

# Modeling the relationship between pre-service teachers' TPACK and digital nativity

Isil Kabakci Yurdakul<sup>1,2</sup>

Published online: 26 October 2017

© Association for Educational Communications and Technology 2017

**Abstract** The purpose of this study is to build a structural equation model that predicts the relationship between Technological Pedagogical Content Knowledge (TPACK) competencies and digital nativity. The data was collected from 1493 Turkish pre-service teachers. Two instruments were used in the data collection; a TPACK-deep scale and a Turkish adaptation of the Digital Native Assessment Scale (DNAS). Structural equation modeling (SEM) was conducted to investigate the assumption that digital nativity was a predictor of TPACK competency. It was found that pre-service teachers considered themselves to have high-level ability in both digital nativity and TPACK competency. The most prominent finding of the study was that digital nativity is a significant predictor of TPACK competency. Based on the research findings, implications for practice and suggestions for future studies are also provided.

**Keywords** TPACK · TPACK-deep · Digital nativity · DNAS · Pre-service teachers

## Introduction

'Digital natives' is a frequent term used to define recent generations of individuals. According to Prensky (2001), digital natives are individuals who were born after 1980, with ability at using digital technologies such as computers, mobile devices, and the Internet. Some researchers base their description of digital natives on such variables as the availability of technology and the breadth of its use, prior experience, self-efficacy and

---

✉ Isil Kabakci Yurdakul  
isilk@anadolu.edu.tr

<sup>1</sup> Department of Computer Education and Instructional Technologies, Anadolu University, Eskisehir, Turkey

<sup>2</sup> Egitim Fakultesi, BOTE Bolu Yunus Emre Kampusu, Anadolu Universitesi, 26470 Eskisehir, Turkey

education (Bennett et al. 2008; Brown and Czerniewicz 2010; Helsper and Eynon 2010; Ng 2012; Tapscott 1998).

Individuals of the digital native generation have advanced skills and knowledge concerning information and communication technologies. In addition, among the attributes of this generation is their ability to integrate the Internet into their lives in all aspects, regardless of their ages and backgrounds. Depending on definitions and statements in the related literature, the overall characteristics of digital native individuals can be summarized as follows: reaching a series of new technologies; carrying out multiple tasks and processes simultaneously; using technologies with ease; using the Internet as their primary source of information; accessing information quickly through multiple media sources; and using the Internet for learning as well as more general activities (Bennett et al. 2008; Helsper and Eynon 2010; Toledo 2007).

Considering the aforementioned digital nativity definitions and traits, it is reasonable to regard the current generation of pre-service teachers as digital natives. The literature suggests that pre-service teachers access digital media outlets more often, spend more time on online activities, and stay connected with different technologies. Consequently, this statement is in line with the common assumption that today's pre-service teachers are digital natives (Southall 2012).

## Theoretical background

Multiple studies have attempted to explain the characteristics of digital nativity specifically through the use of technology (Cameron 2005; Jones et al. 2010; Lei 2009; Li and Ranieri 2010; Sánchez et al. 2011; Margaryan et al. 2011; Thinyane 2010; Thompson 2013). Researchers have also employed variables of digital literacy (Li and Ranieri 2010; Ng 2012; Thompson 2013) and technology use (Kennedy et al. 2008; Lei 2009; Margaryan et al. 2011; Nagler and Ebner 2009; Ng 2012) in their investigations. Despite such attempts to define and explain digital nativity through technology use parameters, few studies have aimed to establish a sound digital nativity structure. In this respect, Teo's (2013) digital nativity framework, based on his Digital Nativity Assessment Scale (DNAS), is among the first constructs to cover digital nativity.

In Teo's (2013) four-factor structure, digital nativity consists of four dimensions; (1) GrewT- grew up with technology, (2) ComfortM- comfortable with multitasking, (3) ReliantG- reliant on graphics for communication, and (4) InstantGR- thrive on instant gratification and rewards.

