A Study of Mathematics Teachers Conceptions of Their Own Knowledge of Technological Pedagogical Content Knowledge (TPACK)

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Content

Abstract

In this study, a sample of mathematics teachers at upper secondary level rated their knowledge with respect to the key domains described by the Technological Pedagogical Content Knowledge (TPACK) framework. The results indicated that teachers expressed that they had a high level of knowledge in terms of pedagogy and content and the combination of these, but the knowledge level was lower in terms of technology such as software installation or troubleshooting of computers. The results also indicated that there were small differences in the expressed level of knowledge between sexes and years of teaching experience. The study indicated that effective integration of digital tools should include training both in the educational use and the actual operation of the tools.

C. Bernack-Schüler et al. (eds.), *Views and Beliefs in Mathematics Education,*
Freiburger Empirische Forschung in der Mathematikdidaktik,
DOI 10.1007/978-3-658-09614-4_13,

1 Introduction

In society today, we use a lot of digital equipment, such as computers, iPads and smart phones. This equipment is used in various forms such as forums, searching for facts, keeping in contact, etc. According to Säljö (2010), digital technology, has in recent decades seen enormous development. Computers have gained immense storage capacity through faster processors and well-developed software. The trends in education also show that the use of Internet and the availability e.g. through smart phones will be increasingly demanded (The Horizon Report, 2011). The changes society has undergone, on the digital side, the last few years' means that teachers are facing all kinds of digital tools related to their work. While it is not certain that computers and digital technology alone can improve teaching; good teachers also need to be available (Säljö, 2010). Todays schools compete with a variety of information and knowledge channels such as TV, video and computer games, the Internet, apps, etc. It could be argued that teachers should at least know about the different kinds of learning opportunities that are available for students in a digital world.

In Sweden, the curriculum for mathematics at upper secondary level says:

> Teaching should also give students the opportunity to develop their ability to use digital technology, digital media, and other tools which can occur in subjects typical of programmes. (Swedish National Agency for education, 2012, p. 1).

This means that digital tools should be a part of mathematics education in Sweden. NCTM also recognizes ICT as a part of education:

> Technology is an essential tool for learning mathematics in the 21st century, and all schools must ensure that all their students have access to technology (NCTM, 2008, p. 1).

As previously stated, access to technology is not enough. How the technology is used is dependent on the teachers and their knowledge. This has been pointed out by Drijvers:

> …the teacher has to orchestrate learning, for example by synthesizing the results of technology-rich activities, highlighting fruitful tool techniques, and relating the experiences within the technological environment to paper-and-pen skills or to other mathematical activities (Drijvers, 2012, p. 12).

This means that teachers should integrate knowledge of student thinking and learning strategies along with knowledge of the subject with the use of digital tools in their teaching. This is a relatively new area of research in Sweden and the question is whether today's teachers have the skills to integrate knowledge of student thinking and learning strategies, knowledge of the subject and with digital tools.

The study is a replica of the study that Archambault and Crippen (2009) did in the USA which examined a national sample of 596 K-12 online teachers and measured their knowledge with respect to three key domains as described by the TPACK framework. Here, I will specifically examine how teachers assess their own competence in integrating pedagogy, mathematics and digital tools in their teaching practice. The research questions were,

- What is the perceived level of knowledge among teachers in mathematics that is specific to digital tools, pedagogy and subject content, including combinations of these?
- What differences are there in the perceived level of knowledge among teachers in mathematics that is specific to digital tools, pedagogy and subject content, including combinations of these, depending on the factors gender and teaching experience?

2 Background

The concept of pedagogical content knowledge (PCK) was introduced by Shulman (1986). He raised the issue of the need for a more coherent theoretical framework with regard to what teachers should know and be able to do. Mishra and Koehler (2006) built on Shulman´s notion of PCK to articulate the concept of technological pedagogical content knowledge here referred to as TPACK.

The framework TPACK consists of three areas of knowledge: content knowledge (the topic to be taught), pedagogical knowledge (process and / or methods of learning and teaching), and technological knowledge (both ordinary such as the blackboard and more advanced such as computers) including the connections between these areas, (Mishra & Koehler, 2006) as illustrated in Figure 1 below. The relationship between these fields of knowledge is complex and nuanced (Mishra & Koehler, 2006; Schmidt et.al, 2009). For further definitions of each area of TPACK, see Koehler & Mishra (2008).

