I have TPCK! – What does that mean?
Examining the External Validity of TPCK Self-Reports.

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Abstract: Two studies using a TPCK self-rated knowledge scale provide insights into the construct being measured by that scale. These validity studies from two different populations – accomplished teachers in the United States and pre-service teachers in Germany – examine the correlations between TPCK and a variety of knowledge, belief, and attitude variables. Both studies show the TPCK measure correlating most strongly with personal experience and pro-technology attitudes, and less strongly with objective knowledge measures.

Introduction

The Technological Pedagogical Content Knowledge (TPCK or TPACK) construct has generated a great deal of interest, and focused scholarly attention, on the use of new technologies for the support of content learning. Yet as with any new construct, one of the first tasks of the research community is to find ways of measuring it, in order to make it accessible to empirical research. In this paper, we seek to examine the relationships between a popular survey measure of TPCK and related measures, illuminating the nature of the underlying construct.

Scholars have been measuring constructs relating to ICT adoption in the classroom for years, looking at beliefs (e.g., first- and second-order barriers, Ertmer, 2005), cognitive appraisal (perceived usefulness and ease of use in the TAM model, e.g. Holden & Rada, 2011), and affective appraisal of technology (attitudes, e.g., Knezek & Christensen, 2008) as predictors of the use of technology in teaching. Similarly, recent scholarship has sought to tap into pre- and in-service teachers' TPCK. Complementing a row of qualitative approaches (e.g., Harris, Grandgenett, & Hofer, 2010; Koehler, Mishra, & Yahya, 2007; Kohen & Kramarski, 2012), self-report measures have been developed to provide for larger samples and quantitative analyses (Archambault & Barnett, 2010; Schmidt et al., 2009). An early survey instrument developed by Schmidt and colleagues (2009) has seen wide adoption and also scrutiny. The factorial validity has shown to be problematic (Archambault & Barnett, 2010; Koh et al., 2010; Lee & Tsai, 2010) and the interrelations of the sub-scales have been shown to differ in studies with large samples of pre-service teachers in Asian countries (Chai, Koh, Ho, & Tsai, 2012; Chai, Koh, & Tsai, 2010; Koh, Chai, & Tsai, 2010; Lin, Tsai, Chai, & Lee, 2012). On the one hand, these studies suggest that the relationships between the TPCK construct and the TPK, TCK, and TK constructs may not be as originally hypothesized. On the other hand, they still operate on ambiguous preconditions regarding the validity of TPCK self-report measures.

Recently, scholars have been noting the close relationship between knowledge and other variables. For example, Chai et al. (2012) discovered in their study that cyberwellness, an important and ethical context factor for computer use in schools, was related to TPCK scores. In their review of TPCK research, Voogt and colleagues (Voogt, Fisser, Pareja Roblin, Tondeur, & van Braak, 2012) concluded that at this point in the development of the TPCK framework we need empirical studies to clarify what is meant by teachers' *knowledge* in the TPCK context. Furthermore, we need to know how it is related to other knowledge measures and how it is separate from other constructs like beliefs, dispositions, and behavior. Most importantly, we need to understand what it is we measure when we use self-report instruments to assess TPCK.

This paper presents two studies using different populations and different approaches, but similar TPCK measures, to help illuminate these relationships. Each study kept the variability in pedagogical knowledge somewhat constrained, allowing for better understanding in the variability in the TPCK. In study 1, participation was limited to accomplished teachers with several years of teaching experience. Study 2 was focused on pre-service teachers, and included PK measures. The two studies handled the variability of content and technology differently however. Study 1 left the technology unspecified, but focused the TPCK questions on particular subject areas. Study 2 specified

video as the target technology, while leaving the subject area of application undefined except through reference to the teacher's curriculum.

In this paper we seek to contribute to the understanding of this same TPCK measure through a different form of validation. We do not seek to compare TPCK to other knowledge measures, but rather to understand the nature of construct measured by the central sub-scale TPCK through its relationships with other non-knowledge constructs, as well as knowledge measures tapping into the basic sub-domains technology and pedagogy. On the empirical level we seek to advance our understanding of the self-report TPCK measure. On the theoretical level, we seek to clarify the conceptualization of "knowledge" within the context of TPCK research.

Study 1

The first study used data from a survey of teachers in the United States who had been certified as accomplished teachers (for more on this study, see Author, 2011). Measures from an online survey provided opportunities to examine these accomplished teachers' ratings of their technological pedagogical content knowledge (TPCK). The focus on this population allowed for the study of the variability in TPCK self-ratings while limiting the variability in PCK.

