Education and Information Technologies
https://doi.org/10.1007/s10639-023-12237-y

Early childhood pre-service teachers' attitudes towards digital technologies and their relation to digital competence

Olli Merjovaara[1] · Kenneth Eklund[2] · Tuula Nousiainen[3] · Satu Karjalainen[4] · Merja Koivula[1] · Arttu Mykkänen[5] · Raija Hämäläinen[1]

Received: 10 May 2023 / Accepted: 25 September 2023

Abstract
This study examines early childhood pre-service teachers' attitudes towards digital technologies and their relations to their self-perceived digital competence. Attitudes towards digital technologies were divided into core attitudes: general attitudes towards digital technologies; attitudes towards educational use of digital technologies; and perceived ease of digital technology use. Technological knowledge [TK] and technological content knowledge [TCK] dimensions of the TPACK framework were used to assess pre-service teachers' self-perceived digital competence. Two structural equation models, a correlated-traits model and a second-order factor model, were used to analyse the relations between attitudes and digital competence. Based on the results, the early childhood pre-service teachers held positive attitudes towards digital technologies. Both models fit the data well, but the correlated-traits model explained a larger portion of variance in competence measures. Moreover, this model provided a more fine-grained picture of the associations between attitudes and competence. The general attitudes towards digital technologies and perceived ease of digital technology use were related to both TK and TCK, whereas attitudes towards educational use of digital technologies were not. Therefore, the correlated-traits model was viewed as better at describing the relations between attitudes towards digital technologies and digital competence. The study contributes to the development of teacher education. Instead of considering the current generation of pre-service teachers as a homogeneous group, this study aims to understand how they differ in their attitudes and how they perceive their own competence to use digital technologies.

Keywords Early childhood education · Teacher education programs · Digital competence · Attitude towards technology

Extended author information available on the last page of the article

Published online: 10 January 2024

1 Introduction

Digital technologies have become a fundamental part of people's everyday lives and education. In recent years, they also have become a prominent part of early childhood education (Fenty & Anderson, 2016), as digital citizenship and required digital competence affect not only adults, but also young children (see Lauricella et al., 2020). Simultaneously, Generation Z is enrolling in teacher education now. This generation and its digital competence have been a topic of various debates and studies (e.g., Hernandez-de-Menendez et al., 2020; Tóth et al., 2022). Generation Z has been labelled 'digital natives' as the first generation in which digital technologies have been ubiquitous throughout their lives. However, we must remember the critical notion that 'there is no such thing as a digital native who is information-skilled simply because (s)he has never known a world that was not digital' (Kirschner & De Bruyckere, 2017, p. 135). Instead, they are not automatically confident when using digital technologies in an educational context and in a pedagogically meaningful way (Brown et al., 2016) due to a lack of educational digital competence (Alelaimat et al., 2020; Masoumi, 2021).

The present study is grounded in a notion that (digital) competence can be defined as the integrated application of knowledge, skills and attitudes during task performance (Baartman et al., 2007). Thus, it is important to highlight that digital competence and the utilisation of knowledge, skills and attitudes in a specific context, e.g., work, may differ significantly. Previous studies have highlighted the importance of attitudes, e.g., studies conducted with in-service teachers found that even if a teacher has the required technology available and good general digital skills, this does not necessarily lead to integration of technology into pedagogical practice (Aldhafeeri et al., 2016). In previous studies conducted with in-service teachers, attitudes towards technology have been found to be a strong predictor of pedagogical technology integration (Aldhafeeri et al., 2016; Altun, 2019; Blackwell et al., 2016) in the context of early childhood education. Aldhafeeri et al. (2016) found that even though early childhood educators had the necessary technological skills, and their classrooms were equipped with suitable technology, the teachers' negative attitudes towards digital technologies prevented successful technology integration. Previous studies mainly have focussed on in-service teachers, while pre-service teachers' attitudes towards digital technologies have been underexamined. Therefore, this study focuses on pre-service teachers' attitudes towards digital technologies. The context of this study is Finnish early childhood teacher education and with pre-service teachers we refer to students enrolled in a teacher education programme. The Finnish early childhood teacher study programme consists of three years of studies to attain the bachelor's degree which is the legal requirement in Finland to work as a teacher in early childhood education.

So far, previous research concerning pre-service teachers' attitudes towards digital technologies mainly has focussed on pre-service teachers' attitudes during the final stage of their studies (e.g., Scherer et al., 2018; Yerdelen-Damar et al., 2017), but research in the context of pre-service teachers during the starting phase of their teacher education has been the topic of fewer studies (e.g., Mertala, 2019). Furthermore, research concerning early childhood pre-service teachers remains limited (i.e.,

Altun, 2019; Dong & Xu, 2021; Mertala, 2019). Several studies have found that pre-service teachers tend to hold mostly positive attitudes towards digital technologies (e.g., Aslan & Zhu, 2017; Scherer et al., 2018). However, when it comes to early childhood pre-service teachers, extant research indicates that they have reservations about using digital technologies with young children, and from this perspective, they do not seem to differ from in-service teachers (Dong & Xu, 2021; Mertala, 2019). This challenges the narrative of digital natives and provides reason to view the current generation of pre-service teachers as a heterogenous group when it comes to attitudes towards digital technologies (Mertala, 2019). However, to develop higher education and study programmes, it is essential to understand students' attitudes towards digital technologies and their pedagogical use at the beginning of their training. Therefore, this study aims to broaden the understanding of attitudes that first-year pre-service teachers hold towards digital technologies and to examine the relations between attitudes towards digital technologies and study participants' perceived digital competence.

