

Synthesis of survey questions that accurately discriminate the elements of the TPACK framework

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Abstract

A number of validated survey instruments for assessing technological pedagogical content knowledge (TPACK) do not accurately discriminate between the seven elements of the TPACK framework particularly technological content knowledge (TCK) and technological pedagogical knowledge (TPK). By posing simple questions that assess technological, pedagogical, and content knowledge (TK, PK and CK) the logical associations forming the TPACK framework can be used to synthesise TPK, TCK survey items that are inherently valid. This process can further be applied to constructing TPACK survey questions that agree closely with those from validated surveys.

Key words:

TPACK, education, computers, ICT, synthesis, survey.

Introduction

According to Shulman (1986; 1987) teacher knowledge includes knowledge of subject content (content knowledge - CK), and knowledge of teaching methods and strategies (pedagogical knowledge - PK). Knowledge of how to teach specific content to specific learners in specific contexts is described as pedagogical content knowledge (PCK). Interestingly, Shulman (1987) described four other categories which, together with the first three, comprise the “knowledge base of teaching”; knowledge of the materials for instruction, including visual materials and media (curricular knowledge); knowledge of the characteristics of the learners, including their subject-related preconceptions (learner knowledge); knowledge of educational contexts, including classrooms, schools, district, and beyond (context knowledge); and knowledge of educational goals and beliefs.

Shulman's (1986) work on pedagogical content knowledge (PCK) was extended by the addition of a third domain - Technological Knowledge (TK) (Mishra & Koehler, 2006). In a sense Shulman foreshadowed the TPACK framework. Recent proponents in the early twenty first century believe that there is a defining characteristic of technological knowledge (TK) in its relationship to Shulman's PCK (Angeli & Valanides, 2005;

Mishra & Koehler, 2006; Niess, 2005). The synergy of the integration of the three knowledge domains--technology, pedagogy and content, is illustrated (Figure 1) by a Venn diagram with its emerging four constructs, technological pedagogical knowledge (TPK), technological content knowledge (TCK), pedagogical content knowledge (PCK) and technological pedagogical content knowledge (TPACK) also written as TPACK for better pronunciation and to indicate it is a 'Total PACKage' for teaching with technology (Thompson & Mishra, 2007).

