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Differences in preservice teachers' readiness to use ICT in education and development of TPACK

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Abstract: Education for the 21st century society requires the use of Information and Communication Technology (ICT) in education. This presents challenges for preservice teacher education. Thus, more cognate understanding about preservice teachers' readiness to use ICT in education, coupled with knowledge related to ICT in education, is needed. Furthermore, it is important to understand that preservice teachers have various levels of readiness to use ICT in education, thereby creating a demand to investigate sub-groups within preservice teachers. This study focuses on differences of readiness and development of knowledge between preservice teachers' based on two theoretical constructs: Theory of Planned Behavior and TPACK. Results indicate differences in readiness of preservice teachers' sub-groups. Still, positive development trends in terms of knowledge of ICT in education can be found during the first two years of preservice teacher education. Limitations and future research are discussed.

Keywords: Preservice teachers**,** ICT in education, TPB, TPACK, clustering, longitudinal, differences, development, self-efficacy

Introduction

Students are expected to learn so called "21st century skills" in school. Within these skills, Information and Communication Technology (ICT) is a target for learning but also a tool to expand the development for working and learning other 21st century skills such as collaboration, problem solving, creative and critical thinking (Finnish National Board of Education, 2014; see also Voogt & Roblin, 2012). Consequently, there is a growing need to emphasize the role of ICT in education. This need exists not only the basic education, but also teacher education, in order for teachers to adapt to the changes and needs of society. Furthermore, for teacher cohorts, it is not only for understanding and knowing how to use ICT, but especially knowing how to use it in teaching itself. Thus, teachers' need to have the requisite skills to take advantage of ICT in education in pedagogically meaningful ways. But an interesting question is, are all teachers (especially preservice teachers) "cut from the same grain" in terms of readiness (i.e. intentions, attitudes and self-efficacy) to use ICT in education in pedagogically meaningful ways? To address this question, we deployed two theoretical frameworks, namely Theory of Planned Behavior (TBP; Ajzen, 1999) of ICT in education and Technological Pedagogical Content Knowledge (TPACK; Mishra & Koehler, 2006).

Theory of Planned Behavior (TPB)

In the TPB framework (Figure 1), actual behavior is determined by four constructs: (1) behavioral intentions, (2) attitudes, (3) subjective norms and (4) perceived behavioral control (Ajzen, 1991). (1) Behavioral

intentions (i.e. will teacher use something in teaching or not), is determined by the other constructs to follow (i.e. points 2-4). (2) Attitudes refer to whether one sees the behavior as positive or negative. (3) Subjective norm refers to more social perspective related to the behavior i.e. how important other persons (e.g. friends, colleagues and administrators) value the behavior. (4) Perceived behavioral control refer to both (a) resources that are available and (b) also ones' opinion of his/her skills to conduct the certain behavior (Ajzen, 2002). In this study, the focus is on the skills of respondents (i.e. 4b), which is framed on self-efficacy, because the preservice teachers may not able to assess the actual future ICT resources during their teacher education studies (Ajzen, 2002). Based on Teo and Tan (2012), the TPB framework is a valid model for explaining the intentions of preservice teachers regarding the use of ICT for teaching and learning. Previous studies have shown that attitudes have the strongest association with preservice teachers' behavioral intentions to use ICT in education (Teo and Tan, 2012). Therefore, the TPB model and its constructs (Figure 1) were deployed as one of the two major frameworks within this study measuring readiness of preservice teachers to use ICT in the classroom.