2 Theoretical background

2.1 TPACK

As digital technologies have become an integral part of learning and teaching in the twenty-first century, different frameworks have been developed to grasp the multifaceted nature of digital competence required in different educational contexts. These frameworks have been created from both educational policy and conceptual perspectives. Examples of policy-level frameworks are the European Commission's DigCompEdu (Redecker, 2017) and UNESCO's ICT Competency Framework for Teachers (2018). Other conceptual approaches that have been adopted in the education field (Falloon, 2020) include Puentedura's (2006) Substitution, Augmentation, Modification, and Redefinition (SAMR) and Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge (TPACK), which is used in this study. TPACK builds on Schulman's (1986) pedagogical content knowledge (PCK) theory. With TPACK, the teacher's necessary knowledge about how to integrate technology into pedagogy is divided into three domains: technology, pedagogy, and content. The domains are viewed as equally important from the perspective of developing meaningful teaching (Wang et al., 2018). However, the domains are viewed not as stand-alone parts of a competence, but rather as overlapping, thereby creating combinations that eventually form the TPACK, as seen in Fig. 1.

In addition to specific technological skills and knowledge, TPACK acknowledges that teaching and learning always happen in a specific context. These contexts influence the development of TPACK (Rosenberg & Koehler, 2015). Originally, these contextual factors were defined only as student background, grade level, subject matter and available technology (Mishra & Koehler, 2006), but recent research (Blackwell et al., 2016; Porras-Hernandez & Salinas-Amescua, 2013) has taken a wider view of these contextual factors and their relation to digital competence. One of these contextual factors is teachers' attitudes towards digital technologies (Blackwell et al., 2016), which is this study's main focus.

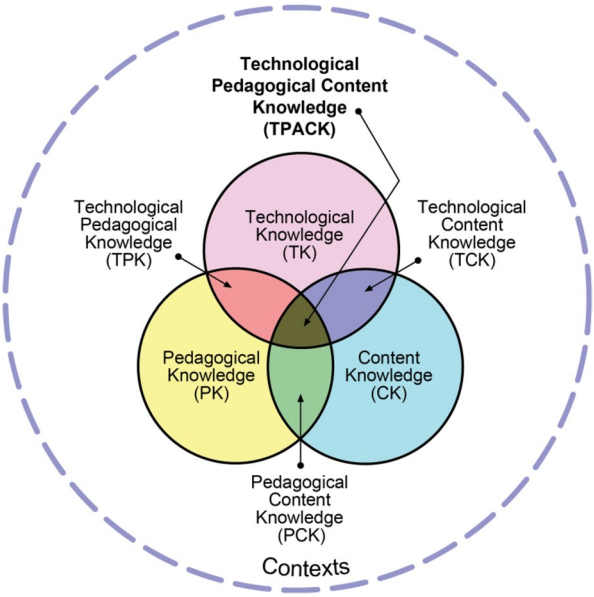

Fig. 1 The TPACK framework. Note. Adapted from http://tpack.org. Reproduced with permission from the publisher

2.2 Pre-service teachers' attitudes towards digital technologies

Aslan and Zhu (2017) defined attitudes as an individual's predisposition to respond favourably or unfavourably to an object, person or event (cf. Ajzen, 1988). Teachers' attitudes towards digital technologies have been examined using specific theories, e.g., the Davis' (1985) technology acceptance model (TAM) (Siyam, 2019; Teo et al., 2008) and unified theory of acceptance and use of technology (UTAUT) (Venkatesh et al., 2003), and by categorising attitudes towards digital technologies based on their relation to the technology use context. In this study, pre-service teachers' attitudes towards digital technologies were divided into three core categories, following the example of Tondeur et al. (2018) and Scherer et al. (2018): *general attitudes towards digital technologies (GATT), attitudes towards educational use of digital technologies (EDATT),* and *perceived ease of digital technology use (EASE)*.

First, *general attitude* measures a person's attitude towards digital technologies on a general level without any relation to a pedagogical context. Positive general attitudes towards digital technologies have been found to predict better competence in supporting learners' digital technology use (Tondeur et al., 2018), but other extant research found no relation between pre-service teachers' general attitudes towards digital technologies and pedagogical integration of digital technologies (Aslan & Zhu, 2017).

Second, previous research (e.g., Valtonen et al., 2018) has found that pre-service teachers generally have positive *attitudes towards the pedagogical use of digital technologies*. However, there might be variation between pre-service teachers from different subject domains (Padmavathi, 2016). As noted earlier, early-childhood pre-service teachers have been found to express reserved attitudes towards the pedagogical use of digital technologies, as they have concerns about possible negative effects that digital technologies may inflict on young children (Dong, 2018; Palaiologou, 2016; Dong & Xu, 2021).

Finally, *ease of use* has been found to be related to pre-service teachers' digital competence. Tondeur et al. (2018) found that high perceived ease of use positively impacted pre-service teachers' competence to support their pupils' digital competence, as well as design learning environments rich with digital technologies. However, negative perceptions of ease of use seem to have impacted pre-service teachers' self-efficacy and can lead to barriers in using digital technologies for educational purposes (Scherer et al., 2018). A relation between ease of use and pre-service teachers' intention to integrate digital technologies into the pedagogy also has been found in studies conducted with early childhood pre-service teachers (Kalogiannakis & Papadakis, 2019; Teo, 2011).