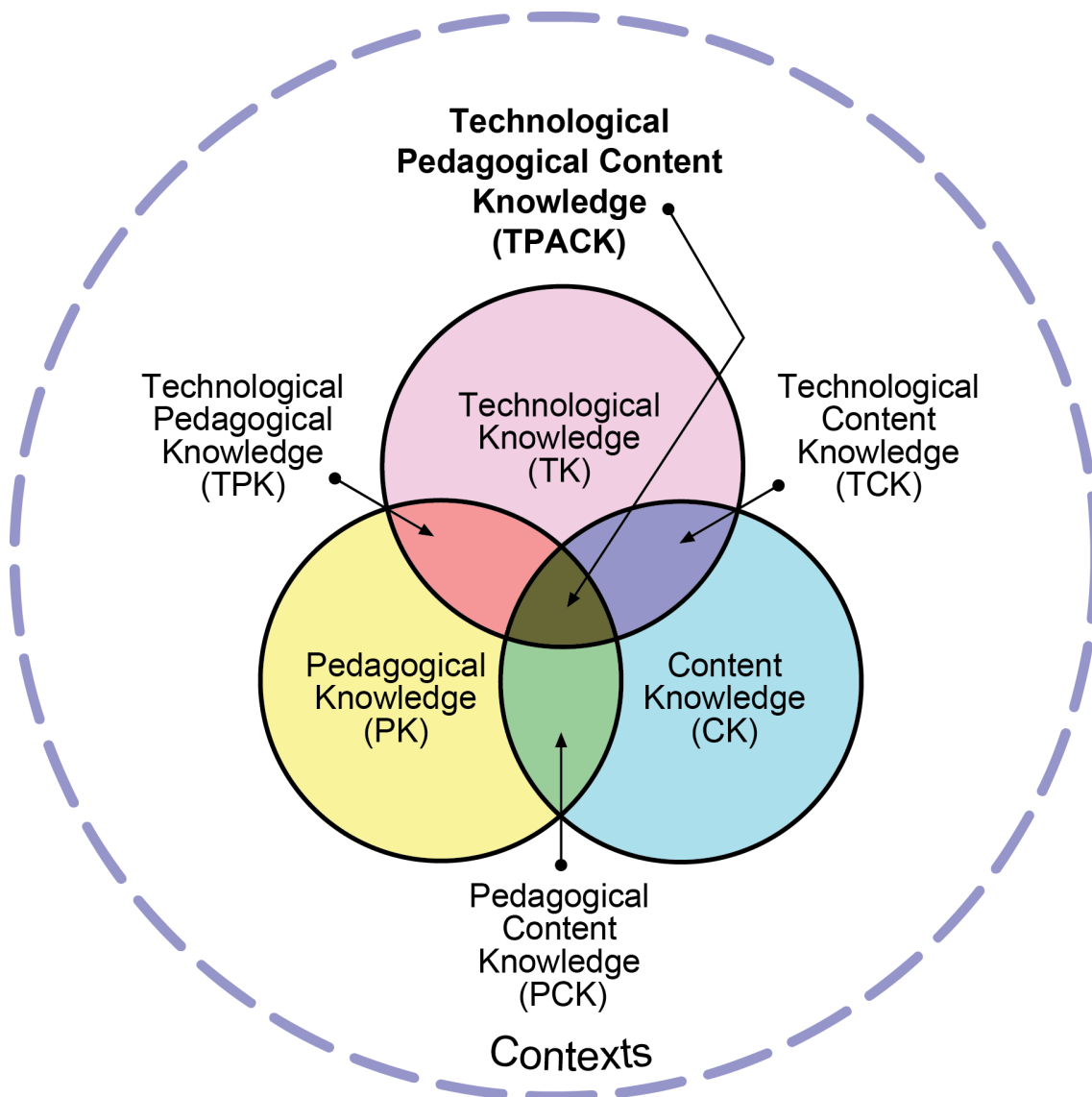


Figure 1: Technological Pedagogical Knowledge Framework (TPACK)

(Mishra & Koehler, 2006; Shulman, 1986)

These domains and their constructs are fundamental to enhance understanding of appropriate ways to integrate technology in the learning environment. This understanding is integral to building teachers' confidence in planning activities and transforming learning in innovative and creative ways, thus reducing the tension to develop the confidence in integrating appropriate technology for teaching and learning. Therefore it is pertinent to outline the importance of each component of the framework.

Content knowledge (CK): Shulman (1986) postulated that CK involves the theories, principles and concepts of a particular discipline. But with the rapid increase of access to information, educators must think about emerging content areas such as organizing important concepts according to themes in their subject areas and retrieving them when it is needed quickly and with little effort (Bransford, Brown, & Cocking, 1999). Additionally content delivery is not only memorising facts and applying skills but positioning it to problem situations interwoven across interdisciplinary themes to increase the relevance for today's learners (Casner--Lotto & Brenner, 2006).

Pedagogical knowledge (PK): This knowledge domain deals with a host of teaching processes. Teachers should understand subject matter deeply and flexibly so that they can facilitate students to construct their own learning and clarify any misconceptions pertaining to the topics to be taught (Shulman, 1986). Pedagogy and technologies for learning have a close relationship and therefore the scope and style of pedagogy change as technology changes. The number of learning technologies, beyond the classroom and away from the teacher, provides the opportunities of opening a new schema for education. As educators we have to continue rethinking the style and scope of pedagogy as the digital age continues to create challenges with new and emerging technologies (Beetam & Sharpe, 2013).

Technological Knowledge (TK) is knowledge about low--level technology such as books and chalk and blackboard, as well as more advanced technologies. This involves the skills required to select and operate ICT equipment such as laptop computers, video projectors, interactive whiteboards and document/digital cameras. It includes knowledge of operating systems, and computer hardware, as well as the ability to deploy and maintain software tools such as word processors, spread sheets, browsers, email and other web--based resources in the classroom.

Pedagogical Content Knowledge (PCK): When teachers integrate content knowledge and pedagogical knowledge in the preparation of delivering curriculum activities, a new domain emerges, pedagogical content knowledge. Shulman (1986) discussed this emergence of new knowledge as an understanding of "how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (p. 8).

Technological content knowledge (TCK) refers to the knowledge of how technology can be used to create new representations and transformations for specific content. Educators should understand by using a specific (appropriate) technology they can change the way learners (especially those with varying learning abilities) practice and conceptualise specific content goals and objectives (Mishra & Koehler, 2006).

Technological pedagogical knowledge (TPK) refers to how teaching might change as the result of using particular technologies. Mishra and Koehler (2007) articulated:

This might include an understanding that a range of tools exists for a particular task, the ability to choose a tool based on its fitness, strategies for using the tool's affordances, and knowledge of pedagogical strategies and the ability to apply those strategies for use of technologies (p. 1028).

