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THE IMPACT OF A PROFESSIONAL DEVELOPMENT PROGRAM ON IN-SERVICE TEACHERS' TPACK: A STUDY FROM ESTONIA

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Abstract

Recently there has been a considerable interest in the Technological Pedagogical Content Knowledge (TPACK) framework for effective technology integration (Koehler et al., 2013). Researchers have been measuring how effective their professional development efforts have been for the development of teachers' TPACK (Graham et al., 2009; Guzey & Roehrig, 2009). So far research is based only on short-term courses, so longitudinal studies are needed to examine the TPACK development of teachers across time (Hoffer & Grandgenett, 2012; Koh & Sing, 2011).
A two-year in-service training program of educational technology (60 ECTS), based on the TPACK framework, was developed at Tallinn University Haapsalu College to support in-service teachers to effectively embed ICT into their classroom teaching. The first group of teachers (n=20) enrolled in the program in January 2014. This paper reports some preliminary findings of a longitudinal action research, the main aim of which is to evaluate the impact of the in-service training program of educational technology on teachers' TPACK.
The key questions for this research were: how do teachers' perceptions of their TPACK levels change after participating in the training program for a year; which of the seven knowledge domains of the TPACK framework develop more than others; what is the impact of different knowledge domains on teachers' TPACK perceptions.
The TPACK questionnaire developed by Schmidt et al. (2009) was used to measure in-service teachers' self-assessments of their TPACK during the first meeting of the training program and at the end of the first academic year.
The research results revealed increase in all the domains of the TPACK framework. There was significant development of the teachers' TK and TPACK, but only limited growth in CK and PK. Strong positive correlations were found between TCK, TPK and TPACK in the post-course survey.
Key words: *ICT, in-service teachers, professional development, TPACK.*

Introduction

Many educational organizations point to the importance of training teachers to more effectively integrate technology in their classroom (International Society for Technology in Education, 2008; Partnership for 21st Century Skills, 2010). Yet, research implies that effective use of technology remains challenging for most teachers (Lemke, Coughlin & Reifsneider, 2009; Koehler et al., 2013).

The EST_IT@2018 report launched by the Estonian Development Fund lists the strengths and weaknesses of the Estonian educational system. One of the weaknesses mentioned is that teacher-training institutions do not ensure that their graduates possess the necessary ICT skills for teaching (Eesti Arengufond, 2010). In-service teachers also report feeling unprepared on how to use ICT in the classroom to support learning. ICT was the second highest area identified

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as a 'high development need' by in-service teachers in the TALIS survey in 2013 (OECD, 2014).

Evidence shows that increasing professional development opportunities for teachers is an efficient way of boosting ICT use in teaching and learning, since it helps to build highly confident teachers (European Schoolnet, 2013). However, Keller et al. (2008) have pointed out that not all professional development opportunities are equally effective. Traditional one-time teacher training workshops and conferences do not seem to have a lasting impact on teachers' practice (Carlson & Gadio, 2002; Enochsson & Rizza, 2009). Instead, continuous and sustained training is needed (Sardone & Devlin-Scherer, 2008). Lawless and Pellegrino (2007) also stress that high-quality professional development must be longer in duration, provide access to new technologies for teaching and actively engage teachers in meaningful activities for their individual contexts. Moreover, providing only technical skills training to teachers is not enough. Teachers also need professional development in the pedagogical application of those skills to improve their teaching (Carlson & Gadio, 2002).

Recently there has been a considerable interest in the Technological Pedagogical Content Knowledge (TPACK) framework, which aims to describe the kinds of knowledge needed by a teacher for effective pedagogical practice in a technology-enhanced learning environment (Mishra & Koehler, 2006; Harris, Mishra & Koehler, 2009). The TPACK framework argues that effective technology integration for teaching specific subject matter requires understanding the relationships between technology, pedagogy, and content.

There are altogether seven knowledge domains within the TPACK framework (Figure 1):

1) technological knowledge (TK) - knowledge of various technologies, such as smartphones, interactive whiteboards;

2) content knowledge (CK) - knowledge of the subject matter being taught to students, e.g. Estonian, mathematics, geography;

3) pedagogical knowledge (PK) - knowledge of teaching methods, lesson planning, assessment and general classroom management skills;

4) pedagogical content knowledge (PCK) - knowledge of how to teach particular content-based material to students;

5) technological content knowledge (TCK) - knowledge of how to select and use different technologies to communicate particular content knowledge;

6) technological pedagogical knowledge (TPK) - knowledge of using technology to implement different teaching methods;

7) technological pedagogical content knowledge (TPACK) - knowledge of using technology to implement teaching methods for different types of subject matter content (Koehler & Mishra, 2009).