Participants

Of the 307 participants who completed the TPCK items, 81% were female and 19% male. They ranged in age from 30 to 66 (M = 48.9, SD = 9.1). Their classroom experience ranged from 6 to 46 years, with an average of over 19 years of experience (M = 19.1, SD = 7.9). They represented a broad mix of subjects, grades, and school populations. Not all of the 307 respondents to the survey who completed the TPCK measure also completed the focal measures of this study; therefore the sample sizes range from 209 to 304 depending on the measures included in each analysis.

Measures

Self-rated TPCK. Respondents rated their TPCK on 5 items, slightly modified from a survey of pre-service teachers (Schmidt, et al., 2009). References to pre-service education were removed or modified to reflect the experiences of in-service teachers. Where the original items were not specific about content area, the online survey tool was used to present content-specific items that reflected the subjects that teachers reported they currently taught. Thus the original survey item "I can use strategies that combine content, technologies and teaching approaches that I learned about in my coursework in my classroom" became "I can use strategies that combine [math] content, technologies, and teaching approaches that I learned about elsewhere, in my classroom." The five items are presented in Table 1. Analyses of the 5 items showed that they were internally consistent (Cronbach's alpha coefficients ranged from .94 to .96 depending on subject area).

Table 1. Self-rated TPCK items

To what degree do you agree with the following statements?
I can teach lessons that appropriately combine [social studies], technologies and teaching approaches.
I can choose technologies that enhance the [social studies] content for a lesson.
I can use strategies that combine [social studies] content, technologies, and teaching approaches that I learned about elsewhere, in my classroom.
I can select technologies to use in my classroom that enhance what I teach and what students learn.
I can provide leadership in helping others to coordinate the use of [social studies] content, technologies, and teaching approaches at my school and/or district.

Responses to the 5-point scale (strongly disagree to strongly agree) were averaged for each subject area taught. The highest TPCK self-rating across subjects for any respondent became the TPCK score. Averaged scores ranged from 1 to 5, with a mean TPCK score of 3.94 (*SD* = .78). The TPCK score distribution was skewed to high end of the scale, indicating that most respondents rated themselves highly knowledgeable.

Exploration of production activities. Items developed by Barron (2004) were used to measure the extent to which participants had engaged in activities that required them to produce using new technologies. The 16 activities related to creativity and innovation, collaboration and communication, or critical thinking and problem solving.

Respondents were asked to indicate the number of times they had participated in each activity from a choice of: never, 1-2 times, 3-6 times, and 7+ times.

Personal activities. The total number of activities respondents had ever engaged in became their personal activity breadth score. Participants' exploration scores ranged from 0 to 16, with a mean of 6.78 (*SD* = 3.08, *N* = 304). The modal number of production activities ever engaged in personally was 6.

Exploration with students. The total number of activities respondents had ever asked their students to engage in during class time became their exploration score. Participants' exploration scores ranged from 0 to 15, with a mean of 3.95 (*SD* = 3.39, *N* = 302). The modal number of production activities assigned to students was 0.

Frequency of use with students. A measure of frequency of computer use with students was included in a follow-up survey sent to the respondents who had indicated they are currently teaching. Participants were asked "On average, how often do you plan for a typical student to use a computer during class?" and asked to choose from: Never, Less than Once a Month, 1-2 Times a Month, 1-2 Times a Week, and 3 Times a Week or more. Of the 209 respondents who answered this question, 56% planned for students to use computers in class at least weekly.

Technological Pedagogical Content (TPC) Beliefs. This scale drew on items from prior studies such as for example "Technology helps students grasp difficult [subject] concepts more easily" (Russell, Bebell, O'Dwyer, & O'Connor, 2003). Participants were asked to rate the 8 items on a 5-point scale from (1) Strongly Disagree to (5) Strongly Agree. Of the items, half (4) reflected positive and half negative impacts of technology use on student learning. Responses to the negative statements were reverse coded before averaging the responses. The scale showed high internal consistency (Cronbach's α=.84 to .89 depending on subject). The highest of all subject-specific scales was used for each participant.

*Self-rated Familiarity with Internet Terms (Technology Knowledge)***.** On a scale developed and validated by Hargittai (2005), participants rated their familiarity with 27 Internet-related terms from none (1) to full (5). The scale has been shown to correlate highly with observed search behaviors on the Internet. Each participant received a score based on the average of all items completed, not including three additional bogus terms, which were used as a validity check. Scores ranged from 1.2 to 4.96, with a mean of 2.74 (*SD* = .84).