As we can see, attitudes towards digital technologies can be viewed as a multifaceted phenomenon moderated by educational context. In previous studies (Scherer et al., 2018; Tondeur et al., 2017), these various attitude categories – i.e., GATT, EDATT and EASE – have been found to correlate between each other. This raises the question of whether these attitude categories should be viewed individually or combined into one big entity, i.e., a more holistic approach.

As these various attitude categories all seem to be related to digital competence (Tondeur et al., 2018), and teacher education has been found to be an effective way and place to foster development of both attitudes towards digital technologies and perceived digital competence (Aslan & Zhu, 2017; Gill & Dalgarno, 2017), it is necessary to understand the relations between attitudes towards digital technologies and digital competence. To be able to design teacher study programme content so that these relations and variances among pre-service teachers are considered, it is paramount that an understanding of these relations be developed during the initial phase of teacher education.

2.3 Research questions

This study has two main goals. First, it aims to broaden the understanding of first-year early childhood pre-service teachers' attitudes towards digital technologies by examining whether differences exist between the three core attitude scales' mean values and whether the attitude scales differ from expected mean value. The study's second aim, in line with Scherer et al. (2018), is to analyse the relations between attitudes towards digital technologies and TPACK by using structural equation modelling (SEM). Previous research (Scherer et al., 2018) has indicated that final-year pre-service teachers' positive attitudes towards digital technologies are related to both TK and TCK dimensions of TPACK. This study aims to discover whether this also is evident with early childhood pre-service teachers during the initial phase of their training. Furthermore, we examine whether the relationships between attitudes and competence are better described by a model that approaches each attitude component separately or that combines the three categories into one general attitude factor.

Research questions

1. Do the mean values of first-year early childhood pre-service teachers' core attitudes towards digital technologies (GATT, EASE, EDATT) differ from the expected mean value and do they differ from each other?

2. How are pre-service teachers' attitudes towards digital technologies related to TPACK factors TK and TCK?

3 Method

3.1 Participants and data collection

The participants (N = 304) in this study were first-year early childhood education students from three Finnish universities. The participants ranged in age from 18 to 57 (M = 27.19, Mdn = 22.00, SD = 9.80), comprising 282 women, 18 men and four participants who identified themselves as neither. The low percentage of men among the participants' (6.4%) represents well the ratio of men (6.0%) who started in early childhood teacher education programme in 2021 (Finnish National Agency for Education, 2021) when the data were collected.

The data were collected during the fall semester of the 2021–2022 academic year using an online survey that contained questions concerning pre-service teachers' attitudes towards digital technologies on the two dimensions (TK and TCK) of a TPACK self-efficacy scale, their opinions on digital technologies' possible effects on children's development, their free-time digital technology use and background information. As the scales used in the survey were translated into Finnish, a pilot study was conducted to ensure the translated scales' reliability. In all three participating universities, the early childhood teacher programme includes mandatory courses where the students learn about the pedagogical use of digital tools as a part of early childhood pedagogy. At the time of the data collection, in one university there were two courses related to digital technologies during the first year of studies totalling 4,5 credits. In the second participating university one course of 4 credits was held during the first year and in the third university one course of 1 credit was held during the first year and one 5 credit course during the second year, totalling 6 credits.

To ensure minimal impact of courses related to digital technologies to the participants' attitudes and competence, the data collection was timed in all three universities to the beginning or before these courses. At one university, students answered the survey during a course lecture on one of the courses related to digital technologies. At the other two universities, data were collected during course lectures that were unrelated to the topic, and an orientating video informed participants about the research and its goals. Participation in the study was voluntary. E-mail addresses were collected from those who wished to participate in a lottery for gift cards to thank them for their participation.

3.2 Measures

3.2.1 Attitudes

A three-part survey was administered to measure attitudes towards digital technologies.[1] The first part was a five-item scale to measure general attitudes towards digital

[1] In all scales used, the term ICT originally was used instead of digital technologies.

technologies (GATT) (Evers et al., 2009). The GATT scale included items related to the person's interest in digital technologies, pleasurable experiences related to digital technologies and perceived usefulness of digital technologies. The second scale (EDATT) included three items that measured attitudes towards educational use of digital technologies. EDATT included questions related to the person's views on digital technologies' usefulness for educational purposes. The final attitude scale (EASE) was a three-item scale that measured perceived ease of digital technology use. Other scholars previously have used all three attitude scales (e.g., Scherer et al., 2018; Teo, 2011; Tondeur et al., 2018). The scales were based on a 1 (completely disagree) to 5 (completely agree) Likert scale. All three scales' reliability was good based on Cronbach's alpha and McDonald's omega (see Table 1).

3.2.2 TPACK

Pre-service teachers' self-beliefs were measured using Schmidt et al.'s (2009) TPACK scales. Instead of measuring all four TPACK dimensions, this study focussed on technological content knowledge (TCK) and technological knowledge (TK) due to the participants being first-year pre-service teachers who only recently had started their studies. As the participants had not yet amassed any pedagogical experience in their studies, their self-assessments in pedagogically emphasised TPCK and TPK dimensions would have been strongly hypothetical in nature. The TPACK scales also were five-point Likert scales with a range of 1 (completely disagree) to 5 (completely agree). According to Cronbach's α and McDonald's ώ, both TPACK scales' reliability was excellent (Table 1).