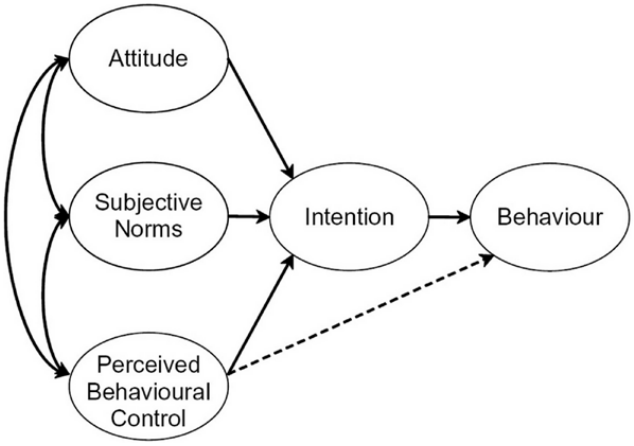

Figure 1. Theory of Planned Behavior constructs (Ajzen, 1999)

TPACK

Technological Pedagogical Content Knowledge (TPACK; Mishra & Koehler, 2006) is a theoretical framework describing teachers' knowledge with three areas: Technological knowledge (TK), Pedagogical knowledge (PK), Content Knowledge (CK). These areas are combined to represent more comprehensive constructs including Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK) and ultimately with combination of these all the TPACK itself. The TPACK framework can be seen as a flexible model, which does not consider the actual pedagogical practices (Brantley-Dias, & Ertmer, 2013). Rather, it provides possibilities for researchers to modify the framework for various research purposes and pedagogical approaches. For example, Valtonen, Sointu, Mäkitalo-Siegl and Kukkonen (2015) grounded the TPACK pedagogical practices align with 21st century skills. Altogether, the TPACK framework provides seven areas of knowledge that serve as the heart of good teaching with ICT (Koehler, Mishra, & Cain, 2013).

TPB and TPACK

Both TPB and TPACK theoretical frameworks have been actively used for studying preservice teachers as users of ICT in education (Teo & Tan, 2012; Voogt, Fisser, Roblin, Tondeur, & van Braak, 2013; Valtonen, Sointu et al., In Press). However, we have identified areas warranting more research. First, a challenge with both frameworks is that in the majority of the studies, all of the data are seen as one group, without identifying possible differences in the starting level construct (e.g., high/low attitude or knowledge) between respondents. That is, studies using the TPACK and TPB frameworks seldom make differences amongst respondents merely treating the respondents as one homogenous group. Second, there seems to be a lack of longitudinal approaches focusing especially for the development of these areas. Within TPACK there have been some longitudinal studies (e.g., Chai, Koh, & Tsai, 2010; Hofer, & Grandgenett 2012), but these have been focused on even a rather small target group, or, they took place only for a short period of time (e.g. a single course). Still, this topic is important especially in the teacher education context. For example, Kontkanen and colleagues (2016) refers to preservice teachers' TPACK as a proto-TPACK in which its nature is seen as a developing knowledge entity indicating a need for more detailed knowledge of the development trend and affecting factors. Third, an area needing further research is to design studies that combine these actively used theoretical frameworks as a single, comprehensive study. These data are

needed in order to provide a more profound picture of the target group (e.g. preservice teachers) and also for providing insights into the possible connective or overlapping areas of these frameworks.

This study focuses on these previously described areas. Our first aim was to describe the differences among preservice teachers based on three areas of TPB-ICT. Namely, the three areas that we assessed were attitudes, self-efficacy, and behavioral intentions. Our second aim was to outline the development of TPACK within the first two years of preservice teacher education. To address this aim, the TPB groups from the first phase of the study were used, thus describing the development of preservice teachers TPACK in these groups.

Methods

Participants

The target group included 188 preservice teachers' from three Finnish universities. Data were collected in two waves as part of preservice teacher education courses during autumn 2014 (T1) and autumn 2015 (T2). Participation was voluntary for preservice teachers and the research aims and methods were explained to them. Also, the permissions for collecting the data was acquired from the administrators of each three university teacher education unit. The group included 76.1% female (N_{female} = 143) and 23.9 % male (N_{male} = 45) preservice teachers which represents typical gender distribution in Finnish preservice teacher education (see e.g., Valtonen et al., In press). The mean age of respondents was 21.7 (SD = 3.0). The participants of this study will graduate as classroom teachers in Finnish basic education grades 1 to 6.