The GrewT (grew up with technology) factor aims at individuals surrounded by and interacting with technologies and media, such as cell phones, social networks, gaming, instant messaging, texting and smart phones as they grow up. The ComfortM (comfortable with multitasking) factor means that digital natives are able to handle more than one task simultaneously as they use technology. For example, digital natives can use multiple computer applications at the same time to accomplish various tasks. The ReliantG (reliant on graphics for communication) factor represents digital natives' tendency to employ graphical means in communication processes. Lastly, the InstantGR (thrive on instant gratification and rewards) factor indicates that digital natives strive for instant feedback when they communicate with others and access information (Teo 2013; Teo et al. 2014).

This four-factor structure of digital nativity brings about a different perspective to digital nativity research and lays the foundations for future studies. In one study employing

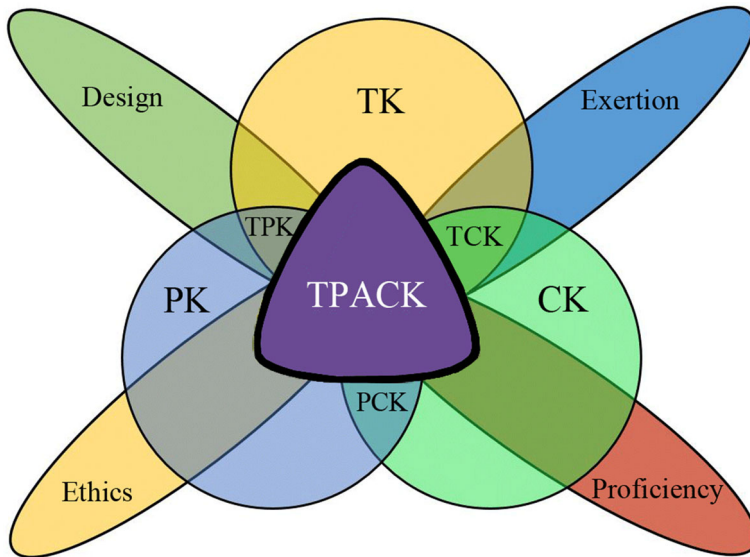
this framework, it was found that the majority of pre-service teachers regard themselves as digital natives (Teo et al. 2014). This result not only reflects pre-service teachers' self-perceptions, but also indicates that technology is a regular part of their daily routines. This situation raises the question of whether pre-service teachers' digital nativity and knowledge of technology integration are related. Other researchers also pose this question and call for research to close this gap in the educational technology literature (Oh and Reeves 2014a, b; Pierson and Cozart 2004; Southall 2012).

Educational technology researchers have developed a wide range of frameworks to assess technology integration practices, including Technological Pedagogical Content Knowledge (TPACK). TPACK is often utilized to examine pre-service teachers' technology integration knowledge. TPACK covers the entire technology integration process while emphasizing teachers' knowledge, skills, and competencies, which makes it a pedagogy-centered model of technology integration. TPACK emerged as an extension of Shulman's (1986) pedagogical content knowledge (PCK) framework by adding technology knowledge to the domain. The main components of the model are content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK). Content knowledge refers to the subject-matter knowledge a teacher possesses. Pedagogical knowledge embodies knowledge and skills required to plan, implement, and evaluate instructional events. Technological knowledge covers a teacher's ability to use a variety of hardware, software, and systems, such as tablet computers, mobile devices, interactive whiteboards, presentation software (e.g.; Prezi), and social media sites (e.g.; Facebook and Twitter).

The combinations and intersections of these components constitute the subcomponents; Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK) and TPACK (Koehler and Mishra 2005, 2009; Mishra and Koehler 2006). To elaborate, PCK guides a teacher when selecting an appropriate instructional method to teach a concept. TCK covers using technology to keep up with recent developments in a content area. TPK refers to employing technology in instructional processes, such as using a learning management system to carry out instructional activities. As TPACK is the intersection of these knowledge types, teachers need to be well-versed in all of them to achieve effective technology integration. For example, assessing student achievement in a topic through a process involving computer simulations would require knowledge of all TPACK components.