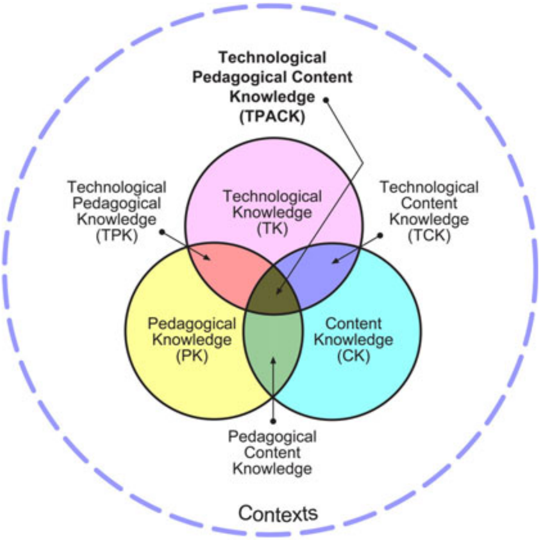

Figure 1 Framework of TPACK (Koehler, u.d.)

Archambault & Crippen (2009) studied TPACK in K-12, online teachers. Their results indicated that teachers perceived themselves to be proficient in the areas of pedagogy, subject content and the combination of these. However when it came to technology, the teachers expressed that they had less knowledge. The study also showed strong correlations between pedagogy and subject content, whilst the relationship between technology and pedagogy, and technology and subject matter was weak. The responses to the open-ended questions revealed difficulties with learning the new technology (Archambault & Crippen, 2009). Similar views have been observed in Turkish prospective primary teachers regarding the use of computers in mathematics education (Doğan, 2012). Although the Turkish teachers stated that the use of computers can help them to teach mathematics, they did not feel confident about it.

3 Method

The data collection was done through a web survey where the responses were automatically anonymous. That meant that the questionnaire was easy to administrate and compile. The disadvantages of online surveys is the same as traditional surveys, i.e. sources of error due to non-response, sampling, coverage and measurement errors are the same (Avery, 2006).

The questionnaire was a translated and modified version of that used by Archambault & Crippen (2009). Modifications were made to satisfy Swedish conditions and the level of the school system to be investigated (upper secondary school). A number of background questions were added, such as gender, university education and teaching experience. The questions were initially constructed using the areas of TPACK and the 23 questions were grouped in these areas (see table 1). The opportunity to comment on each section was given in open questions. The responses were given in a 5-point Likert scale, ranging from 1 = very poor to 5 = very good. A pilot study was made to test the instrument.

Table 1 The structure an variation in the questionnaire.

Area	Part	Question	Variation
Pedagogical knowledge (PK)	A	1-3	0.6
Technological knowledge (TK)	B	4-6	1.04
Content knowledge (CK)	C	7-9	0.6
Pedagogical Content knowledge (PCK)	E	13-16	1
Technological Content knowledge (TCK)	D	10-12	1.08
Technological Pedagogical knowledge (TPK)	F	17-20	1.28
Technological Pedagogical Content knowledge (TPACK)	G	21-23	1.16

These are some sample statements from the survey:

A. My ability to adapt teaching method to the students' knowledge

B. My ability to help students troubleshoot technical problems on their computers

C. My ability to decide what mathematical concepts and how they should be taught in my class

D. My ability to use different software in teaching (eg, Word, Powerpoint, Excel, etc.)

E. My ability to support students in noticing connections between different concepts

F. My ability to use different approaches to teaching through digital tools

G. My ability to teach so that students achieve proficiency in digital software module specified in the curriculum and syllabus

The schools participating in this study were located in a medium sized state located in central Sweden. The selected schools where chosen based on their presentation of themselves where the criteria was stressing the use of ICT in education. 13 schools were chosen from an initial group of 25. In these 13 schools there were 71 mathematics teachers. Due to technical problems, 7 teachers couldn´t participate in this study leaving the maximum number of potential respondents to 64. Of these, 26 replied giving a response rate of 41 %. Mean value and standard deviation was calculated for each question. Due to the small number of respondents, no further statistical analysis was made and the results were compared with previous research. This study is descriptive and the result cannot be generalized beyond the response group. However general tendencies can be indicated.

4 Result

The results are summarized and presented by the different areas of TPACK and from now on I will use the abbreviations for the different areas. First we look at the differences between the areas of PK, CK and PCK that are higher than the other TK, TCK, TPK and TPACK, see Table 2:

Table:2 Descriptive results within the areas concerning teachers' estimadted ability in different situations.

Area	Mean value	Standard deviation
Pedagogical knowledge (PK)	3.960	0.701
Technological knowledge (TK)	3.160	1.233
Content knowledge (CK)	4.227	0.741
Pedagogical Content knowledge (PCK)	4.250	0.766
Technological Content knowledge (TCK)	3.747	1.034
Technological Pedagogical knowledge (TPK)	3.360	1.063
Technological Pedagogical Content knowledge (TPACK)	3.347	1.149

Table 2, also shows that the spread among individual teachers is greater in the areas of TK, TCK, TPK, and TPACK than in the areas of CK, PK and PCK.