3.3 Data analysis

To answer the first research question – whether the three attitude scales' means differed from the hypothesised mean value of 3 – a one-sample t-test was used. Furthermore, a repeated-measures ANOVA, including attitude scale scores as the within-subject factor, was conducted to determine whether the three attitude scales' means differed statistically significantly from each other.

Table 1 Descriptive statistics, one-sample t-test and scale properties

Scale	M	SD	Min	Max	Skewness	Kurtosis	α	$ώ_t$	*t(303)*	*p*
GATT	3.84	0.63	1.80	5.00	-0.31	-0.29	0.78	0.80	23.4	< 0.001
EDATT	3.99	0.67	2.00	5.00	-0.42	-0.14	0.77	0.78	25.5	< 0.001
EASE	3.51	0.93	1.00	5.00	-0.53	-0.26	0.90	0.90	9.6	< 0.001
TCK	3.29	0.88	1.00	5.00	-0.35	-0.27	0.85	0.85	5.1	< 0.001
TK	3.38	0.81	1.14	5.00	-0.20	-0.46	0.88	0.88	8.2	< 0.001

N = 304, GATT = General attitudes towards digital technologies, EDATT = Attitudes towards the educational digital technology use, EASE = Perceived ease of digital technology use, TCK = Technological content knowledge, TK = Technological knowledge, α = Cronbach's alpha, $ώ_t$ = McDonald's omega total

SEM was used with the second research question. Two different models were established to view the relations between the three attitude scales (GATT, EDATT and EASE) and two TPACK dimensions (TK and TCK). Both estimated models' goodness of fit was evaluated using five indicators: χ^2 test, comparative fit index (CFI), Tucker-Lewis fit index (TLI), root mean square error of approximation (RMSEA), and standardised root mean square residual (SRMR). Both models were estimated using Mplus software (Version 8.8) (Müthen & Müthen, 1998–2023).

4 Results

4.1 Pre-service teachers' attitudes towards digital technologies

In the first research question, we examined pre-service teachers' attitudes towards digital technologies – namely whether they were negative, neutral or positive – and whether attitude levels differed from each other. A one-sample t-test indicated that the means were higher than the hypothesised scale mean of 3 in all three attitude scales, suggesting that pre-service teachers expressed rather positive attitudes towards digital technologies (Table 1). A repeated measures ANOVA with a Greenhouse–Geisser correction indicated that all three attitude scales' means differed from each other ($F[1.77, 534.75] = 53.3$, $p < 0.001$). Post hoc pair-wise comparisons with a Bonferroni adjustment indicated that attitudes towards pedagogical use of digital technologies had a higher mean score than general attitudes towards digital technologies. Perceived ease of digital technology use had a lower mean score than general attitudes towards digital technologies and attitudes towards pedagogical usage of them. Furthermore, the variance in perceived ease of digital technology use was largest.

4.2 The relations between attitudes towards digital technologies and TPACK

The second research question investigated the relations between the three core attitudes towards digital technologies and the two TPACK dimensions: TK and TCK. As a first step, correlations within the three attitude scales, as well as between them, and both measures of digital technology use, namely TK and TCK, were examined (see Tables 2 and 3). The three attitude scales were moderately (Cohen, 1992), but not highly, associated with each other. Variance inflation factors for the three attitudes varied between 1.29 and 1.46, suggesting a low multicollinearity level between these scales. Correlations between the three attitude scales and TCK were all low. Instead, correlation strength between the three attitude scales and TK seemed to differ: Perceived ease of digital technology use and TK were associated strongly, whereas only a moderate correlation was found between EDATT and TK. The strength of the association between GATT and TK fell in between these two extremes, but the associations between all attitude scales and TCK were of similar strength, i.e., weak, although statistically significant.

Table 2 Pearson correlation coefficients between attitude scales and digital competence

Variable	1	2	3	4	5
1. GATT	-				
2. EDATT	0.469***	-			
3. EASE	0.449***	0.351***	-		
4. TCK	0.274***	0.206***	0.224***	-	
5. TK	0.535***	0.318***	0.697***	0.376***	-

***p < 0.001

Table 3 Model fit

Model	Measurement model	X^2	*df*	*p*	RMSEA	90% CI RMSEA	CFI	TLI	SRMR
M1	CTM	1.703	2	0.427	0.000	[0.000, 0.108]	1.000	1.000	0.014
M2	SOFM	5.561	3	0.135	0.042	[0.000, 0.121]	0.993	0.977	0.015

CTM = Correlated-traits model, SOFM = Second-order factor model, Scaling correction factor

Based on the correlations, two models were established to examine the relations between pre-service teachers' attitudes towards digital technologies and the two TPACK dimensions: TK and TCK. The first model was a *correlated-traits model* (M1), and the second was a *second-order factor model* (M2). These two models' constructs were based on Scherer et al.'s (2018) models. Both models fit the data well, based on the fit indices (see Table 3).

4.2.1 Model M1: Correlated-traits models

The correlated-traits model was constructed first by adding hypothesised paths between all measures, after which non-significant paths were removed one by one. The final model with all significant paths is presented in Fig. 2. General attitudes towards digital technologies (GATT) were associated quite evenly with both TPACK dimensions. More positive general attitudes were related to higher values in both TK and TCK. Perceived ease of digital technology use (EASE) also was associated positively with both TPACK dimensions. The relation between EASE and TK was much stronger than the one between EASE and TCK. The attitude towards educational use of digital technologies (EDATT) was not directly associated with either of the two TPACK dimensions, although it was associated with both GATT and EASE, through which it had indirect associations with both TK and TPACK.