There exist various structures that aim to define and elaborate TPACK in the literature. Examples of such structures include ICT-TPACK (Angeli and Valanides 2009), TPCK-W (Technological Pedagogical Content Knowledge-Web) (Lee and Tsai 2010), TPASK (Technological Pedagogical Science Knowledge) (Jimoyiannis 2010), TPCK-SRL (Kohen and Kramarski 2012) that focuses on teachers' self-regulated learning (SRL), TPACK-S (Saengbanchong et al. 2014) that emphasizes student knowledge (SK), TPACK-in-Action model (Koh et al. 2014), TPACK-Practical (Yeh et al. 2014) and Technological Pedagogical Content Knowledge Self-Efficacy (TPACK-SeS) (Bilici et al. 2013). TPACK-deep is one of the structures and its distinguishing factor is its emphasis on the TPACK sub-component. The TPACK-deep structure is shown in Fig. 1 (Kabakci Yurdakul et al. 2012).

The TPACK-deep scale has a four-factor structure. These factors are design, exertion, ethics, and proficiency. The design factor covers designing and developing ICT-supported teaching and learning processes to improve learning. The exertion factor covers the ability to select and use appropriate technologies in various teaching tasks, ranging from planning to evaluation. The ethics factor refers to the demonstration of legal and ethical behavior regarding the use of ICT in the teaching and learning processes. The proficiency factor covers leadership skills in the process of integration of technological resources into the



**Fig. 1** The framework of TPACK-deep

teaching (Kabakci Yurdakul and Çoklar 2014; Kabakci Yurdakul et al. 2012). Taken together, the TPACK-deep framework serves as a tool for the examination of the technology integration competencies of pre-service teachers.

Studies are being conducted to elucidate TPACK and identify influential factors using either TPACK-deep or other TPACK variants. The results, in general, indicate that pre-service teachers' TPACK competencies have direct positive relationships with technology use (TU) and technology knowledge (TK) (Archambault and Barnett 2010; Chai et al. 2010; Chai et al. 2011; Chai et al. 2013; Kabakci Yurdakul and Çoklar 2014; Koh et al. 2013). In addition, there exist correlational studies that investigate relationships among TPACK components (TK, CK, PK, TCK, PCK, PTK). There are also studies focusing on different aspects of TPACK. For example, Blau et al. (2014) investigated teachers' TPACK and digital wisdom development simultaneously and found that the concepts overlap. Similarly, Shamir-Inbal and Blau (2016) maintain that teachers' TPACK and digital wisdom development should be supported to maximize the potential impact of technology on learning outcomes. An investigation of the interplay between TPACK and digital nativity is likely to contribute to effective technology integration practices. Such an investigation would also result in a more detailed understanding of digital

The purpose of this study is to identify the relationship of preservice teachers' TPACK competencies and digital nativity level. In line with the purpose, the following hypothesis is formed:

**Hypothesis** Pre-service teachers' digital nativity is a significant predictor of their TPACK competencies.

## Methodology

### Participants

Turkey consists of seven geographical regions with distinct economic and cultural features. To create a representative sample, a cluster sampling approach was employed to randomly choose two state universities from each region. Upon receiving approval from the institutional review boards of the chosen universities, pre-service teachers in all degree programs were invited to participate. A total of 1493 pre-service teachers volunteered for the study from 14 different teacher training institutions. Participant demographics are provided in Table 1.

In geographical terms, Turkey is made up of seven different regions that differ from one another with respect to economic and cultural factors. Thus, the teacher training institutions were selected on a random basis from seven different universities, each found in one geographical region.

As seen in Table 1, 72.6% of the participants were female and 27.2% were male. With regard to experience of computers and the Internet, the majority of the participants had 5–10 years of experience in computer use (69.3%) and 5–10 years of experience in Internet use (66.3%). Most of the participating pre-service teachers (48%) reported using the Internet 1–3 h daily. They were followed by others whose daily Internet use habits were 3–5 h (19.9%) and up to 1 h (21%).