*Internet for Teaching Ideas***.** A measure of frequency of Internet use for teaching ideas was included in a follow-up survey sent to the respondents who had indicated they are currently teaching. Participants were asked "This school year, how often have you used an Internet resource to get teaching ideas?" and asked to choose from: Never, Less than Once a Month, 1-2 Times a Month, 1-2 Times a Week, and 3 Times a Week or more. Of the 211 respondents who answered this question, 63.5% reported using the Internet for teaching ideas at least weekly.

Results Study 1

In order to determine the external validity of the TPCK self-report scale in the US sample, we first computed zero-order correlations of the TPCK scale with the personal information (see Table 2) and other teaching related constructs (see Table 3). Correlations with personal characteristics showed no relationship between the TPCK self-ratings and age or gender. In contrast, there was a significant positive correlation between the TPCK scale and the number of computer-based production activities participants had engaged in, $r(304) = .44$, $p < .001$. Participants reporting a wider breadth of personal computer production activities also rated their TPCK higher. They also reported more familiarity with Internet terms, $r(302) = .41$, $p < .001$.

Table 2. Study 1 Correlations and descriptive statistics for TPCK scale with personal characteristics.

	(2)	(3)	(4)	(5)	*M*	*SD*
(1) TPCK	-.04	-.08	**.41****	**.44****	3.91	.80
(2) Age		-.05	**-.16***	-.07	48.88	9.07
(3) Gender			**-.21****	**-.14***		
(4) Familiarity with Internet Terms				**.60****		
(5) Personal production activities on computer					6.78	3.08

*$p < .05$. **$p < .01$.

Correlations between TPCK self-ratings and teaching-related variables showed many strong relationships. There was a significant positive correlation between the TPCK scale and the frequency with which the teacher used the Internet for teaching ideas, $r(211) = .30$, $p < .001$. Participants reporting higher TPCK also reported more frequent Internet use. Similarly, participants reporting higher TPCK also reported more frequent use of computers with their students, $r(209) = .20$, $p < .001$.

The TPCK self-ratings correlated even more strongly with the number of activities ever attempted with students, $r(302) = .38$, $p < .001$. Participants reporting higher TPCK also reported exploring more production activities. Finally, participants reported more positive beliefs about the value of technology to support students' learning, $r(264) = .40$, $p < .001$.

Table 3. Study 1 Correlations and descriptive statistics for TPCK scale with teaching-related measures.

	(2)	(3)	(4)	(5)	*M*	*SD*
(1) TPCK	**.30****	**.20****	**.38****	**.40****	3.91	.80
(2) Use of Internet for teaching ideas[a]		.25**	.27**	.25**	2.82	1.16
(3) Frequency of student computer use[a]			.08	.32**	2.44	1.32
(4) Breadth of activities with students				.01	3.95	3.39
(5) TCP Beliefs					3.93	.57

Note. [a]Spearman's rho was used for non-parametric variables.
*$p < .05$. **$p < .01$.

Study 2

Based on the general model of aspects of teacher competence by Baumert and colleagues (Kunter & Baumert, 2011; Kunter et al., 2007), in study 2 teachers knowledge (PK and TK), pedagogical beliefs (cf. Law, 2008), and dispositional attitudes towards technology (enthusiasm) were assessed in addition to demographic characteristics to validate the TPCK self-report scale.

Participants

Pre-service teachers of different subject areas that had completed their 4th semester at the University of Tuebingen (Germany) were recruited via the mailing list of the University. The final sample consisted of $N = 82$ pre-service teachers. All were enrolled in the university's teacher training to become secondary educators (Gymnasium level). Ninety-six percent had already completed teaching internships where they themselves had taught $M = 34.6$ hours per week ($SD = 2.7$). In Germany teachers usually 2 teach two subjects; in this sample 53% of participants studied German language arts, 34% sciences, 18% history, 11% mathematics, and 59% other subjects.

Procedure

Participants completed an online questionnaire as part of a pre-measurement of an experimental study concerned with the use of video technology in instruction whose results are to be reported elsewhere (Krauskopf, Zahn, & Hesse, in preparation). Overall, participants participated at three measurement points of which here only measures from the first are reported. As compensation, participants who completed the full study received a compensation of 25€ and general information on the study's results.

Measures

Demographics. Participants provided demographic information (age, gender, *1= male*, *2 = female*, high school graduation grade average, range 1-6, *1 = best grade*), followed by information about their university teacher training (semester of study).