Technological pedagogical content knowledge (TPACK) refers to the knowledge required by teachers for integrating technology into their teaching in specific disciplines, interdisciplinary or multidisciplinary content and pedagogical areas. TPACK is an integrative understanding of the three knowledge domains--content, pedagogy and technology. It includes the most useful forms of representing and communicating content in constructive ways for students to comprehend specific concepts and topics of a discipline/disciplines with the use of technology. It encompasses theories of epistemology, and includes knowledge of how appropriate technologies can be utilised to build on existing knowledge and consequently 'to develop new epistemologies or strengthen old ones (Mishra & Koehler, 2008).

Since its proposal by Mishra and Koehler (2008) there has been a lot of published work on TPACK including many articles, and survey instruments. For example, Voogt, Fisser, Pareja Roblin, Tondeur, and van Braak (2013) reviewed the literature related to 243 peer--reviewed articles referring to TPACK published between 2005 and September 2012. Only 54 articles (22%) were categorised as showing 'good' quality of consistency, data collection and analyses. Koehler, Shin, and Mishra (2012) identified a total of 141 instruments used in various studies to measure TPACK - many of them showed no evidence of reliability or validity assessment.

Albion (2014) made available a draft survey instrument that was partly the basis for the Teaching Teachers for the Future (TTF) instrument. The survey items were initially grouped as TCK, TPK and TPACK. But the TCK group was renamed "Knowledge of ICT in your content area" and the TPK group was renamed "Knowledge of ICT for learning and teaching". Items from both these groups subsequently appeared in the TTF instrument. The TPACK group was renamed "Knowledge of ICT for learning and teaching in specific content areas". This instrument was re-named the TTF TPACK Survey Instrument (Finger et al., 2013). It differentiates between TPACK and a joint TPK/TCK measure (R. Jamieson-Proctor et al., 2013). In contrast, one widely used

survey instrument (Schmidt et al., 2009) clearly identifies the TK, PK, CK, TPK, TCK and PCK survey items (Appendix A).

Differentiation of TCK, TPK and PCK was addressed through exploratory factor analysis of a TPACK survey for online teaching (Archambault & Crippen, 2009) which produced items for CK, PK and PCK loaded as one factor and items for TPK, TCK, and TPACK were loaded as another. Lee and Tsai (2010) isolated the factors of TK, TPK, TCK, and TPACK but found that two items, PK and PCK were loaded as a factor. The study by Liang, Chai, Koh, Yang, and Tsai (2013) produced only one factor loaded on the TPK and TCK items and consequently they had to merge them as TPTCK subscale.

The challenges encountered with the TPACK framework could have emerged because of multiple assumptions. There are many lenses in the interpretation, understanding and conceptualization of the TPACK framework to inform the thinking, design and implementation of research (Graham, 2011; Voogt et al., 2013). Notably three pathways are responsible for the production of TPACK. TPK intersected with TCK or PCK can produce TPCK (TPACK). An intersection of TCK and PCK can also produce TPACK. This proves the difficulty in delineating the TCK, TPK, and PCK domains.

Jordan (2014) traced the development of the TPACK instrument, its adaptations and applications. She cites the Schmidt et al. (2009) instrument as being one of the most influential instruments to be developed, but concludes that theoretical weaknesses have hindered its development. Brantley- Dias and Ertmer (2013) argued the constructs of TPACK are too vague and very difficult to comprehend and utilise.

This paper attempts to address these perceived weaknesses by proposing a logically correct method of synthesising, and analysing, TPACK instrument elements.

Research questions

Can survey questions, which accurately discriminate between the elements of TPACK, be synthesised using the TPACK construct?

Does a comparison of validated survey questions with synthesised measures allow a re-assessment of TPK and TCK in existing survey instruments?

Methodology

Two unambiguous questions are proposed for each basic element of TPACK; technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK) (Table 1). It is not claimed that these are the only questions - Schmidt et al. (2009) propose 7 or more survey items for each of these elements (Appendix A).

Table 1

Synthesised TK, PK, and CK Questions

| Domain | Questions |
|--------|---|
| TK | TK1. <i>How confident are you in integrating ICT such as PowerPoint, Excel, projectors, interactive white boards in regular delivery of instructions?</i> |
| | TK2. <i>How confident are you to use web-based tools and teaching resources such as YouTube, Google, WebQuest, Google Scholar?</i> |
| PK | PK1. <i>How confident are you in your knowledge of teaching and learning strategies?</i> |
| | PK2. <i>How confident are you to organise your lessons to interest students of varying abilities in your classes?</i> |
| CK | CK1. <i>How confident are you that you know and understand the subjects that you are teaching?</i> |
| | CK2. <i>How confident are you that you can answer all students' questions on the material you are teaching and give meaningful explanations?</i> |

The wording of these questions follows part of the TTF TPACK survey questions which are prefaced by the phrase “How confident are you that you have the knowledge, skills and abilities to support students’ use of ICT to...”. (Jamieson-Proctor et al., 2012). The authors of this paper understand that a self--assessment of ‘confidence’ is not a measure of knowledge; an assessment of knowledge is beyond the scope of a survey instrument of this nature.