### Instruments

In this study, two data collection instruments are used. They are TPACK-deep scale and a Turkish adaptation of the Digital Native Assessment Scale (DNAS).

**Table 1** Demographic backgrounds of the participants

Variables	n	Percentage (%)
Gender		
Female	1086	72.6
Male	407	27.2
Computer use experience <sup>a</sup>		
Up to 5 years	225	15.2
5–10 years	1024	69.3
11 and up	229	15.5
Internet use experience <sup>a</sup>		
Up to 5 years	425	28.9
5–10 years	974	66.3
11 and up	70	4.7
Daily internet use <sup>a</sup>		
None	4	0.3
1 h or less	295	21
1–3 h	685	48
3–5 h	284	19.9
5 h and up	138	9.8

<sup>a</sup>Some participants refused to provide details

### *TPACK-deep scale*

The TPACK-deep scale developed by Kabakci Yurdakul et al. (2012) was used to assess pre-service teachers' TPACK competency. The scale was developed in two phases involving exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). The participants were 995 Turkish pre-service teachers, 498 of whom contributed to EFA and 497 contributed to CFA. The TPACK-deep scale consists of 33 items and 4 factors. The factors are design, exertion, ethics and proficiency (Kabakci Yurdakul et al. 2012). Sample items from the scale are shown in Table 2. Overall Cronbach's alpha coefficient for the scale was .95. The Test–retest reliability of the coefficient of the scale was calculated as .80 (Kabakci Yurdakul et al. 2012).

The level of TPACK competencies were interpreted as low, medium, and high based on the subscale mean score ranges of '1.00–3.00', '3.01–5.00', and '5.01–7.00', respectively.

### *Digital Native Assessment Scale (DNAS)*

The second data collection instrument of the study is the Turkish version of Teo's (2013) Digital Native Assessment Scale (DNAS). Teo et al. (2014) conducted the scale's Turkish adaptation study with 557 Turkish pre-service teachers and employed confirmatory factor analysis and multiple indicators, multiple causes modeling methods. The resulting Turkish adaptation exhibited a factor structure similar to the original. The scale is comprised of 21 items and 4 factors and uses a 7-point Likert scale for items. The factors of the scale are (a) grew up with technology, (b) comfortable with multitasking, (c) reliant on graphics for communication, and (d) thrive on instant gratifications and rewards (Teo et al. 2014). Sample items for each factor are provided in Table 3 (Teo 2013).

**Table 2** Sample items from the TPACK-deep scale

TPACK-deep scale factors	Sample items
Design	I can develop appropriate assessment tools by using technology
	I can organize the educational environment in an appropriate way to use technology
Exertion	I can use technology-based communication tools (blog, forum, chat, e-mail, etc.) in the teaching process
	I can use innovative technologies (Facebook, blogs, twitter, podcasting, etc.) to support the teaching and learning process
Ethics	I can provide guidance to students by leading them to valid and reliable digital sources
	I can behave ethically regarding the appropriate use of technology in educational environments
Proficiency	I can become a leader in spreading the use of technological innovations in my future teaching community
	I can use technology to find solutions to problems (structuring, updating and relating the content to real life, etc.)

**Table 3** Sample items for DNAS Scale's factors

Factors of DNAS scale	Sample items
Grew up with technology	I use the internet every day I use computers for many things in my daily life
Comfortable with multi-tasking	When using the internet for my work, I am able to listen to music as well I am able to communicate with my friends and do my work at the same time
Reliant on graphics for communication	I use pictures more than words when I wish to explain something I prefer to receive messages with graphics and icons
Thrive on instant gratifications and rewards	When I send out an email, I expect a quick reply I expect the websites that I visit regularly to be constantly updated