4.2.2 Model M2: Second-order factor model

The second-order factor model (see Fig. 3) was constructed next. A second order latent attitude factor (gATT) was constructed from the three attitude scales first. Next,

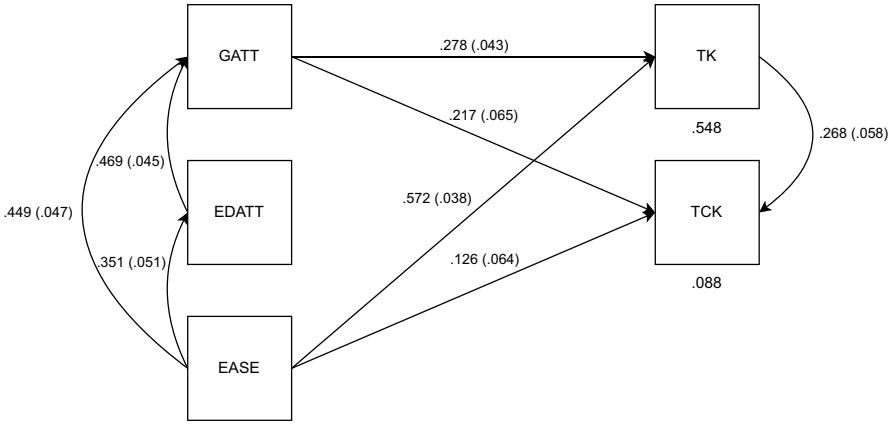

Fig. 2 Model 1: The correlated-traits model

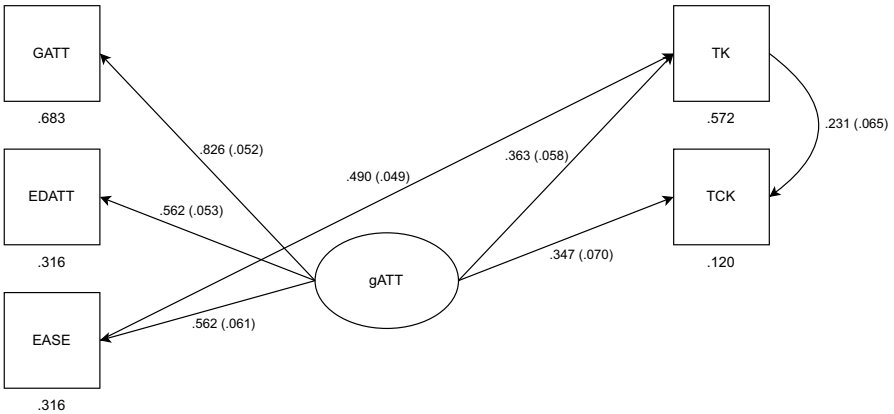

Fig. 3 Model 2: The second-order factor model

hypothesised paths between it and both TPACK measures were added. Finally, an additional path between EASE and TK was added based on the modification indices that the Mplus program suggested. The final model is presented in Fig. 2. From the three attitude scales, GATT was associated more strongly with the latent factor gATT than with EASE or EDATT. The general factor of attitudes towards digital technologies (gATT) found positive relations with both TPACK dimensions (TCK and TK). The association strengths between gATT and TCK, on one hand, and gATT and TK, on the other hand, were quite even. As in the *correlated-traits model*, a strong direct association between EASE and TK clearly also was visible in the *second-order factor model*, in which EASE was related to TK both directly and indirectly via gATT, whereas the other two attitude scales were related only through gATT.

5 Discussion

This study examined first-year early childhood pre-service teachers' attitudes towards digital technologies and how these attitudes are related to their perceived digital competence. The first research question examined early childhood pre-service teachers' attitudes towards digital technologies. They had positive attitudes towards all three core attitudes, but attitudes towards pedagogical use registered the highest mean score. Recent studies have reported mixed results concerning early childhood pre-service teachers' attitudes towards the use of digital technologies in early childhood education (see Birkollu et al., 2017; Mertala, 2019). Our results are in line with previous studies' findings that pre-service teachers hold positive attitudes towards digital technologies and view them as an important part of early childhood education (e.g., Alelaimat et al., 2020; Casillas et al., 2020). Other studies (e.g., Dong & Xu, 2021; Mertala, 2019) have reported that early childhood pre-service teachers' attitudes towards digital technologies do not differ very much from those of in-service teachers, and that they tend to have reserved attitudes towards the benefits of using digital technologies with young children, viewing them as a threat to play-based pedagogy and children's well-being. In this sense, this study's results are somewhat contradictory. Explaining the reasons behind these positive attitudes towards the educational use of digital technologies lies beyond this study's scope, but possibly, participants found it difficult to assess critically the pedagogical aspect of digital technologies used in early childhood education without having any pedagogical experience yet. Considering that the perceived ease of digital technology use registered the lowest mean score and greatest variance among the participants indicates that even though the current generation of pre-service teachers view digital technologies and their pedagogical use in a generally positive light, they remain a heterogeneous group with different skills and self-esteem levels when it comes to their self-perception of their digital competence. This is in line with previous research (e.g., Valtonen et al., 2018) and is an important finding, as perceived ease of use is a strong predictor of the integration of digital technologies into pedagogical activities (Teo, 2011). The results support previous conclusions that the 'digital native' generation needs training just like other generations (Alelaimat et al., 2020).