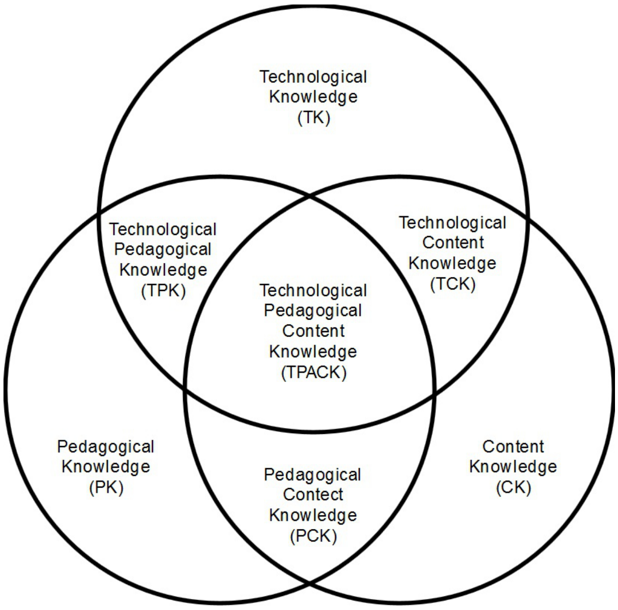

Figure 1: TPACK framework.

Using TPACK as a framework for measuring teaching knowledge could potentially have an impact on the type of professional development experiences designed for in-service teachers (Schmidt et al., 2009). In recent years researchers have been measuring how effective their professional development efforts have been for the development of teachers' TPACK (Graham et al., 2009; Guzey & Roehrig, 2009).

One strategy to determine growth in TPACK over time is to use assessments before and after a special course or training program (Chai, Koh & Tsai, 2010; Hu & Fyfe, 2010; Hoffer & Grandgenett, 2012). In their study of pre-service teachers in an educational technology course in Singapore, Chai, Koh and Tsai (2010) concluded that participants made significant gains in CK, PK, TK, and most substantially in TPACK with fairly large effect sizes. Hu and Fife (2010) completed a similar study in an educational technology course in Australia. Post-course survey results indicated that the teachers' confidence in their ability to connect their use of technology with content and pedagogy increased significantly. Hoffer and Grandgenett (2012) examined pre-service teachers' TPACK across an 11-month training program and detected significant growth in the students' TPACK throughout the study. Kurt, Mishra and Kocoglu (2013) conducted a survey of pre-service teachers in Turkey and the findings revealed that there was a statistically significant increase in their TK, TCK, TPK and TPACK scores. Graham et al. (2009) studied the TK, TCK, TPK and TPACK of in-service teachers who participated in an intensive professional development program in a US university. The results indicated that the participants began and ended the course with the greatest level of confidence in their TK, followed by TPK, TPACK and finally TCK.

There is evidence that teachers' overall TPACK perceptions are influenced by certain knowledge domains of TPACK. Some studies (Chai, Koh & Tsai, 2010; Chai, Koh, Tsai & Tan, 2011) have revealed that pedagogical knowledge (PK) and technological pedagogical knowledge (TPK) have the biggest impact on the development of TPACK. Koh and Sing (2011) discovered strong positive correlations between pre-service teachers' TPK, TCK and TPACK. In a qualitative study, Koh and Divaharan (2011) also found that pre-service teachers focused mostly on issues associated with TPK.

So far research in this field is mostly based on short-term courses; thus, longitudinal studies are needed to examine the TPACK development of both pre-service and in-service teachers across time (Hoffer & Grandgenett, 2012; Koh & Sing, 2011). Hoffer and Grandgenett (2012) add that triangulated study designs that span multiple years will help to not only better understand how TPACK develops, but also know which factors support and inhibit this growth. Moreover, TPACK studies have generally been reported for US teachers (e.g. Schmidt et al., 2009; Archambault & Crippen, 2009; Graham et al., 2009). The effectiveness of TPACK-based training courses has not yet been reported in Estonia.

Taking all this into consideration, a two-year in-service training program of educational technology (60 ECTS) was developed in Tallinn University Haapsalu College during the academic year of 2012/2013 to support in-service teachers to effectively embed ICT into their classroom teaching. The program consists of 17 different subjects and pedagogical practice. It is based on the Technological Pedagogical Content Knowledge (TPACK) framework developed by Punya Mishra and Matthew J. Koehler in 2006 and the National Educational Technology Standards for Teachers developed by ISTE (International Society for Technology in Education) in 2008.