The two questions proposed in Table 1 to survey Technological Knowledge (TK) namely:

TK1.

How confident are you in integrating ICT such as PowerPoint, Excel, projectors, and interactive white boards in your regular delivery of instructions?

TK2.

How confident are you to use web-based tools and teaching resources such as YouTube, Google, WebQuest, Google Scholar?

Which are similar in style to one of the TTF TPACK survey instrument questions, namely:

How confident are you that you have the knowledge, skills and abilities to support your students' use of ICT to support numeracy learning?

But there is a significant difference – the TTF TPACK question includes the clause:

support your students' use of ICT,

Which is arguably TK, and

to support numeracy learning

Which is arguably CK. Thus this question combines TK and CK and is thus TCK.

In contrast, the two questions TK1 and TK2 are only seeking information about the teacher's confidence in the use of technology, and are not concerned with the teacher's pedagogical skills or their confidence of subject knowledge.

Likewise the two Pedagogical Knowledge (PK) questions in Table 1 are directed only at assessing the teacher's pedagogical knowledge and teaching skills; the two Content Knowledge (CK) questions are concerned only with the subject matter that is being taught.

There is no claim made that the questions posed in Table 1 are the only questions that can be constructed to assess TK, PK, and CK. Rather these questions are convenient for this study because they result in synthesised TCK, PCK, TPK and TPACK survey questions that are similar to those in the Schmidt et al. and TTF TPACK survey instruments.

Synthesis using the TPACK framework

The TPACK framework identifies Technological Pedagogical Knowledge (TPK) as the common area, or area of intersection of the two elements TK and PK, as in the TPACK Venn diagram (Figure 1).

Put mathematically:

$TPK = TK \cdot PK$ or $TPK = TK \cap PK$, where the “.” and “ \cap ” are mathematical symbols used to signify the logical intersection. Linguistically the word ‘and’ can be used to

indicate the intersection of two sets. Thus “Technological Pedagogical Knowledge is the combination of Technological Knowledge and Pedagogical Knowledge”.

It must be emphasised that the logical ‘and’ implies the intersection of two sets or elements, and not their union or addition. For example the statement --- ‘15 children in my class have fair hair and blue eyes’ --- asserts that there are 15 students in the class who have both fair hair and blue eyes. It does not imply, for example, that there are 10 students with fair hair and 5 students with blue eyes (a total of 15) in the class.

We can use this construction to synthesise TPK questions from the component TK and PK questions.

Thus from TK1.PK1 we get:

TPK1:

How confident are you in your knowledge of teaching and learning strategies to integrate ICT such as PowerPoint, video projectors, and interactive white boards, with your delivery of instructions?

Results

Using the two TK, PK and CK questions from Table 1, four survey questions can be synthesised using the logical constructs for each of TPK, TCK and PCK as shown in Table 2.

Table 2

Synthesised TPK, TCK and PCK Survey Questions

| Domain | Construct | Question |
|--------|-----------|--|
| TPK | TK1.PK1 | <i>1. How confident are you to integrate your knowledge of teaching and learning strategies with your delivery of instructions using ICT such as PowerPoint, video projectors, interactive white boards in regular delivery of instructions?</i> |
| | TK1.PK2 | <i>2. How confident are you in integrating ICT such as PowerPoint and Excel to interest and inspire students of varying abilities in your classes?</i> |
| | TK2.PK1 | <i>3. How confident are you to integrate your knowledge of teaching and learning strategies using web-based tools and teaching resources such as YouTube, Google, WebQuest,</i> |

