45 items to measure in-service teachers' confidence in using Information and Communication Technology (ICT) for teaching and learning. They conducted an exploratory factor analysis on responses of 929 Australian in-service teachers and reduced the number of items based on factor loadings. With the shortened version, they ran a confirmatory factor analysis to come up with the best fitting structural equation model with 20 items that can be categorized into two factors (see Table 3).

Open-Ended Questionnaires

Open-ended questionnaires ask participants to record written or typed responses to a set of prompts prepared by researchers. Twenty TPACK instruments were coded as open-ended questionnaires. All of the open-ended questionnaires were aimed at pre- or in-service teachers' TPACK (see Table. 3).

A typical TPACK open-ended questionnaire asks pre- or in-service teachers to write about their overall experience in an educational technology course or professional development program that emphasizes the TPACK. For instance, So and Kim (2009) asked pre-service teachers, who were enrolled in an ICT integration for teaching and learning course, to write brief responses to prompts such as "What do you see as the main strength and weakness of integrating ICT tools into your PBL lesson?" The authors then coded students' responses specifically focusing on the representations of content knowledge with relation to pedagogical and technological aspects.

For reliability, only three out of twenty open-ended questionnaires presented evidence of reliability (e.g., inter-rater reliability). For validity, except for one instrument (Robertshaw & Gillam, 2010), none of the open-ended questionnaires explicitly addressed the issue of validity (see Table 3).

Performance Assessments

Performance assessments evaluate participants' TPACK by directly examining their performance on given tasks that are designed to represent complex, authentic, real-life tasks. Researchers can assess their subjects' performance in completing a task, or the product resulting from such performance (Gall et al., 2007). A total of 31 TPACK instruments were coded as performance assessments. Except for one performance assessment targeted at faculty instructors (Koehler, Mishra, & Yahya, 2007), almost every instrument was designed to measure pre- or in-service teachers (see Table 3).

Some TPACK performance assessments ask participants to create and maintain a set of artifacts such as portfolios and reflective journals (Suharwoto, 2006), while others consist of scenario- or problem-based questions that require deeper levels of TPACK for solutions (Graham, Tripp, & Wentworth, 2009).

Individual products or responses are typically evaluated either by experts in the field or researchers, based on a set of specific criteria framed within the TPACK model. For example, Harris, Grandgenett, and Hofer (2010) developed a rubric to measure the quality of a TPACK-based technology integration in teaching by incorporating the TPACK framework into the Technology Integration Assessment Instrument (TIAI) that was initially designed by Britten and Cassady (2005). Harris and her colleagues collaboratively worked with local technology-using teachers, administrators, and TPACK experts and revised the rubric's items. They then engaged in multiple rounds of revisions while testing the rubric on lesson plans created by 15 experienced technology-using teachers.

Only six performance assessment measures provide evidence of reliability by presenting the inter-rater reliability or test-retest reliability to show how their measures were stable over time. Except for one instrument (Harris, Grandgenett, & Hofer, 2010), none of the performance assessments present evidence of validity.

Interviews

Interviews consist of a set of oral questions asked by the interviewer and oral responses by the interviewee (Gall et al., 2007). Usually interviews are recorded in videotapes, audiotapes or notes and later transcribed for researchers to systematically analyze. Out of 66, a total of 30 studies used interviews that were conducted in a semi-structured manner (see Table 3). Except for two cases where interviews were specifically designed for faculty (Mishra, Peruski, & Koehler, 2007; Williams, Foulger, & Wetzel, 2010), most interviews were geared toward measuring the TPACK of pre- or in-service teachers.

Typically, during an interview, participants were asked a series of pre-determined questions and, if needed, were asked follow-up questions by the interviewers. For example, to examine changes in pre-service teachers' TPACK, Ozgun-Koca (2009) asked them to discuss the advantages/disadvantages of calculator usage and the effects on the teaching and learning process and environment. The author then followed up with questions such as "when calculators would be more beneficial."

None of the thirty studies reported concrete evidence that established the reliability of their interview measures. Five studies reported that the interviews were coded by multiple coders but did not present any reliability index. In addition, none of the studies that implemented interviews address the issue of validity explicitly (Table 3).

Observations

Researchers also conducted observations that included video recording or field-note taking of a class or session, to examine how participants' levels of TPACK changed over a certain period of time. Out of 66, a total of 29 studies used observations as a means to measure their participants' TPACK. Except for one instrument (Koehler, Mishra, & Yahya, 2007), all the observations were targeted at measuring development in pre- or in-service teachers (see Table 3). Usually, the researcher observed in the classroom how a teacher integrated technology in her own teaching while videotaping. The videotape was then transcribed into a written form that can be read and coded by researchers based on their coding scheme. For example, in Suharwoto's study (2006) researchers attended and videotaped all the courses taught by internship teachers to examine how they implement technology in their own teaching in the actual classroom settings. Once the observations were completed, researchers analyzed the transcript of the observation following the TPACK-based coding scheme.

For reliability, only three studies reported the reliability index, which shows the agreement rate between the coders. For validity, none of the studies presented any concrete evidence that the coding schemes of observations were valid other than reporting that they were based on the TPACK framework (see Table 3).