The aim of this study was to examine the perceived development of in-service teachers' TPACK during the first year of their educational technology professional development. The key questions for this research were: 1) how do teachers' perceptions of their TPACK levels change after participating in the training program for a year; 2) which of the seven knowledge domains of the TPACK framework develop more than others; 3) what is the impact of different knowledge domains on teachers' TPACK perceptions.

Methodology of Research

General Background of Research

The first academic year of the professional development training program designed in Haapsalu College included nine different courses (altogether 30 ECTS): *Effective Computer Usage* (5 ECTS), *Teaching and Learning in the Digital Age* (3 ECTS), *Basics of Multimedia* (3 ECTS), *Digital Literacy* (3 ECTS), *Digital Media Production* (4 ECTS), *e-Society, Law and Security Issues in e-Learning* (3 ECTS), *Creating Digital Learning Resources* (3 ECTS), *Web-Based Learning Environments and Networks* (3 ECTS), *Educational Video Design and Implementation in the Classroom* (3 ECTS). These courses provide in-service teachers with different knowledge domains of the TPACK framework. Content knowledge (CK) and pedagogical content knowledge (PCK) are the only domains not taught during the program as the participating teachers are considered experts in their subject matter.

During the studies the participants learn to create and analyse different teaching resources (educational videos, presentations, learning activities) and lesson plans. The designed training program strives to adhere to the following instructional approaches and conditions: active engagement, authentic learning experiences, a variety of learning strategies, peer collaboration, sharing, support, reflection, etc. The training of in-service teachers takes place every other Friday and Saturday (altogether sixteen 8-hour training days in a semester). In addition to face-to-face meetings there is constant online communication through blogs, email, Facebook and Twitter.

The present study is the first part of a longitudinal action research, which aims to examine the impact of the in-service training program of educational technology on teachers' TPACK, especially the application of TPACK in the classroom and its effect on student learning.

The practice of action research has been fairly common among researchers interested in teaching practices and teacher education. Action research appears to be a particularly effective method for studying and improving TPACK (Manfra & Bullock, 2013). Borthwick & Pierson (2008) stress that successful professional development efforts must resemble the iterative action research cycle: "encouraging teachers to begin any training by thinking about what they can learn from it and how, what they are to learn is situated in the work that they already do;

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posing questions for how teaching and learning can improve; collaborating with peers and those more experienced to work to solve problems of practice; and evaluating and sharing findings with one another as part of an ongoing effort at collective improvement" (p. 211). The purpose of action research is to bring about change in specific contexts. It involves a cyclical process of action and reflection and a systematic approach to data collection and analysis (Manfra & Bullock, 2013).

One key criterion that distinguishes action research from other types of research is that there is always someone directly involved in the situation who serves as researcher (Hinchey, 2008). The author of this paper is both the head of the training program and one of the lecturers of educational technology in the training program.

Sample of Research

The sample of the pilot study was the group of in-service teachers who started their educational technology professional development program in Tallinn University Haapsalu College in January 2014. In-service teachers' letters of motivation served as an entrance examination to help decide which teachers would be admitted to the training program. The candidates (n=33) were asked to evaluate their knowledge and skills in the field of educational technology and their motivation to participate in the program. All the selected participants (n=20) were in-service teachers with several years of teaching experience. Of the 20 in-service teachers enrolled in the training program, 17 participated in the study. One participant unenrolled from the program in the third week of the semester and two participants at the end of the first semester. The remaining 17 teachers completed all data collection instruments in the study.

13 of the 17 participants worked as class teachers (primary school teachers), five were qualified as English teachers and two were teachers of Estonian. All the participants were female. The teachers ranged in age from 28 to 62 with a mean of 42 years.

Instrument and Procedures

The TPACK questionnaire developed by Schmidt et al. (2009) was selected to measure the in-service teachers' self-assessments of their TPACK. Self-report measures, which ask participants to rate the degree to which they agree to a given statement, are one of the most frequently used methods to measure participants' TPACK (Koehler, Shin & Mishra, 2012).

The survey instrument was used with one modification – a module of creative / talent-based subjects (art, handicraft, music) was added to include all the subjects that Estonian class teachers generally teach in their classrooms. The final instrument contained 52 statements for measuring teachers' self-assessments of the seven TPACK domains. All the statements were on a five-point Likert scale: 1) strongly disagree; 2) disagree; 3) neither agree nor disagree; 4) agree; 5) strongly agree.