Private c*omputer use frequency* (1 item, *1 = less than once a week*, *5 = daily*) and *general technology experience* (self-rated experience, 3 items, *1 = very low*, *6 = very high*, Cronbach's $\alpha = .75$) were assessed by self-reports. Additionally, *TK* assessed by introducing an example technology (WebDIVER, http://diver.stanford.edu/what.html) to the participants and summing up the number of recalled WebDIVER functions (0 = function not recalled, 1 = function recalled) into a sum score with a theoretical maximum of 10. This task was completed by a slightly smaller sample at the beginning of the experimental study (N=74).

TPCK self-rating. The TPCK subscale of the self-report measure developed by Schmidt et al. (2009) also used in study 1 was used in a German version (translation by corresponding author). Because this study was directed to participants teaching a range of subjects, the items were formulated as subject-general. Instead of specific subjects, the term "in my teaching" was used. Overall, the scale showed sufficient internal consistency, Cronbach's $\alpha = .88$.

Pedagogical knowledge (PK). To assess declarative aspects of participants' general PK, a slightly shortened version of the measure used by Krauskopf et al. (2012) consisting of 18 items was applied. The items had a multiple choice format with one correct answer each. As PK indicator the overall sum score was computed. Items were taken from a measure specific to the German teacher training guidelines regarding pedagogical-psychological knowledge (Schulte, Bögeholz, & Watermann, 2008) and example items of the ETS Praxis Test (Educational Testing Service, 2006) that are available online but generally unknown to German students.

Pedagogical beliefs about video. These beliefs were assessed in order to be able to differentiate between knowledge and more global pedagogical assumptions, here about using a specific technology, namely video. The measure was adapted from Souvignier and Mokhlesgerami (2005) and participants rated items on two subscales: c*onstructivist orientation* items (2 items, example "Students should be allowed to explore their own ways of dealing with video material before you show them how to approach a text or a film") and *explicit instruction orientation* items (3 items, example "Students learn how to deal with video material most effectively when you provide them with instructions on how to go about working with texts and films") were rated by participants on a 4-point Likert scale (1 = *completely disagree*, 4 = *completely agree*). Both scales showed sufficient internal consistencies, Cronbach's $\alpha \geq .75$.

Technology Enthusiasm. As a dispositional construct pre-service teachers enthusiasm regarding the use of technology in teaching was assessed. The items were based on Kunter et al. (2008), and two items were adopted (example: "I myself am enthusiastic about the possibilities of new media"). Items were rated on the same 4-point Likert scale as the belief items and showed sufficient internal consistency, Cronbach's $\alpha = .76$.

Results Study 2

In order to determine the external validity of the TPCK self-report scale in the German sample, we first computed zero-order correlations of the TPCK scale with the demographic information (see Table 4) and other teaching related constructs (see Table 5). Correlations with demographic information showed that there was a negative relation between self-reported TPCK and the duration of studies, $r(82) = -.29$, $p = .01$, indicating that the longer participants had studied the lower they rated their TPCK. In contrast, there was a significant positive correlations of the TPCK scale with the self-reported private computer use frequency, $r(82) = .38$, $p < .001$. Participants reporting a higher frequency of private computer also reported higher TPCK.

Table 4. Correlations and descriptive statistics for TPCK scale with demographic variables.

	(2)	(3)	(4)	(5)	(6)	*M*	*SD*
(1) TPCK	.03	-.15	**-.29***	**.38****	.17	4.42	0.92
(2) Gender[a]		-.**29***	-.**23***	.14	.04		
(3) Age			**.86****	-.**67****	-.05	24.85	4.36
(4) # of semesters				-.**80****	-.16	9.54	6.63
(5) Computer use frequency, private					.12	4.90	0.51
(6) High school graduation grade average[b]						2.17	0.51

Note. [a]Gender was dummy coded: male = 1, female = 2. [b]1 = highest grade.
*$p < .05$. **$p < .01$.

Correlations with pedagogical knowledge, beliefs and enthusiasm about technology revealed positive relations of self-reported TPCK with a constructivist orientation regarding the use of video in teaching, $r(82) = .39$, $p < .001$, and enthusiasm for technology in teaching, $r(82) = .59$, $p < .001$. This indicates that pre-service teachers who reported a stronger constructivist orientation and more enthusiasm about technology for teaching also reported higher TPCK.

Table 5. Correlations and descriptive statistics for TPCK scale with knowledge, beliefs, and motivation measures.