## Data analysis

Descriptive statistics were used to determine the participants' digital nativity levels and TPACK competency levels. Based on the data collected, reliability coefficients for the TPACK-deep and the DNAS were calculated. The Cronbach's alpha values confirmed the reliability of the instruments, and values were .969 and .916 respectively. The relationship between digital nativity and TPACK competencies was examined through correlational methods. In addition, a structural equation model (SEM) was developed and maximum likelihood estimation path analysis applied to investigate whether digital nativity is a significant determinant of the TPACK competency level. In SEM, model fit should be examined using multiple fit indices (Arbuckle 2009; Blunch 2008). The model's fit to the data was tested with Chi square goodness of fit ( $\chi^2/sd$ ), root mean square error of approximation (RMSEA), normed fit index (NFI), Tucker-Lewis index (TLI), and comparative fit index (CFI). IBM SPSS (Statistical Package for Social Sciences) 21 was utilized to calculate descriptive statistics and correlations, and AMOS (Analysis of Moment Structures) 16 was employed to run the structural equation model analysis. The significance level was set to .01 for all analyses.

## Findings and results

### Pre-service teachers' digital nativity levels and TPACK competencies

The mean scores for the participants' digital nativity levels and TPACK competency levels are provided in Table 4. The overall mean score for digital nativity was 5.25. As to digital nativity dimensions, the highest means belonged to 'thrive on instant gratifications and rewards' ( $M = 5.40$ ), 'comfortable with multitasking' ( $M = 5.37$ ), and 'grew up with technology' ( $M = 5.32$ ). On the other hand, the 'reliant on graphics for communication' factor received the lowest mean score of 4.74.

The participants' overall TPACK competency mean score was 5.27. Ethics was the factor with the highest mean score ( $M = 5.45$ ), whereas proficiency had the lowest mean

**Table 4** Mean and standard deviations for DNAS and TPACK-deep scale

	General (n = 1493)			General (n = 1493)	
	$\bar{X}$	SD		$\bar{X}$	SD
DNAS Factors			TPACK-deep Factors		
GrewT	5.32	1.34	Design	5.20	1.00
ComfortM	5.37	1.32	Exertion	5.37	.98
ReliantG	4.74	1.34	Ethics	5.45	1.04
InstantGR	5.40	1.09	Proficiency	4.95	1.16
Digital Nativity	5.25	1.01	TPACK-deep	5.27	.92

( $M = 4.95$ ). Table 5 demonstrates the statistical values and the correlations among the factors of the TPACK-deep scale and DNAS.

As seen in Table 5, there are significant correlations between each pair of factors of the TPACK-deep scale. The correlation coefficients range from .64 to .95. As to the correlations between individual factors and overall scale scores, the exertion factor shows the highest correlation ( $r = .95$ ) and the ethics factor shows the lowest correlation ( $r = .82$ ). Moreover, the correlation between the overall mean scores of TPACK-deep scale and DNAS is .47 and significant at level .01. Individual DNAS factors significantly correlate with the overall TPACK-deep mean score ( $p < .01$ ) in varying degrees, ranging from  $r = .27$  to  $r = .45$ . Likewise, DNAS overall score significantly correlates with individual TPACK-deep factors, ranging from .32 to .49. Hence, it is safe to say that there is a significant relationship between TPACK competencies and digital nativity level.

### Digital nativity level as a predictor of TPACK competency

A structural equation model was generated using AMOS 16.0 software to test whether digital nativity was a determinant of TPACK-deep. Structural equation modeling (SEM) is a method used to analyze interrelationships among variables, and commonly-used in social sciences (Bollen 2002). According to Kline (2005), SEM is a method used to determine relationships between a scale and the independent variables hypothesized to influence the scale. The degree of fit among latent, exogenous (predictor/independent), and endogenous (outcome/dependent) variables is assessed through various fit indices and the decision regarding the models' acceptance or rejection is based on fit statistics (Schumacker and Lomax 2010). In this study, all factors within the TPACK-deep scale and DNAS are exogenous latent variables that aim to predict the endogenous latent variables of TPACK competency and digital nativity level. In this context, the structural equation model shown in Fig. 2 was generated to test whether the four-factor digital nativity scale is a determinant of the four-factor TPACK-deep scale.