Correlations between attitudes and TPACK dimensions TK and TCK revealed uneven relations between the three attitudes and both TK and TCK. Despite moderate associations between attitudes, it was possible to test two different models to analyse relations further between attitudes and digital competence, a correlated-traits model with all three attitude scales separately and a second-order factor model that included a general attitude factor. Both models demonstrated the relation between TK and TCK, as well as attitudes towards digital technologies, as has been reported in several previous studies with pre-service teachers (Altun, 2019; Scherer et al., 2018; Yerdelen-Damar et al., 2017). The relations between the core attitudes and TK were stronger in both models than the relations between attitudes and TCK. The strong relation between perceived ease of use and technological knowledge could be viewed as self-explanatory, but still is important information for teacher training, as the relation between perceived ease of use and self-efficacy in digital technology use has been reported in

previous research (e.g., Tondeur et al., 2018). The results support Yerdelen-Damar et al.'s (2017) findings that to foster development of pre-service teachers' digital competence during teacher training, pre-service teachers' attitudes cannot be overlooked.

As these models have been used previously with data comprising final-year pre-service teachers (Scherer et al., 2018), this study aimed to provide new information about pre-service teachers at the beginning of their training. Based on the results, it seems that with these data, the three core attitudes should be viewed separately, instead of forming a general factor to explain pre-service teachers' attitudes towards digital technology. The correlated-traits model clearly demonstrated how all three attitude scales were related differently to the TPACK dimensions and how attitudes towards pedagogical use of digital technologies were not statistically related to either of the TPACK scales. The second-order factor model that utilised a factor comprising all three attitude scales indicated an uneven loading of the three scales on the general attitudes factor. Based on these results, the correlated-traits model was better-suited to describe the relations between attitudes and TPACK dimensions. This result differs from those of Scherer et al. (2018) with final-year pre-service teachers. These varying results raise the question of whether the same models can be used when comparing first- and final-year pre-service teachers' attitudes towards digital technologies. More research is needed on first-year pre-service teachers to determine whether the results are the same with other data sets.

6 Limitations and conclusion

Regarding our results, the following limitations need to be considered. In this study, the TPACK framework's pedagogically focussed scales were excluded, with only the scales with technological emphasis included, as it was assumed that first-year pre-service teachers could not reasonably assess their pedagogical competence at the beginning of their teacher studies. The results support this decision, as attitudes towards educational use were not related to either of the TPACK scales, and it seems that variations in attitudes were more random in nature. The exclusion of the other TPACK scales makes it impossible to assess the relation between the whole TPACK and attitudes towards digital technologies, and to compare the results with studies that have included all TPACK scales. This study also cannot explain the reasons behind pre-service teachers' varying attitudes or explain the observed relations. In the future, a more qualitative approach is needed to better understand how these attitudes are formed and how pre-service teachers perceive the possible reasons behind the relations between their attitudes and their perceived digital competence. In addition, this study doesn't take into account possible gender differences related to the use of digital technologies or if the non-native language needed to operate the digital technologies has an impact on the attitudes towards digital technologies. Therefore, further studies are needed to investigate the gender and language differences.

Despite these limitations, our study has clear advantages. The results provide insight into first-year pre-service teachers' attitudes and increase understanding on how even though attitudes towards digital technologies are generally high, variation remains among students. Particularly important for teacher education is the finding

that perceived ease of digital technology use had the lowest mean score among the pre-service teachers. As the results indicated that perceived ease of use had the strongest relation to technological knowledge of all three attitude scales, it is evident that the current generation of pre-service teachers still needs support in developing their skills and knowledge on how to use digital technologies in contexts that are not familiar to them. In teacher education, this can be achieved by providing pre-service teachers with guided opportunities to experiment with different digital technologies in pedagogical contexts to develop their self-efficacy and digital competence.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10639-023-12237-y.

Funding Open Access funding provided by University of Jyväskylä (JYU).

Data availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of Interest None.

References

Ajzen, I. (1988). *Attitudes, personality, and behavior*. Homewood, IL: Dorsey Press.

Aldhafeeri, F., Palaiologou, I., & Folorunsho, A. (2016). Integration of digital technologies into play-based pedagogy in Kuwaiti early childhood education: Teachers' views, attitudes and aptitudes. *International Journal of Early Years Education, 24*(3), 342–360. https://doi.org/10.1080/09669760.2016.1172477

Alelaimat, A. M., Ihmeideh, F. M., & Alkhawaldeh, M. F. (2020). Preparing preservice teachers for technology and digital media integration: Implications for early childhood teacher education programmes. *International Journal of Early Childhood, 52*(3), 299–317. https://doi.org/10.1007/s13158-020-00276-2

Altun, D. (2019). Investigating pre-service early childhood education teachers' technological pedagogical content knowledge (TPACK) competencies regarding digital literacy skills and their technology attitudes and usage. *Journal of Education and Learning, 8*(1), 249.