| | | |
|-----|---------|--|
| | | <i>Google Scholar ?</i> |
| | TK2.PK2 | <i>4. How confident are you to integrate your knowledge of teaching and learning strategies using ICT such as PowerPoint, Excel, projectors and interactive white boards in regular delivery of instructions?</i> |
| TCK | TK1.CK1 | <i>1. How confident are you in using ICT to support your knowledge of the subject you are teaching?</i> |
| | TK1.CK2 | <i>2. How confident are you using ICT to answer all students' questions on the material that you are teaching and give meaningful explanations?</i> |
| | TK2.CK1 | <i>3. How confident are you in using web-based tools to support your knowledge of the subject you are teaching?</i> |
| | TK2.CK2 | <i>4. How confident are you in using web-based tools to answer all students' questions on the material that you are teaching and give meaningful explanations?</i> |
| PCK | PK1.CK1 | <i>1. How confident are you that you know and understand the subjects that you are teaching and that you can apply your knowledge of teaching and learning in the delivery of instructions to students of varying abilities in your classes?</i> |
| | PK1.CK2 | <i>2. How confident are you that you can apply your knowledge of teaching and learning in providing answers to all students' questions on the material that you are teaching and give meaningful explanations?</i> |
| | PK2.CK1 | <i>3. How confident are you that you know and understand the subjects that you are teaching and are able to inspire students of varying abilities in your classes?</i> |
| | PK2.CK2 | <i>4. How confident are you in your ability to interest and inspire students of varying abilities and also answer their questions on the material that you are teaching and give meaningful explanations?</i> |

The intersection of the TPK, TCK and PCK elements can be used to construct TPACK questions; thus

TPK2:

How confident are you using IT such as PowerPoint to interest and inspire students?

PCK3:

How confident are you in your ability to interest and inspire students in the subjects that you are teaching?

This results in the following TPACK question (TPK1.PCK3):

How confident are you in using ICT such as PowerPoint in your ability to interest and inspire students in the subjects that you are teaching?

It might be thought that this process using these constructs (such as TPACK = TCK1.PCK1) would result in 66 questions (that is ${}^{12}C_2$, the number of different combinations that two items can be selected from a total of 12 items), but this is not the case because some of the constructs result in duplication of the TK, CK or PK elements:

For example: TPK2.TCK3 = (TK1.PK2).(TK2.CK1) = (TK1.TK2).PK2.CK2

In other cases there is duplication of the constructs:

For example: TPK1.PCK1 = (TK1.PK1).(PK1.CK1) = TK1.PK1.CK1, and

TCK1.TPK1 = (TK1.CK1).(TK1.PK1) = TK1.PK1.CK1.

Note that TK1.TK1 = TK1.

In all there are only 8 unique TPACK constructs from the TPC, TCK and PCK elements. These can be most easily identified by reference to their component TK, PK and CK elements as shown in Table 3.

Table 3

Synthesised TPACK Survey Questions

| | | <i>How confident are you.....</i> |
|-----------------|-------------|---|
| J-D&D TPACK1 | TK1.PK1.CK1 | in your knowledge of teaching and learning strategies, you know and understand the subjects that you are teaching and can integrate ICT such as PowerPoint and Excel in your everyday teaching? |
| J-D&D TPACK2 | TK1.PK1.CK2 | in your knowledge of teaching and learning strategies and can integrate ICT such as PowerPoint and Excel to |

| | | |
|-----------------|-------------|---|
| | | answer all students' questions and give meaningful explanations? |
| J-D&D TPACK3 | TK1.PK2.CK1 | that you know and understand the subjects that you are teaching, and that you can organise your lessons and integrate ICT such as PowerPoint and Excel to interest students of varying abilities in your classes? |
| J-D&D TPACK4 | TK1.PK2.CK2 | that you can integrate ICT such as PowerPoint and Excel and organise your lessons to interest students with varying abilities and answer all students' questions on the material you are teaching and give meaningful explanations? |
| J-D&D TPACK5 | TK2.PK1.CK1 | in your knowledge of teaching and learning strategies, and can use web-based tools and teaching resources such as YouTube, Google, WebQuest to interest students of varying abilities? |
| J-D&D TPACK6 | TK2.PK1.CK2 | in your knowledge of teaching and learning strategies and can use web-based tools and teaching resources such as YouTube, Google, WebQuest to answer all students' questions on the material you are teaching, and give meaningful explanations? |
| J-D&D TPACK7 | TK2.PK2.CK1 | that you know and understand the subjects that you are teaching and can use web-based resources such as YouTube, Google, WebQuest to interest students of varying abilities in your classes? |
| J-D&D TPACK8 | TK2.PK2.CK2 | that you can use web-based tools and teaching resources such as YouTube, Google, WebQuest and organise your lessons to interest students of varying abilities, answer all students' questions on the material you are teaching, and give meaningful explanations? |

Discussion

In the development of the TTF TPACK survey instrument, 135 questions were proposed and a subset (46) was chosen and validated in a major survey of teachers' and pre-service teachers' TPACK in Australian schools and universities (Albion, Jamieson Proctor, & Finger, 2010). Schmidt et al. (2009) devised 75 survey items for

measuring pre-service teachers' self-assessment of each of the seven TPACK domains; a panel of nationally known researchers with expertise in TPACK validated the survey items. There was no reported attempt in the development of either of these instruments to use the logical constructs from the fundamental TPACK elements, TK, PK and CK as described above.