Measures

The questionnaire concludes two parts. The first part, Theory of Planned Behavior in ICT education (TPB-ICT; Valtonen, Kukkonen et al., 2015), which contains 17 statements rated on a six-point Likert-type scale (1 = strongly disagree - 6 = strongly agree). Preservice teachers rate statement such as *The use of ICT in education is integral to today's society* (Attitudes), *My future students will assume that I can use ICT for teaching* (Subjective norms), *I am very skillful in using new ICT when I need it* (Self-efficacy), and *I will make sure that my students will use ICT in their studies* (Behavioral intentions). Previous studies with TPB-ICT have demonstrated adequate internal consistency and structural validity (Kettunen, 2015; Valtonen, Kukkonen et al., 2015). We used only autumn 2014 (T1) data in the analysis with TPB-ICT instrument.

The second part of the questionnaire used for measuring TPACK was the TPACK21 instrument (Valtonen, Sointu et al., 2015). The TPACK21 instrument contains 36 statements rated on a six-point Likert-type scale (1 = I need lot of information about the measured area – 6 = I have strong knowledge of the measured area). Areas related to the pedagogical knowledge are grounded on 21st century skills like collaboration, critical thinking, problem solving etc. (see e.g., Voogt & Roblin, 2012). Preservice teachers rate statements such as *Facilitating students' discussions during group work (2–5 students)* (Pedagogical Knowledge [PK21]), *I am familiar with new technologies and their features* (Technological Knowledge [TK]), *I know the basic theories and concepts of natural sciences* (Content Knowledge in Science [CK]), *In teaching, I know how to make use of ICT as a medium for sharing ideas and thinking together* (Technological Pedagogical Knowledge 21 [TPK21], *In teaching natural sciences, I know how to guide students' content-related problem solving in groups (2–5 students)* (Pedagogical Content Knowledge 21 [PCK21]), *I know ICT-applications which are used by professionals in natural sciences* (Technological Content Knowledge [TCK], and, *In teaching natural sciences… I know how to use ICT as a tool for sharing ideas and thinking together* (Technological Pedagogical Content Knowledge 21 (TPACK). In previous studies, TPACK21 questionnaire has demonstrated adequate initial reliability and structural validity (Valtonen, Sointu et al., 2015; Sointu, Valtonen et al., 2015). We used both, autumn 2014 (T1) and autumn 2015 (T2) measurement points in the analysis with TPACK21 instrument.

Data analysis

SPSS v22 was used to compute all statistics reported in this study. The items from the TPB-ICT instruments were combined into composite scores. The internal consistency of each composite score was assessed using Cronbach alpha (α). Additionally, α was used to determine the internal consistency of TPACK21 T1 and T2 subscales. TPB-ICT scores were entered into a K-means cluster analysis to determined groups of participants based on TPB-ICT scores. K-means cluster analysis is one way to extract cluster memberships the data and to obtain smaller more homogeneous groups of respondents based on clustering (e.g., Jain, 2010; Nummenmaa, 2009). The theoretical foundations of TPB-ICT was followed closely in creating and interpreting optimal solution for the clustering. The factors used in cluster analysis were Attitudes, Self-efficacy and Behavioral intention. Reason for not

using Subjective norms subscale was the small variation in that subscale i.e. it did not brought any added value to the clustering process. Finally, the results of TPACK21 in T1 and T2 were compared with paired sample t-tests for understanding the development of ICT in education knowledge, and differences between various TPB-ICT preservice teacher clusters with One-Way ANOVA.