Aslan, A., & Zhu, C. (2017). Investigating variables predicting Turkish pre-service teachers' integration of ICT into teaching practices. *British Journal of Educational Technology, 48*(2), 552–570. https://doi.org/10.1111/bjet.12437

Baartman, L. K. J., Bastiaens, T. J., Kirschner, P. A., & van der Vleuten, C. P. M. (2007). Evaluating assessment quality in competence-based education: A qualitative comparison of two frameworks. *Educational Research Review, 2*(2), 114–129. https://doi.org/10.1016/j.edurev.2007.06.001

Birkollu, S. S., Yucesoy, Y., Baglama, B., & Kanbul, S. (2017). Investigating the Attitudes of Pre-service Teachers Towards Technology Based on Various Variables. *TEM Journal, 6*(3), 578–583. https://doi.org/10.18421/TEM63-20

Blackwell, C. K., Lauricella, A., & Wartella, E. (2016). The influence of TPACK contextual factors on early childhood educators' tablet computer use. *Computers & Education, 98*, 57–69.

Brown, C. P., Englehardt, J., & Mathers, H. (2016). Examining preservice teachers' conceptual and practical understandings of adopting iPads into their teaching of young children. *Teaching and Teacher Education, 60*, 179–190. https://doi.org/10.1016/j.tate.2016.08.018

Casillas, S., Cabezas, M., & García, F. J. (2020). Digital competence of early childhood education teachers: Attitude, knowledge and use of ICT. *European Journal of Teacher Education, 43*(2), 210–223. https://doi.org/10.1080/02619768.2019.1681393

Cohen, J. (1992). A Power Primer. *Psychological Bulletin, 112*(1), 155–159. https://doi.org/10.1037/0033-2909.112.1.155

Davis, F. D. (1985). A technology acceptance model for empirically testing new end-user information systems: Theory and results. (PhD). Cambridge, MA: Massachusetts Institute of Technology. https://dspace.mit.edu/bitstream/handle/1721.1/15192/14927137-MIT.pdf?sequence=2. Retrieved April 27, 2023.

Dong, C. (2018). Preschool teachers' perceptions and pedagogical practices: Young children's use of ICT. *Early Child Development and Care, 188*(6), 635–650. https://doi.org/10.1080/03004430.2016.1226293

Dong, C., & Xu, Q. (2021). Pre-service early childhood teachers' attitudes and intentions: Young children's use of ICT. *Journal of Early Childhood Teacher Education* (ahead-of-print), 1–16. https://doi.org/10.1080/10901027.2020.1726843

Evers, M., Sinnaeve, I., Clarebout, G., van Braak, J., & Elen, J. (2009). MICTIVO. Monitoring ICT in het Vlaamse Onderwijs. Eindrapport OBPWO-project 06.05: Monitor voor ICT-integratie in het Vlaamse onderwijs. Ghent University/KU Leuven. [Final report of OBPWO-project 06.05: Monitor for ICT integration in Flemish education.]

Falloon, G. (2020). From digital literacy to digital competence: The teacher digital competency (TDC) framework. *Educational Technology Research and Development, 68*(5), 2449–2472. https://doi.org/10.1007/s11423-020-09767-4

Fenty, N. S., & Anderson, E. (2016). Creating Digital Narratives: Guideline for Early Childhood Educators. *Childhood Education, 92*(1), 58–63. https://doi.org/10.1080/00094056.2016.1134243

Finnish National Agency for Education (2021). *Yliopistojen uudet opiskelijat* [New students in universities] https://vipunen.fi/fi-fi/_layouts/15/xlviewer.aspx?id=/fi-fi/Raportit/Yliopistokoulutuksen%20uudet%20opiskelijat-n%C3%A4k%C3%B6kulma%20koulutusala.xlsb. Retrieved August 14, 2023.

Gill, L., & Dalgarno, B. (2017). A qualitative analysis of pre-service primary school teachers' TPACK development over the four years of their teacher preparation programme. *Technology, Pedagogy and Education, 26*(4), 439–456. https://doi.org/10.1080/1475939X.2017.1287124

Hernandez-de-Menendez, M., Escobar Díaz, C. A., & Morales-Menendez, R. (2020). Educational experiences with Generation Z. *International Journal on Interactive Design and Manufacturing, 14*(3), 847–859. https://doi.org/10.1007/s12008-020-00674-9

Kalogiannakis, M., & Papadakis, S. (2019). Evaluating pre-service kindergarten teachers' intention to adopt and use tablets in teaching practice for natural sciences. *International Journal of Mobile Learning and Organisation, 13*(1), 113–127. https://doi.org/10.1504/IJMLO.2019.096479

Kirschner, P. A., & De Bruyckere, P. (2017). The myths of the digital native and the multitasker. *Teaching and Teacher Education, 67*, 135–142.

Lauricella, A. R., Herdzina, J., & Robb, M. (2020). Early childhood educators' teaching of digital citizenship competencies. *Computers and Education, 158*, 103989. https://doi.org/10.1016/j.compedu.2020.103989

Masoumi, D. (2021). Situating ICT in early childhood teacher education. *Education and Information Technologies, 26*(3), 3009–3026. https://doi.org/10.1007/s10639-020-10399-7

Mertala, P. (2019). Wonder children and victimising parents – preservice early childhood teachers' beliefs about children and technology at home. *Early Child Development and Care, 189*(3), 392–404. https://doi.org/10.1080/03004430.2017.1324434

Mishra, P., & Koehler, M. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054.

Müthen, B., & Müthen, L. (1998–2023). Mplus (Version 8.9). Los Angeles, CA: Muthen & Muthen.