	(2)	(3)	(4)	(5)	(6)	*M*	*SD*
(1) TPCK	.16	.00	**.39****	.03	**.59****	4.42	0.92
(2) PK[a]		.21	.12	.01	.08	9.05	2.38
(3) TK (WebDIVER)[b]			.02	-.05	.05	7.12	2.22
(4) Constructivist orientation (video)				**-.49****	**.29***	4.71	1.19
(5) Explicit instruction orientation (video)					-.02	3.47	1.03
(6) Technology enthusiasm, disposition						4.67	0.95

Note. TPCK = Technological Pedagogical Content Knowledge, PK = Pedagogical Knowledge.
[a]Theoretical maximum 22. [b]N=74
*$p < .05$. **$p < .01$.

Discussion

Study 1 suggests that the TPCK self-ratings capture a construct that is independent of age or gender, but related to personal experience with production activities on the computer. As a behavioral variable, the personal activities measure may be interpreted as an indicator of exploration, possibly evidencing knowledge. But it may also suggest a disposition in favor of technological tools in general.

The other behavioral variables measured activities related to teaching and learning. All of these—using the Internet for teaching ideas, assigning students to work on computers, and asking students to try production activities on the computer—showed statistically significant relationships to the TPCK self-measures. Again these variables can be seen as evidence of knowledge, some level of which might reasonably be required to perform these tasks. Yet other interpretations arise when taken together with the strong correlation between TPCK ratings and pro-TCP beliefs. Those teachers who responded most favorably to the statements about technology's value in supporting student learning may be basing their responses on what they "know" from their experiences, but it is equally possible that their beliefs about the value of technology arise out of a disposition that contributes to their willingness to seek out those same experiences.

Similarly, the results of study 2 show that in the German pre-service teachers sample, TPCK self-reports were also significantly related to private computer use as well as constructivist beliefs and an enthusiastic disposition towards technology. However, TPCK was not related to performance at a PK test and participants recalling facts about a sample technology.

Overall, these findings can be interpreted as indication of TPCK self-reports tapping into aspects of pre-service teachers' knowledge of utilizing technology in instruction. The correlations with computer use in class in study 1 can be considered indicators of knowledge. Yet the fact that personal computer experience shows a stronger relationship to TPCK self-ratings than objective measures of TK and PK raises the question to what extent the TPCK scale specifically measures professionally relevant knowledge. That TPCK, TK and PK are not related could be considered a proof of discriminant validity, yet other studies have shown (Krauskopf et al., 2012) that PK is a relevant predictor for technological reasoning for lesson planning. Both TK and PK might arguably be considered prerequisites for developing actual TPC-*Knowledge* and thus these relations need to be investigated further.

These results across two different populations in two different studies do converge to provide a type of validity to the construct underlying the TPCK measure however. In both studies we find correlations with measures of personal computer experience (terms and personal exploration in study 1 and personal use frequency in study 2). We also find correlations with beliefs about the value of technologies in supporting student learning, both in the TCP belief scale in study 1 and in study 2 with a more constructivist orientation towards using video material. Because the TPCK measure relates strongly to measures of personal experience with technology, we are faced with the possibility that the measure is strongly influenced by teachers' personal dispositions toward technology. This is supported by the correlation between TPCK self-ratings and pro-technology beliefs in study 1, and the pro-technology disposition items (enthusiasm) in study 2.

Limitations

As correlational studies, these results do not give us insight into direction of causality, meaning that it cannot be determined whether higher TPCK renders teachers more enthusiastic about using technology in teaching, or if teachers with a preexisting disposition in favor of technology seek out opportunities to engage with it. It is possible that some other factor influences both variables. We have some indication from other studies that disposition may predict behavior. Kunter et al. (2008) define enthusiasm as a dispositional variable and show that it predicts instructional quality.

Methodologically we need to show that the TPCK scale also relates to knowledge assessed in different ways, especially as expressed through actual instructional use of technology and student learning. Here, this could not be done. These findings were limited to self-report measures of knowledge, behavior, beliefs and enthusiasm.

Conclusion and Future Directions

What do we actually measure when applying TPCK self-reports? The current study calls into question the assumption that this measure captures pre- and in-service teachers' knowledge of technology use in teaching. Overall, the construct assessed by the TPCK scale seems to be influenced largely by beliefs and dispositions, although it clearly incorporates aspects of the intention for behavioral exploration. However, due to the mixed findings regarding performance measures its validity regarding assessing actual knowledge needs empirical support. Future studies will have to provide evidence of what assessing TPCK with self-reports actually adds to our understanding of teachers' technology use—is it rather a general disposition or indeed knowledge that can be developed in teacher education?

In light of these findings, it seems even more important to conduct studies where all the relevant constructs determined in the current research are integrated simultaneously. This would enable us to specifically determine whether TPCK self-reports would discriminately explain the quality of instruction that tries to leverage the potential of new technologies.

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