Consider the construction TK2.PK2.CK1 in Table 3:

How confident are you that you know and understand the subjects that you are teaching and can use web-based resources such as Youtube, Google, Webquest to interest students of varying abilities in your classes.

Although this question is rather wordy it is clearly founded on the original TK, PK, and CK survey items shown in Table 1.

Compare this to a question in the TTF TPACK survey instrument:

How confident are you that you have the knowledge, skills and abilities to support your students' use of ICT to provide motivation for curriculum tasks?

And with a (TPACK) item from the Schmidt et al. (2009) survey instrument:

I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn.

It can be seen that there are three elements that are common to each as shown in Table 4

Table 4

Elements of TPACK from Three Survey Instruments

| | J-D&DTPACK3 | TTF TPACK | Schmidt et al |
|------------|---|---------------------------|-----------------------------|
| Technology | <i>web-based tools</i> | <i>use of ICT</i> | <i>technologies</i> |
| Pedagogy | <i>interest and inspire students of varying abilities</i> | <i>provide motivation</i> | <i>enhance what I teach</i> |
| Content | <i>knowledge of the subject you are teaching</i> | <i>curriculum tasks</i> | <i>what students learn</i> |

In all three cases the survey question for assessing TPACK contains TK, PK and CK elements, but the synthesised question (J-D&DTPACK3) is unambiguous in its references to these elements.

Deconstruction of survey items

The TTF TPACK survey instrument elements can be analysed using the synthesis technique described above in reverse; that is by reducing the survey elements into their fundamental components. This can provide a re--assessment of TPK and TCK in existing survey instruments with the aim of providing a firm basis for classification of the elements. As mentioned in the literature review there is conjecture as to the classification of the TPK and TCK items in the TTF TPACK survey instrument.

Consider the following items from the TTF TPACK TPK/TCK survey (Jamieson--Proctor et al., 2013):

TTF TPACK1

How confident are you that you have the knowledge, skills and abilities to support your students' use of ICT to teach specific subject areas in creative ways?

TTF TPACK2

How confident are you that you have the knowledge, skills and abilities to design learning sequences, lesson plans and assessments that incorporate ICT use by students?

Table 5 shows a possible deconstruction of these survey items.

Table 5

Deconstruction of Survey Questions

| TPACK Element | TTF TPACK1 | TTF TPACK2 |
|---------------|------------|------------|
|---------------|------------|------------|

| | | |
|-----------------|--|--|
| Technology (TK) | <i>use of ICT</i> | <i>Incorporate ICT use by students</i> |
| Pedagogy (PK) | <i>teach specific subject areas in creative ways</i> | |
| Content (CK) | | <i>design learning sequences, lesson plans and assessments</i> |
| J-D&D (2014) | TPK | TCK |

However there is some ambiguity in the classification of some items: “Teach specific subject areas” could be classed as PCK rather than CK.

Limitations to the synthesis method

In the Schmidt et al. (2009) survey instrument (Appendix A) we see that the first three sets of questions are grouped as TK (Technology Knowledge). CK (Content Knowledge) and PK (Pedagogical Knowledge).

The PCK question PCK27:

I know how to select effective teaching approaches to guide student thinking and learning in mathematics.

results from the intersection (PCK27 = PK24.CK9), that is

PK24:

I can use a wide range of teaching approaches in a classroom setting (such as collaborative learning, direct instruction, inquiry learning, problem/project based learning etc.), and

CK9:

I can use a mathematical way of thinking.

But a synthesis of these two elements could result in a significantly different question, which is:

I can use a mathematical way of thinking to select effective teaching approaches.

However the synthesis method of this publication can be used to accurately combine two of the Schmidt et al. (2009) items, TK5 and PK21 (Appendix A):

TK5.PK21:

I know about a lot of different technologies and I can adapt my teaching based-upon what students currently understand or do not understand.

Which is very close in meaning (if somewhat wordier but somewhat more wordy) to a question from the Schmidt et al.(2009) survey (Appendix A).

TPK35: I can choose technologies that enhance the teaching approaches for a lesson

An example is presented in Table 5 of the question in the TTF TPACK survey (TTF TPACK (1)) that could be interpreted as either CK or PCK. This ambiguity is not found in the Schmidt et al. survey instrument because of the clear identification of the TK, CK and PK, although it is not known if the compilers of the Schmidt et al. instrument used a synthesis technique similar to that described in this paper.