In compliance with Blunch's (2008) suggestion, the models' fit was examined through multiple fit indices. Table 6 illustrates various fit statistics for the model and acceptable value ranges.

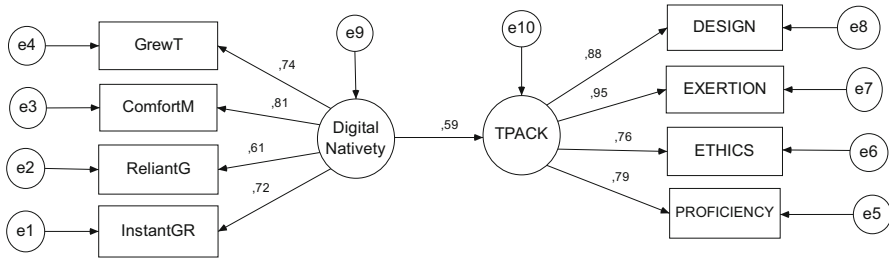
As seen in Table 6, adjusted Chi square ( $\chi^2/df$ ), CFI, TLI, NFI and RMSEA fit indices are examined. The model shows an acceptable or better fit in all indices except for the adjusted Chi square index. Specifically, the model fit values of CFI = .982, TLI = .967



**Table 5** Summary statistics and correlations among the research variables for the total sample (n = 1493)

Variables	TPACK-deep scale				DNAS					
	Design	Exertion	Ethics	Proficiency	TPACK General	GrewT	ComfortM	ReliantG	InstantGR	DNAS General
Design	1.00	.83*	.66*	.70*	.92*	.37*	.40*	.25*	.39*	.43*
Exertion		1.00	.73*	.74*	.95*	.41*	.46*	.29*	.45*	.49*
Ethics			1.00	.64*	.82*	.27*	.29*	.17*	.38*	.32*
Proficiency				1.00	.84*	.33*	.36*	.24*	.37*	.41*
TPACK-Deep					1.00	.40*	.43*	.27*	.45*	.47*

\* p < .01



**Fig. 2** The structural equation model showing interrelations of TPACK-deep scale and DNAS

**Table 6** The fit indices for the structural equation model and the values obtained in the model (n = 1493)

Fit statistics	Fit value for the model	Acceptable fit	Cut off points	Excellent fit	Explanation
$\chi^2/df$	7.180*	$\leq 5$	$\leq 4$ to 5	$\leq 3$	–
CFI	0.982	0.95–0.96	$\geq 0.97$	$\geq 0.97$	Good model
TLI	0.967	0.94–0.90	$\geq 0.95$	$\geq 0.95$	Good model
NFI	0.980	0.94–0.90	$\geq 0.95$	$\geq 0.95$	Good model
RMSEA	0.064	0.06–0.08	$\leq 0.08$	$\leq 0.05$	Good enough model

and NFI = .980 indicate an excellent fit and RMSEA = .064 indicates an acceptable fit. The situation regarding the Chi square value can be explained by the statistics’ inherent sensitivity to sample size. According to Blunch (2008), Chi square statistics tend to fall out of an acceptable range for relatively large samples. Considering the large sample of the present study (n = 1493), and acceptable fit statistics from the remaining indices, the out-of-range adjusted Chi square statistics ( $\chi^2 = 136.411$ ;  $df = 19$ ;  $p > .01$ ) do not constitute a significant source of concern regarding model fit.

In a follow-up, a regression analysis was run to test whether digital nativity level was a significant predictor of TPACK competency. The analysis of standardized regression weights imply a significant relationship between the variables ( $\beta = 0.59$ ;  $p < 0.01$ ). More specifically, one standard deviation increase in digital nativity level leads to an increase in TPACK competence by .59 standard deviations. This finding is in line with the study’s hypothesis that pre-service teachers’ perceived TPACK competencies increase as their digital nativity level increases.