Results

TPB-ICT means, standard deviation, internal consistency (Cronbach α) for all data and means, standard deviation for three different preservice teacher clusters are presented in the table 1. The internal consistency of Attitudes (ATT), Self-Efficacy (SE) and Behavioral Intentions (BI) was acceptable. The cluster analysis was used to identify three groups of preservice teachers. The first Cluster (C1, $N = 43$) had the lowest score in ATT and BI indicating the most negative attitudes and intentions towards the use of ICT in education. Also, their self-efficacy was low. The Cluster 2 (C2, $N = 98$) gained the highest scores in all measured areas: highest scores were in the attitude factor indicating very positive ATT toward the use of ICT in education. The Cluster 3 (C3, $N = 47$) had the most variation among TPB-ICT subscale scores. Within this cluster, the respondents had positive ATT toward the ICT in education, and also their BI to use ICT in their future work was highest of all groups. However, their SE was the lowest all clusters. Results indicate distinct features of three various groups of preservice teachers and an important role of self-efficacy among the preservice teachers' future plans using ICT in education.

Table 1.

TPB-ICT Mean (M), Standard Deviation (SD), Internal Consistency (α) for all data, and M, SD for three different clusters

	All data		*Cluster data*		
	All $N = 188$	*Cronbach alpha*	*Cluster 1* $n = 43$	*Cluster 2* $n = 98$	*Cluster 3* $n = 47$
TPB-ICT subscale:	*M (SD)*	*α*	*M (SD)*	*M (SD)*	*M (SD)*
Attitudes (ATT)	4.13 (0.80)	0.89	3.04 (0.56)	4.53 (0.51)	4.32 (0.52)
Self-Efficacy (SE)	3.55 (1.04)	0.87	2.72 (0.80)	4.35 (0.52)	2.63 (0.60)
Behavioral Intentions (BI)	3.99 (0.80)	0.86	2.99 (0.64)	4.28 (0.60)	4.30 (0.51)
Description of the Cluster			*"low all"*	*"high all"*	*"positive ATT/BI but low self-efficacy"*

Figure 2 presents preservice teachers' TPACK in first (T1) and second (T2) measurement points for all data and for the three extracted TPB-ICT clusters (i.e. C1, C2 and C3). For the all data (dashed line in the Figure 2), all of the preservice teachers' TPACK areas developed positively and statistically significantly ($p = .000$) between T1 and T2 measurement points. The largest development based on *t*-score was in Technological Pedagogical Content Knowledge (TPACK): TPACK21 T1 (M = 2.64, SD = 1.05) to TPACK21 T2 (M = 3.38, SD = 0.96) m t (187) = 9.80, p = .00. Second largest development was in the Pedagogical Content Knowledge (PCK): PCK21 T1 (M = 2.93, SD = 1.00) to PCK21 T2 (M = 3.65, SD = 0.90), t (187) = 9.72, p = .00. The lowest but still positive development was in the Technological Knowledge (TK): TK T1 (M = 2.83, SD = 1.23) to TK T2 (M = 3.15, SD = 1.26), t (187) = 5.02, p = .00.