Padmavathi, M. (2016). A study of student-teachers' readiness to use computers in teaching: An empirical study. *I-Manager's Journal on School Educational Technology, 11*(3), 29–39.

Palaiologou, I. (2016). Teachers' dispositions towards the role of digital devices in play-based pedagogy in early childhood education. *Early Years, 36*(3), 305–321. https://doi.org/10.1080/09575146.2016.1174816

Porras-Hernandez, L. H., & Salinas-Amescua, B. (2013). Strengthening TPACK: A broader notion of context and the use of teachers' narrative to reveal knowledge construction. *Journal of Computing Research, 48*(2), 223e244. https://doi.org/10.2190/EC.48.2.f

Puentedura, R. (2006). Transformation, technology and education: A model for technology and transformation. Retrieved April 27, 2023 from. http://hippasus.com/resources/tte/puentedura_tte.pdf.

Redecker, C. (2017). European framework for the digital competence of educators: DigCompEdu. In Y. Punie (Ed.), *EUR 28775 EN*. Publications Office of the European Union. https://doi.org/10.2760/159770

Rosenberg, J., & Koehler, M. (2015). Context and Technological Pedagogical Content Knowledge (TPACK): A Systematic Review. *Journal of Research on Technology in Education, 47*(3), 186–210. https://doi.org/10.1080/15391523.2015.1052663

Scherer, R., Tondeur, J., Siddiq, F., & Baran, E. (2018). The importance of attitudes towards technology for pre-service teachers' technological, pedagogical and content knowledge: Comparing structural equation modelling approaches. *Computers in Human Behaviour, 80*, 67–80. https://doi.org/10.1016/j.chb.2017.11.003

Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological pedagogical content knowledge (TPACK). *Journal of Research on Technology in Education, 42*(2), 123–149.

Schulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Siyam, N. (2019). Factors impacting special education teachers' acceptance and actual use of technology. *Education and Information Technologies, 24*(3), 2035–2057. https://doi.org/10.1007/s10639-018-09859-y

Teo, T. (2011). Factors influencing teachers' intention to use technology: Model development and test. *Computers and Education, 57*(4), 2432–2440. https://doi.org/10.1016/j.compedu.2011.06.008

Teo, T., Lee, C., & Chai, C. (2008). Understanding pre-service teachers' computer attitudes: Applying and extending the technology acceptance model. *Journal of Computer Assisted Learning, 24*(2), 128–143. https://doi.org/10.1111/j.1365-2729.2007.00247.x

Tondeur, J., Aesaert, K., Prestridge, S., & Consuegra, E. (2018). A multilevel analysis of what matters in the training of pre-service teacher's ICT competencies. *Computers and Education, 122*, 32–42. https://doi.org/10.1016/j.compedu.2018.03.002

Tondeur, J., Scherer, R., Siddiq, F., & Baran, E. (2017). A comprehensive investigation of TPACK within pre-service teachers' ICT profiles: Mind the gap. *Australasian Journal of Educational Technology, 33*(3). https://doi.org/10.14742/ajet.3504

Tóth, T., Virágh, R., Hallová, M., Stuchlý, P., & Hennyeyová, K. (2022). Digital Competence of Digital Native Students as Prerequisite for Digital Transformation of Education. *International Journal of Emerging Technologies in Learning, 17*(16), 150. https://doi.org/10.3991/ijet.v17i16.31791

UNESCO. (2018). ICT competency framework for teachers version 3 (online). https://unesdoc.unesco.org/ark:/48223/pf0000265721. Retrieved April 27, 2023.

Valtonen, T., Kukkonen, J., Kontkanen, S., Mäkitalo-Siegl, K., & Sointu, E. (2018). Differences in pre-service teachers' knowledge and readiness to use ICT in education. *Journal of Computer Assisted Learning, 34*(2), 174–182. https://doi.org/10.1111/jcal.12225

Venkatesh, V., Morris, M., Davis, G., & Davis, F. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*, 425–478.

Wang, W., Schmidt-Crawford, D., & Jin, Y. (2018). Preservice Teachers' TPACK Development: A Review of Literature. *Journal of Digital Learning in Teacher Education, 34*(4), 234–258. https://doi.org/10.1080/21532974.2018.1498039

Yerdelen-Damar, S., Boz, Y., & Aydin-Günbatar, S. (2017). Mediated Effects of Technology Competencies and Experiences on Relations Among Attitudes Towards Technology Use, Technology Ownership and Self Efficacy About Technological Pedagogical Content Knowledge. *Journal of Science Education and Technology, 26*(4), 394–405. https://doi.org/10.1007/s10956-017-9687-z

Authors and Affiliations

Olli Merjovaara[1] · Kenneth Eklund[2] · Tuula Nousiainen[3] · Satu Karjalainen[4] · Merja Koivula[1] · Arttu Mykkänen[5] · Raija Hämäläinen[1]

✉ Olli Merjovaara
olli.s.merjovaara@jyu.fi; olli.z.merjovaara@jyu.fi

[1] Department of Education, University of Jyväskylä, Jyväskylä, Finland

[2] Faculty of Education and Psychology, University of Jyväskylä, Jyväskylä, Finland

[3] Department of Teacher Education, University of Jyväskylä, Jyväskylä, Finland

[4] Faculty of Education and Psychology, University of Oulu, Oulu, Finland

[5] Faculty of Education and Culture, Tampere University, Tampere, Finland