### Discussion

In this study, pre-service teachers’ digital nativity levels and TPACK competencies are examined considering the relationship between the two. First, it has been identified that the participating pre-service teachers regard themselves as high-level digital natives. This finding is in parallel with the pre-service teachers’ self-perception in Teo et al. (2014) study and Southall’s (2012) assertion that today’s pre-service teachers are digital natives. The participants of the study had a high-level of digital nativity in the dimensions of *grew*

up with technology, comfortable with multitasking, and thrive on instant gratifications and rewards, whereas they had a medium-level of digital nativity in the *reliant on graphics for communication* dimension. This finding shows similarities to digital native traits such as rapidly accessing online information (Thompson 2013), and simultaneously carrying out multiple tasks and processes (Bennett et al. 2008; Helsper and Eynon 2010; Prensky 2001; Toledo 2007).

The participants also regarded themselves as highly competent in TPACK. Consequently, the pre-service teachers show a high-level of competence in the design, exertion, and ethics dimensions, and a medium-level of competence in the proficiency dimension. These findings comply with other studies that report pre-service and in-service teachers' perceptions of high-level TPACK competence (Archambault and Crippen 2009; Kabakçı Yurdakul 2011; Kavanoz et al. 2015; Yeh et al. 2014). The findings are also supportive of studies reporting pre-service teachers' positive attitudes towards technology integration (Abbitt 2011; Rehmat and Bailey 2014; Hughes 2013; Spaulding and Martin 2013).

A major finding of the study is the significant correlation between TPACK competence and digital nativity level ( $r = .47, p < .01$ ). Moreover, the design, exertion, ethics, and proficiency dimensions of the TPACK-deep scale correlate with the digital nativity level in varying degrees ranging from .32 to .49. These medium-level correlations are also indicators of an important relationship between the two concepts. A structural equation model was formed based on correlations between TPACK competencies and digital nativity dimensions. The model confirms the hypothesis that digital nativity is a significant predictor of TPACK competency. Therefore, a noteworthy improvement in TPACK competency can be achieved as a consequence of an increased digital nativity level.

The present study identifies a positive relationship between pre-service teachers' digital nativity and perceived TPACK competencies. Similarly, Bang and Luft (2013), report that new science teachers showing digital native traits are also successful at effective technology use in the classroom. In other studies, to the contrary, neither teachers' digital nativity nor their digital immigrant status are found to significantly relate to their technology use during instructional activities (Weller 2011). In addition, reports from the educational technology integration maintain that pre-service teachers have limited knowledge and skills to integrate technology into educational practices despite their digital native traits (Kumar and Vigil 2011; Lei 2009; Li et al. 2015; Southall 2012). Similarly, certain studies indicate a gap between digital native pre-service teachers' technology skills and their knowledge of effective technology integration (Li et al. 2015). Pre-service teachers' inexperience in actual classroom practice may be a cause of this discrepancy of skills. Moreover, mixed results from the literature suggest that technology use by itself is not enough to determine digital nativity.

## Conclusion and recommendations

There is a shift in the research literature that aims to model TPACK in terms of diverse variables. Consequently, a need emerges for studies identifying variables that influence TPACK. As to digital nativity, most studies focus on defining the concept through different variables, yet the literature points out that empirical research is still needed to create more detailed accounts of the digital natives phenomenon (Bennett and Maton 2010; Bennett et al. 2008; Eynon 2010; Hargittai 2010; Helsper and Eynon 2010; Jones and Healing 2010; Kennedy et al. 2008; Kirschner and van Merriënboer 2013). The present study aims

to alleviate these gaps by employing a structural equation model that includes both concepts and predicts the relationship between them.