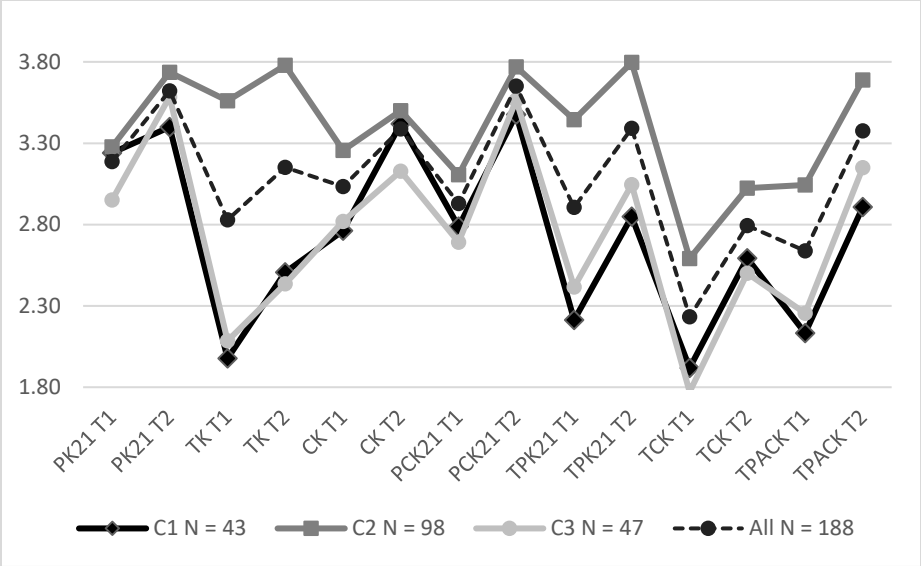

Figure 2. Preservice teachers' TPACK within three TPB-ICT clusters.
Note, the y-axis follows the TPACK21 response scaling (1 = I need lot of information about the measured area – 6 = I have strong knowledge of the measured area).

Similarly, the TPACK areas developed positively between T1 and T2 measurement points within the three extracted cluster (see Figure 2 black, dark grey and light gray lines). However, as these differences between the levels of TPACK areas are compared between the clusters (i.e. C1, C2, C3), it is possible to notice variation between the groups regarding to some TPACK areas. More specifically a significant difference were found in: Technological Knowledge (TK) T1 between C1/C3 and C2 clusters $F(2, 185) = 58.36$, $p = .00$; TK T2 between C1/C3 and C2 clusters $F(2, 185) = 34.44$, $p = .00$; Content Knowledge (CK) T1 between C1 and C2 clusters $F(2, 185) = 4.85$, $p = .01$; Technological Pedagogical Knowledge (TPK21) T1 between C1/C3 and C2 clusters $F(2, 185) = 34.66$, $p = .00$; TPK21 T2 between C1/C3 and C2 clusters $F(2, 185) = 20.90$, $p = .00$; Technological Content Knowledge (TCK) T1 between C1/C3 and C2 clusters $F(2, 185) = 14.40$, $p = .00$; TCK T2 between C3 and C2 clusters $F(2, 185) = 5.30$, $p = .01$; TPACK T1 between C1/C3 and C2 clusters $F(2, 185) = 18.16$, $p = .00$; and TPACK T2 between C1/C3 and C2 clusters $F(2, 185) = 13.09$, $p = .00$. Thus, majority of the differences (eight out of nine) between clusters were related to the technology constructs. When comparing the TPB-ICT cluster Means (table 1) to the patterns in the Figure 1, interesting difference occurs. The major difference of between C1 and C3 was the much higher level of C3 in Attitudes and Behavioral Intentions to use ICT in education, but similar low level in Self-Efficacy. This result indicated a major role of Self-efficacy particularly in the TPACK technology areas.

Conclusions

Our results indicate that participants are not a unique, homogenous group when considered as users of ICT in education. Explicitly, the ICT self-efficacy divides participants into two main groups. This division can also be seen in the development profiles of TPACK. Participants in Cluster 1 and 3 had very similar development profiles compared to participants in Cluster 2. These results are aligned with the results in the study of Koh and Chai (2014), where they divided preservice teachers into two clusters based on their own assessment of TPACK. Bases on their results, in the first cluster, preservice teachers had a higher confidence and the second cluster with lower confidence on their TPACK as our results show. Furthermore, our results show that there are strong differences between Cluster 1 and 3 based on how positively or negatively they value the use of ICT in education and also in how likely they are going to use ICT in the future work as a teacher.

Development of TPACK during the first year in teacher education was overall positive as determined by statistically significant data in all of the measured areas. The most profound positive impact was observed by the combined areas of TPACK. The metrics for TPACK had the biggest gains between measures, this was immediately