In all areas except CK and PCK (which is basically the same), men rated their knowledge higher than women do, although the differences are quite small (Table 3). The largest gender difference exists within the subarea TK where the values differ by more than 1 unit, including TCK (0.7 units), TPK (0.6 units) and TPACK (0.3 units).

Table 3 Descriptive results for issues concerning teachers' estmated ability in different situations by gender

Mean value		
Area	Women	Men
Pedagogical knowledge (PK)	3.923	4.000
Technological knowledge (TK)	2.564	3.806
Content knowledge (CK)	4.256	4.194
Pedagogical Content knowledge (PCK)	4.269	4.229
Technological Content knowledge (TCK)	3.410	4.111
Technological Pedagogical knowledge (TPK)	3.077	3.667
Technological Pedagogical Content knowledge (TPACK)	3.205	3.500

The groups of teacher experience were chosen based on the few respondents; smaller groups would have meant groups with no respondents in it. All areas show a maximum value for those with 10-20 years of teaching experience (table 4). The difference from 0-10 years to 10-20 years is greatest for the area TPACK (1.1 units) for other areas, the differences are between 0.3-0.8 units. The reduction from 10-20 years to 20 years-, is greatest for TPACK (1 unit).

However, as can be seen in table 4, the variations are quite small between the groups.

Table 4 Descriptive results for issues concerning teachers' estimated ability in different situations, sorted by teaching experience

Area	All	0-10 years	10-20 years	20- years
Pedagogical knowledge (PK)	3.960	3.718	4.333	4.111
Technological knowledge (TK)	3.160	2.949	3.778	3.000
Content knowledge (CK)	4.227	3.897	4.667	4.500
Pedagogical Content knowledge (PCK)	4.250	4.115	4.417	4.375
Technological Content knowledge (TCK)	3.747	3.564	4.111	3.778
Technological Pedagogical knowledge (TPK)	3.360	3.192	3.875	3.208
Technological Pedagogical Content knowledge (TPACK)	3.347	3.051	4.167	3.167

5 Discussion

This study has used TPACK as a framework for measuring the perceived level of knowledge of a group of mathematics teachers working in schools explicitly focusing on ICT and other digital tools, these teachers should have knowledge related to these areas. It turned out to be difficult and complex. The pilot study revealed difficulties in distinguishing the areas implying that TPACK as a framework has difficulties in measuring the level of knowledge in the various fields, but it can still be a framework that describes what a teacher needs to have knowledge about, what distinguishes teachers from educators or technicians. From this present study a few conclusions can be drawn.

In the study of what the perceived level of knowledge of mathematics teachers at secondary level is within the framework TPACK, teachers express that they have good or very good knowledge about traditional teaching (teaching that doesn't integrate digital tools). However, they are more insecure in their knowledge regarding technology and the integration of technology in teaching. There are also some differences among individual teachers. In the respondents' written comments there are two branches, those who want to try and integrate the technology but do not have time or feel they don't know enough about the technology and need to learn it first, and those who do not wish or need to use technology at all. As one of the respondents writes "You can view different representations of a concept even without the use of digital tools, it's called a review." This can be interpreted as an unwillingness to change that is one of the criteria for a mathematics teacher with good TPACK skills, according to Grandgenett (2008). The results of this study may be due to several factors, including what experience teachers have acquired in their professional activities. The survey shows a trend toward higher levels of knowledge in all areas after 10-20 years of teaching experience, which is supported by Samuelsson and Samuelsson (2011) and Nilsson (2010). Teacher education may also be a factor, if not previously learned to teach through digital tools, it can be hard to do it on your own unless the persons own interest is involved. According to Graham (2009), it is natural that the subareas with technology is lower than most but with practical training, these skills can increase. It could also be that the development in technology progresses so very quickly that it is difficult to "keep up". If an education today would contain "the latest" in technology and education, it would still be "old" when the student graduates. As Dewey (1916) says, "If we teach today as we taught yesterday, then we rob our children of tomorrow." By changing teacher training and providing appropriate technical experience can we improve mathematics education (Landry, 2010).

The results of this study are in line with the observations of Archambault & Crippen (2009), they are almost identical despite different contexts and respondents. It seems like it exist a general view about yourself and your perceived knowledge regarding the areas of TPACK.

As a teacher educator, we cannot assume that the pedagogical knowledge of ICT follow for instance the use of ICT or the other way around. We need to be more specific about how to use it, when to use it, and be able to say why we should use it.

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