The online survey was administered to all the participants during the first meeting of the training program in January 2014 and at the end of the first academic year in January 2015. Before the pre-course survey the TPACK framework was introduced to the participants in the classroom, the purpose of the study was explained, and the in-service teachers were told that their participation in the study was voluntary. It took approximately 15-20 minutes to fill in the survey.

Data Analysis

In order to analyse the data collected, descriptive statistics were used. Means and standard deviations were calculated for each of the survey items and also for all the knowledge domains of TPACK. A paired samples t-test (also called repeated measures) was used to calculate differences between pre-course and post-course scores and to determine the likelihood that pre-

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post differences were not due to chance. Cohen's d was computed to determine effect size. In order to examine the impact of different knowledge domains on teachers' TPACK perceptions, Pearson's correlation coefficients were calculated between TPACK and all its constructs.

Results of Research

The present study set out to address the following two research questions first: *How do teachers' perceptions of their TPACK levels change after participating in the training program for a year and which of the seven knowledge domains of the TPACK framework develop more than others?*

Table 1 provides the means, standard deviations (SD) and t-test results for all the knowledge domains of TPACK.

Table 1. In-service teachers' TPACK development during the course.

Pre-course survey			Post-course survey		Post-Pre Mean	p	Cohen's d
Knowledge domains	Mean	SD	Mean	SD			
CK	3.34	0.81	3.54	0.87	0.20	.00*	0.24
PK	4.01	0.59	4.19	0.47	0.18	.01*	0.34
TK	3.13	0.77	3.61	0.71	0.48	.00*	0.65
PCK	3.28	0.72	3.58	0.95	0.30	.00*	0.36
TCK	2.94	0.77	3.27	0.92	0.33	.00*	0.39
TPK	3.75	0.68	4.12	0.61	0.37	.04*	0.57
TPACK	3.02	0.89	3.65	0.80	0.63	.00*	0.75

* $p<0.05$

Results from the pre-course survey indicated that the participants began the training program with the greatest level of confidence in their PK, followed by TPK and CK. The teachers were least confident about their TCK and TPACK. At the end of the first academic year the in-service teachers had the greatest level of confidence in their PK, followed by TPK and TPACK, but the lowest level of confidence in their TCK and CK.

The comparison of self-assessment reports revealed significant development of the teachers' technological knowledge (TK) and technological pedagogical content knowledge (TPACK). There was only limited growth in participants' CK and PK, which is not surprising as content knowledge (CK) and pedagogical content knowledge (PCK) were not taught during the program.

Paired t-tests conducted between all the knowledge domains of TPACK indicated the $p < .05$ level of significance for each pairing. The value of Cohen's d was medium (between 0.5 and 0.8) in case of TK, TPK and TPACK.

The mean differences between the pre- and post-course scores were calculated for each statement. The next two tables present the impact of training on teachers' technological knowledge (Table 2) and technological pedagogical content knowledge (Table 3) – the domains that were subject to the largest growth during the training program.

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Table 2. The impact of training on teachers' TK.

Statements	Pre	Post	Change
I know how to solve my own technical problems.	2.76	3.29	+0.53
I can learn technology easily.	3.18	3.35	+0.17
I keep up with important new technologies.	3.47	4.00	+0.53
I frequently play around with the technology.	3.76	4.18	+0.42
I know about a lot of different technologies.	2.47	3.24	+0.77
I have the technical skills I need to use technology.	2.82	3.47	+0.65
I have had sufficient opportunities to work with different technologies.	3.47	3.71	+0.24

As can be seen from the chart, there is observable growth in the post-course survey results for all the statements, but particularly for statements 1, 3, 5 and 6. In the post-course test teachers' self-assessments were the highest for statements 3 and 4, which shows teachers' confidence in their ability to keep up with new technologies and interest in 'tinkering' with technology.

The impact of training on teachers' TPACK is also considerable. The post-course survey results show significant growth, particularly for statements 1, 4, 6, 7 and 8. In the post-course test teachers' self-assessments were the highest for statements 1 and 8. Teachers are confident about their ability to combine mathematics lessons with appropriate technologies and teaching methods and they say they can choose technologies that enhance the content for a lesson.

Table 3. The impact of training on teachers' TPACK.