followed by PCK. These data indicate that preservice teachers gain skills to combine the *foundational* areas i.e. TK, PK and CK better. Based on previous research, the real experiences of learning certain contents with ICT in pedagogically meaningful ways are important for the development of preservice teachers (Ertmer, & Ottenbreit-Leftwich, 2010; Lei, 2009; Tondeur, van Braak, Sang, Voogt, Fisser, & Ottenbreit-Leftwich, 2012). Our results corroborate that of the proceeding literature. During the first year in teacher training, the preservice teachers gained experiences of learning different content within ICT in pedagogically meaningful ways. These courses are grounded on areas of CK and PK. Specifically, Finnish preservice teachers are provided with courses of different content in which they are going to teach (math, literature, arts, etc.). Still, the rather low scores in TK and TCK (especially in Cluster 1 and 3) need more attention in future studies. The role of TK is challenging for teacher education. There are a limited number of courses for this very large topic and also the focus of these courses is more on TPK instead of just TK. While more work is warranted, a potential solution could be to offer optional courses focusing on increasing technological self-efficacy, still it may be that preservice teachers in cluster one may not be very motivated for extra training based on their rather negative attitude and low intention to use ICT in education.

When comparing the results from the areas of TPB and TPACK, we observed similarities. The results of the cluster analysis provided three clearly distinctive groups, but the most profound results of self-efficacy similarity between Cluster 1 and 3. When comparing the results of TPACK between clusters, we can see similarities especially with Cluster 1 and 3 when considering areas of TPACK focusing on technology, especially TCK and TK were both low and remained low after first year of teacher education. Relations between TPB and TPACK demand more research. Importantly, the focus needs to be on what areas of TPACK are explained by self-efficacy. This would provide possibilities to find ways to focus the teacher education to support these areas in order to increase preservice teachers' self-efficacy toward the use of ICT in education.

This study reported changes between two measurements i.e. at the beginning of the first and second year in preservice teacher education. Our assumption is that it is important to continue with a longitudinal approach in order to gain to determine changes over time for the development of areas TPB and TPACK. These results indicate that the ideal model of TPACK, the Venn-diagram with equally strong areas (see e.g., Koehler, Mishra, & Cain, 2013), is merely a theoretical tool or goal for teacher education and professional development. Instead the proto-TPACK suggested by Kontkanen et al., (2016) need to be considered as a frame for following the development of different level TPACK. Proto-TPACK defines preservice teachers' TPACK as a developing entity, where different areas of TPACK are understood as unique developing entities. These results confirms the proto-TPACK assumptions and challenge pre and in-services teacher education to find ways to help (preservice) teachers to acknowledge and develop their areas of TPACK and the intersections between the elements. Aligning with Koehler and Mishra (2006), the aim would be to support the deeper understanding of preservice teachers of the complex relationships between content, pedagogy and technology, and their areas of intersection from different, individual starting points.

Limitations of the study and possibilities for future research

The first limitation of this study is the region with which participants were selected. Namely, solely preservice teachers from Finland (inclusive of three universities) were selected. While this sample size yields statistical power, it may not accurately reflect a broader, national and international perspective of preservice teachers. However, these data provide preliminary constructs on which to conduct larger, broader reaching subsequent studies. Our second limitation is that the psychometric investigation of both TPB-ICT and TPACK21 measures remain preliminary. Specifically, more research into the validity and reliability of these assessments are needed. Lastly, future studies should use both qualitative and quantitative data and mixed-methods for more profound understanding. For this purpose, for example, interviews and diaries could provide important insights into the backgrounds affecting factors of the unique and individual TPACK and TPB structures. With such methods we would be able to gain important additional information using preservice teachers' own words and personal experiences. Moreover, this relates to the notion that certain limitations exists with self-reported data. According to Hadwin and colleagues (2007), self-assessment do not necessarily depict the learners' actual behavior. Still, measures conducted with two questionnaires TPACK and TPB-ICT provided aligning results confirming each other and also previous studies. Additionally in the future, researchers should investigate the phenomenon with more robust methods e.g. latent cluster and profile analysis. Also, more investigation about the development of research tools is needed with long-term data (i.e. three years and more). While the data presented herein establish a baseline preliminary approach, future directions using the design described in this paragraph will add reliability, breadth, and strength to our understanding of the readiness of preservice teachers to use ICT.

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