DISCUSSION

As we look across and beyond the studies in this analysis, a few aspects stand out, positive and negative. The most encouraging is that TPACK is a vibrant area of research, indicated by both the number of studies in this area, and the range of methodological approaches used to study its development. Four of the methodologies (Self Report Measures, Performance Assessments, Interviews and Observations) were equally represented in our sample (between 20-23%). Open-ended questionnaires (13%) were used in somewhat fewer studies. It is understandable why researchers would hesitate in choosing this method, given the complexities of coding and analyzing data from open-ended instruments. Another positive aspect revealed by this current survey is the number of studies that went beyond self-reports to performance assessments or observation of teachers (or teacher candidates). The value of any framework of technology integration and teacher knowledge lies in how it manages to influence practice and it is only through actual observation of performance and assessments thereof that this practice can be empirically tested.

These positives aside, we must point to some significant concerns with this research. The biggest weakness in these current studies is the short shrift given to issues of reliability and validity. Over 90% of the studies we looked at provided no evidence of validity ("the instrument being used measures what it is supposed to measure"), and ought to be of concern to all researchers in this area. This problem is further compounded in that most studies included no evidence of reliability. For instance, our analysis reveals that approximately 69% of the studies had provided no evidence of reliability (the extent to which researchers can be sure the same measurement could be obtained if measured repeatedly). We recommend that future research on TPACK pay a greater attention to these key concerns.

Our survey of the research also reveals important challenges in conducting research about the development and measurement of TPACK. Because TPACK is a complicated construct, lying as it does at the intersection of multiple constructs (which are each complicated in their own way), research on TPACK requires sophisticated understanding of multiple constructs and how they interact with each other. For instance, the fact that the TPACK framework argues for the significant role of content implies that instruments need to be customized to specific content knowledge bases. An instrument designed for a chemistry teacher would be different than one designed for a teacher of music. A bigger challenge to this research comes from the rapid advance of technology. This rapid rate of technological change means that the part of the research instrument that focuses on technology needs to be continually updated as technologies change. For example, a question about email listserv that made sense a few years ago needs to be replaced, possibly by one about RSS feeds!

It is clear from our current survey of the research that each of the studies included in our survey face these issues (frozen as they are in time, technologically speaking) if they wish to be relevant to future research. It is not clear how the instruments used in these studies will have to change in response to the challenge of rapidly evolving technologies. If the instruments do not change they risk losing validity (speaking of Microsoft office tools when the world has moved to cloud computing), however, if we do change these instruments to reflect new technological realities, we risk losing reliability (i.e., confidence that we are still measuring the same thing). New technologies engender new ways of representing content and new forms of pedagogy, making the idea of TPACK a moving target. It will be interesting to see how research in this domain, as it matures, contends with these issues and concerns.

CONCLUSION

In the 2006 article introducing the TPACK framework, Mishra and Koehler point to three key advantages that such frameworks present to researchers and practitioners: *descriptive, inferential* and *application.* First, frameworks (such as TPACK) play an important *descriptive* function, providing researchers with concepts and terminologies with which to describe complex phenomena in a theoretically-grounded manner with methodological precision and rigor. Second, frameworks such as TPACK allow us to make *inferences*, about the educational technology and teacher education. It allows us to make predictions about what approaches may be good for further development, and, as importantly, those, which may not be. Third, frameworks such as TPACK allow us to develop *applications* that bridge the gap between theory and design.

In this paper our focus has been on the first of the three advantages (descriptive), though the many research studies cited clearly inform the other two (inferential and application) as well. The 303 TPACK research publications between 2006 and June 2010 found in our initial search, along with the increasing number of TPACK measures each year (Table 2), strongly indicate that the TPACK framework has indeed provided researchers with a set of conceptual tools with which to articulate precise research questions. The many studies cited also speak to the robustness of the framework and applicability across multiple contexts and domains. That said, much remains to be done. Although it was encouraging to see various efforts are being made to incorporate the TPACK framework into course or professional development programs, several critical issues emerged from our analysis. For instance, we noticed many of the TPACK instruments did a poor job of addressing the issues of reliability and validity. Most interview and observation instruments failed to present convincing evidence that they were reliable and valid TPACK measures.

Our goal of this chapter was not to categorize each TPACK measure into a dichotomized research tradition of quantitative versus qualitative research. Instead, we sought to identify a wide range of TPACK measures used in the field and, in so far as possible, objectively assess their reliability and validity as psychological instruments. We see this as a key step in establishing a sound, empirical and critically evaluated foundation for future research.

Our approach, however, has limitations. Despite our extensive search, it is possible that some studies may have been excluded from our analysis (Cooper, Hedges, & Valentine, 2009). For instance, studies on Information and Communication Technology (ICT) that were published prior to 2006 were not included in our analysis as our search focused on publications that were grounded within the TPACK framework, which was first published in 2006. Given that the literature on ICT is also concerned with helping teachers successfully integrate technology into their classrooms, future research may want to expand the search by including additional keywords such as "ICT." Second, we focused on whether or not the TPACK measures explicitly presented evidence of reliability and validity. Some studies may have assumed that triangulating different sources data would automatically resolve the issue of validity. These implicit approaches to establishing reliability and validity were not the scope of our analysis. Instead we sought clear evidence that the measurement property of the instrument itself was of high quality. Future research should carefully examine this implicit validity assumption associated with the data triangulation processes.

We hope that this chapter makes a significant contribution to the field of TPACK in several different ways. First, we hope that this chapter helps our readers understand the contribution of a variety of research methodologies to measure TPACK. Second, by providing an extensive review of different methods to measure TPACK, the chapter enables the readers to make informed decisions on what types of assessment suit their research questions. Finally, we hope that our comprehensive up-to-date reviews and comparisons of the different types of assessments are useful to anyone wishing to conduct research in the area of TPACK.

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ENDNOTE

[1] References marked with an asterisk indicate studies included in the analysis.