Statements	Pre	Post	Change
I can teach lessons that appropriately combine mathematics, technologies, and teaching approaches.	3.08	3.92	+0.84
I can teach lessons that appropriately combine literacy, technologies, and teaching approaches.	3.18	3.65	+0.47
I can teach lessons that appropriately combine science, technologies, and teaching approaches.	3.08	3.54	+0.46
I can teach lessons that appropriately combine social studies, technologies, and teaching approaches.	2.85	3.62	+0.77
I can teach lessons that appropriately combine creative/talent-based subjects, technologies, and teaching approaches.	2.77	3.08	+0.31
I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn.	3.18	3.88	+0.70
I can provide leadership in helping others to coordinate the use of content, technologies, and teaching approaches at my school and/or district.	2.82	3.59	+0.77
I can choose technologies that enhance the content for a lesson.	3.18	3.94	+0.76

In order to answer the third research question (*What is the impact of different knowledge domains on teachers' TPACK perceptions?*), pre-course and post-course correlation coefficients were calculated between TPACK and its knowledge domains (Table 4).

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Table 4. Correlation coefficients between TPACK and its knowledge domains.

Knowledge domains	Pre-course survey TPACK	Post-course survey TPACK
CK	0.51	0.46
PK	0.32	0.20
TK	0.66	0.57
PCK	0.81	0.57
TCK	0.69	0.74
TPK	0.79	0.59

Strong positive correlations were found between TK and TPACK (r=0.66), TCK and TPACK (r=0.69), TPK and TPACK (r=0.79), PCK and TPACK (r=0.81) in the pre-course survey. In the post-course survey TPACK was significantly correlated with TPK (r=0.59) and TCK (r=0.74). TK and PCK also had moderate positive correlations with TPACK as the results were close to 0.60 (recommended by Fraenkel & Wallen, 2003). The correlations between CK, PK and TPACK were comparatively weaker.

Discussion

The preliminary findings of this study indicate overall strong growth in teachers' perceptions of all the knowledge domains of TPACK, with the largest growth in teachers' TK, TPK and TPACK. The significant growth in TK and TPACK makes sense as different courses during the program provided teachers with many opportunities to learn about new technologies and their implementation in the classroom setting. Researchers believe that teachers' confidence in their TK might later help them to develop confidence in other knowledge domains (Graham et al., 2009). Technological knowledge is undoubtedly one of the foundations for ICT integration, and studies have shown that raising teachers' technological skills increases the likelihood of them using ICT in the classroom (Hammond et al., 2011).

The present study reveals that in-service teachers have the lowest level of confidence in their technological content knowledge (TCK) both in the pre- and post-course survey. This agrees well with the study of Graham et al. (2009). As most of the participants were primary school teachers, they might have been less confident than secondary school teachers in their ability to select and use different technologies to communicate particular content knowledge, especially as most of the teachers did not rate their content knowledge very highly either.

The study also reveals significant correlations between the seven knowledge domains of TPACK, with the highest correlations between TPACK and TPK, and TPACK and TCK. These findings are consistent with the results of Schmidt et al. (2009) and Koh & Sing (2011).

However, the present study has several limitations that should be considered when interpreting its results. Firstly, the duration of the study was limited to the first academic year of the training program. As the knowledge domains of TPACK might not develop at the same time and in the same way, TPACK should be examined at various points during the whole training program.

Secondly, self-assessment reports may be prone to teachers under- or over-reporting their skills. Measuring TPACK using a self-report measure alone may be inadequate (Hoffer & Grandgenett, 2012) as participants tend to respond in ways that reflect positively on their abilities and knowledge.

Finally, the development of TPACK was based purely on the in-service teachers' self-reports. Therefore, it is unclear whether the professional development program has truly changed teachers' practice.

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Conclusions

The value of any framework of technology integration lies in how it manages to influence pedagogical practice. Therefore, the evaluation of the in-service training program continues. The participating teachers will be asked to assess their TPACK once more, after completing the whole training program in December 2015. In addition, interviews with the participants will be conducted to examine what factors support and/or inhibit the development of their TPACK. Classroom observations of the in-service teachers will also be conducted and their lesson plans examined to evaluate the level of TPACK demonstrated in the classroom. Few studies address the effect of teacher professional development on student achievement, although experience around the world has shown that teacher training in the effective use of technology is the key determining factor for improved student performance. Hence, the author also plans to involve the students of the participating in-service teachers in the research.

The findings of the present study are primarily significant for Tallinn University Haapsalu College as these help its program coordinators further develop and improve the training program of educational technology in order to better prepare in-service teachers to integrate technology in their classrooms. Furthermore, the findings have implications for the field of TPACK measurement and research.

It is important to conclude with emphasizing that it is crucial to enable all teachers to be confident with technologies. Technologies can provide powerful tools for student learning, but their value depends on how effectively teachers use them to support instruction.

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