However it is known that TTF TPACK instrument was not ‘built from the ground up’ as described here, and this may account for the consequent uncertainty of the class (TPK or TCK) of some of the survey questions (Albion, personal communication, 2014).

Conclusions

It is not the intention of this study to produce and validate another survey instrument for the assessment of TPACK and its elements. Rather the intention is to critically examine two widely used, accepted and validated survey instruments through the lens of this synthesis concept.

This study has demonstrated applying the rules defining these elements can generate survey questions that discriminate the elements of TPACK. Some survey questions generated by this technique are very similar in wording and meaning to those from two widely adopted TPACK survey instruments. The same techniques described here can be used in reverse to analyse questions in existing validated survey instruments.

The authors have completed an assessment of university engineering academics’ technological pedagogical content knowledge using the TTF TPACK instrument. They propose to repeat this study with academics from other disciplines by deploying and validating a new survey instrument, synthesised as described above, alongside the existing TTF TPACK instrument. This work will serve to gauge the new instrument’s efficacy in discriminating TPK and TCK. This robust and versatile synthesis method should lead to the development and validation of TPACK survey instruments in which there is no ambiguity.

References

- Albion, P. R. (2014). Personal Communication [Draft Survey Items - Students - TPK, TCK & TPACK].
- Albion, P. R., Jamieson-Proctor, R., & Finger, G. (2010). *Auditing the TPACK confidence of Australian pre-service teachers: the TPACK confidence survey (TCS). 21st International Conference of the Society for Information Technology & Teacher Education (SITE 2010).*
- Angeli, C., & Valanides, N. (2005). Preservice elementary teachers as information and communication technology designers: An instructional systems design model based on an expanded view of pedagogical content knowledge. *Journal of Computer Assisted Learning, 21(4)*, 292-302.
- 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(1)*.
- Beetham, H., & Sharpe, R. (2013). *Rethinking pedagogy for a digital age: Designing for 21st century learning.* Routledge
- Bransford, J. D., Brown, A. L., & Cocking, R. R. (1999). How people learn: Brain, mind, experience, and school: National Academy Press.
- Brantley-Dias, L., & Ertmer, P. A. (2013). Goldilocks and TPACK: Is the construct 'just right? *Journal of Research on Technology in Education, 46(2)*, 103-128.
- Casner-Lotto, J., & Brenner, M. W. (2006). *Are They Really Ready to Work? Employers' Perspectives on the Basic Knowledge and Applied Skills of New Entrants to the 21st Century US Workforce. Partnership for 21st century Skills.* Partnership for 21st Century Skills. Washington, DC.
- Finger, G., Jamieson-Proctor, R., Cavanagh, R., Albion, P., Grimbeek, P., Bond, T., Lloyd, M. (2013). Teaching Teachers for the Future (TTF) Project TPACK Survey: Summary of the key findings. *Australian Educational Computing, 27(3)*, 13-25.
- Graham, C. R. (2011). Theoretical considerations for understanding technological pedagogical content knowledge (TPACK). *Computers & Education, 57(3)*, 1953-1960. doi: <http://dx.doi.org/10.1016/j.compedu.2011.04.010>

- Jamieson-Proctor, R., Albion, P., Finger, G., Cavanagh, R., Fitzgerald, R., Bond, T., & Grimbeek, P. (2013). Development of the TTF TPACK Survey Instrument. *Australian Educational Computing, 27(3)*, 26-35.
- Jamieson-Proctor, R., Finger, G., Albion, P., Cavanagh, R., Fitzgerald, R., Bond, T., & Grimbeek, P. (2012). *Teaching teachers for the future (TTF) project: development of the TTF TPACK survey instrument*. Paper presented at the Proceedings of the 2012 Australian Computers in Education Conference (ACEC 2012).
- Jordan, K. (2014). *ACEC2014 Adapting an instrument to measure teacher TPACK*. Paper presented at the ACEC2014 Now it's personal - Innovating Education, Adelaide, South Australia.
[http://acec2014.acce.edu.au/sites/2014/files/ACEC2014 Conference Proceedings.pdf](http://acec2014.acce.edu.au/sites/2014/files/ACEC2014%20Conference%20Proceedings.pdf)
- Koehler, M. J., Shin, T. S., & Mishra, P. (2012). How do we measure TPACK? Let me count the ways. In R. N. Ronau, R. C.R & Niess. M.L (Eds.), *Educational Technology, Teacher Knowledge, and Classroom Impact: A Research Handbook on Frameworks and Approaches*. (pp. 16 - 31). Hershey, PA, USA: Information Science Reference.
- Lee, M., & Tsai, C. (2010). Exploring teachers' perceived self efficacy and technological pedagogical content knowledge with respect to educational use of the World Wide Web. *Instructional Science, 38(1)*, 1-21.
- Liang, J., Chai, C., Koh, J. H. L., Yang, C., & Tsai, C. (2013). Surveying in-service preschool teachers' technological pedagogical content knowledge. *Australasian Journal of Educational Technology, 29(4)*.
- Mishra, P., & Koehler, J. M. (2008). *Introducing Technological Pedagogical Content Knowledge*. Paper presented at the Annual Meeting of the American Educational Research Association, New York City.
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108(6)*, 1017-1054. doi: DOI 10.1111/j.1467-9620.2006.00684.x
- Mishra, P., & Koehler, M. J. (2007). *Technological pedagogical content knowledge (TPCK): Confronting the wicked problems of teaching with technology*. Paper presented at the Society for Information Technology & Teacher Education International Conference.
- Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education, 21 (5)*, 509-523.

- Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological pedagogical content knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Computing in Education, 42(2)*, 123.
- Shulman. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15(2)*, 4-14.
- Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57(1)*, 1-22.
- Thompson, A. D., & Mishra, P. (2007). Breaking News: TPCCK becomes TPACK! *Journal of computing in Teacher Education, 24(2)*, 38-64.
- Voogt, J., Fisser, P., Pareja Roblin, N., Tondeur, J., & van Braak, J. (2013). Technological pedagogical content knowledge – a review of the literature. *Journal of Computer Assisted Learning, 29(2)*, 109-121. doi: 10.1111/j.1365-2729.2012.00487.x

Appendix A TK CK and PK items from Schmidt et al (2009) survey instrument

TK (Technology Knowledge)

- TK1 I know how to solve my own technical problems.
- TK2 I can learn technology easily.
- TK3 I keep up with important new technologies.
- TK4 I frequently play around the technology.
- TK5 I know about a lot of different technologies
- TK6 I have the technical skills I need to use technology.
- TK7 I have had sufficient opportunities to work with different technologies.

CK (Content Knowledge)

Mathematics

- CK8 I have sufficient knowledge about mathematics.
- CK9 I can use a mathematical way of thinking.
- CK10 I have various ways and strategies of developing my understanding of mathematics.

Social Studies

- CK11 I have sufficient knowledge about social studies.
- CK12 I can use a historical way of thinking.
- CK13 I have various ways and strategies of developing my understanding of social studies.

Science

- CK14 I have sufficient knowledge about science.
- CK15 I can use a scientific way of thinking.
- CK16 I have various ways and strategies of developing my understanding of science.

Literacy

- CK17 I have sufficient knowledge about literacy.
- CK18 I can use a literary way of thinking.
- CK19 I have various ways and strategies of developing my understanding of literacy.

PK (Pedagogical Knowledge)

- PK20 I know how to assess student performance in a classroom.
- PK21 I can adapt my teaching based-upon what students currently understand or do not understand.
- PK22 I can adapt my teaching style to different learners.
- PK23 I can assess student learning in multiple ways.
- PK24 I can use a wide range of teaching approaches in a classroom setting (collaborative learning, direct instruction, inquiry learning, problem/project based learning etc.).
- PK25 I am familiar with common student understandings and misconceptions.
- PK26 I know how to organize and maintain classroom management.

PCK (Pedagogical Content Knowledge)

- PCK27 I know how to select effective teaching approaches to guide student thinking and learning in mathematics.
- PCK28 I know how to select effective teaching approaches to guide student thinking and learning in literacy.
- PCK29 I know how to select effective teaching approaches to guide student thinking and learning in science.
- PCK30 I know how to select effective teaching approaches to guide student thinking and learning in social studies.

TCK (Technological Content Knowledge)

- TCK31 I know about technologies that I can use for understanding and doing mathematics.
- TCK32 I know about technologies that I can use for understanding and doing literacy.
- TCK33 I know about technologies that I can use for understanding and doing science.
- TCK34 I know about technologies that I can use for understanding and doing social studies.

TPK (Technological Pedagogical Knowledge)

- TPK35 I can choose technologies that enhance the teaching approaches for a lesson.
- TPK36 I can choose technologies that enhance students' learning for a lesson.
- TPK37 My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom.
- TPK38 I am thinking critically about how to use technology in my classroom.
- TPK39 I can adapt the use of the technologies that I am learning about to different teaching activities.