The findings show that pre-service teachers perceive themselves as high-level digital natives and highly competent in all TPACK dimensions. Another important finding of the study is the identification of digital nativity as a significant predictor of TPACK competence. This indicates that an increase in digital nativity level would probably result in an increase in perceived competency in TPACK. In other words, pre-service teachers' technology use on a daily basis may reflect in their professional lives as well. Nonetheless, teacher training processes should not rely merely on daily technology use. Rather, they should transcend daily technology-based activities by improving digital native skills likely to aid educational technology integration (e.g., multitasking, effective visual communication, and information search strategies). To do so, teaching practice courses could be remodeled in a way that encourages the utilization of digital native skills and technological pedagogical knowledge within authentic learning environments. Similarly, the extant literature suggests that ICT-based lessons, technology-rich instructional materials, content-specific, as well as content-general technology integration courses, are an effective means of improving pre-service teachers' technology knowledge and TPACK competence (Habowski and Mouza 2014; Maeng et al. 2013; Ottenbreit-Leftwich 2012; Polly et al. 2010; Shinas et al. 2015). Therefore, pre-service teachers' digital nativity development would benefit their technology integration skill development. In this respect, this study provides a TPACK and digital nativity perspective to technology integration research.

However, a number of limitations exist in the study. The data was collected using the Turkish adaptation of DNAS (Teo et al. 2014) and the TPACK-deep scale developed by Kabakci Yurdakul et al. (2012). Therefore, the knowledge base on the topic can be extended by comparing this study's findings with future studies employing other scales and structures. Moreover, this study employs only self-report data collection instruments. Future studies may collect data from different populations through other means, so that the effect of the participants' backgrounds can also be investigated.

This study investigates TPACK-deep and digital nativity variables with pre-service teacher participants. A replication with in-service teachers would add to researchers' ability to generalize the results to different target populations. The inclusion of new variables (e.g., digital accuracy, digital wisdom, and digital learning style) stemming from different scientific perspectives would also contribute to more detailed modeling studies on TPACK and digital nativity. Finally, this study employed structural equation modelling as the main means of analysis. Future studies could employ multilevel approaches so that the variance due to the differences among pre-service teachers from different institutions can also be accounted.

#### Compliance with ethical standards

**Conflict of interest** The author declares that they have no conflict of interest.

## References

- Abbitt, J. T. (2011). An investigation of the relationship between self-efficacy beliefs about technology integration and technological pedagogical content knowledge (TPACK) among preservice teachers. *Journal of Digital Learning in Teacher Education*, 27(4), 134–143.
- Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT-TPCK: Advances in technological pedagogical content knowledge (TPCK). *Computers & Education*, 52(1), 154–168.

- Arbuckle, J. L. (2009). *Amos 18.0 user's reference guide*. Chicago, IL: SPSS, Inc.
- Archambault, L. M., & Barnett, J. H. (2010). Revisiting technological pedagogical content knowledge: Exploring the TPACK framework. *Computers & Education*, 55(4), 1656–1662.
- Archambault, L., & Crippen, K. (2009). Examining TPACK among K-12 online distance educators in the United States. *Contemporary Issues in Technology and Teacher Education*, 9(1), 71–88.
- Bang, E., & Luft, J. A. (2013). Secondary science teachers' use of technology in the classroom during their first 5 years. *Journal of Digital Learning in Teacher Education*, 29(4), 118–126.
- Bennett, S., & Maton, K. (2010). Beyond the 'digital natives' debate: Towards a more nuanced understanding of students' technology experiences. *Journal of Computer Assisted Learning*, 26, 321–331.
- Bennett, S., Maton, K., & Kervin, L. (2008). The 'digital natives' debate: a critical review of the evidence. *British Journal of Educational Technology*, 39(5), 775–786.
- Bilici, S. C., Yamak, H., Kavak, N., & Guzey, S. S. (2013). Technological pedagogical content knowledge self-efficacy scale (TPACK-SeS) for pre-service science teachers: Construction, validation, and reliability. *Eurasian Journal of Educational Research*, 52, 37–60.
- Blau, I., Peled, Y., & Nusan, A. (2014). Technological, pedagogical and content knowledge in one-to-one classroom: teachers developing "digital wisdom". *Interactive Learning Environments*, 24(6), 1215–1230.
- Blunch, N. J. (2008). *Introduction to structural equation modeling using SPSS and AMOS*. Los Angeles: SAGE.
- Bollen, K. A. (2002). Latent variables in psychology and the social sciences. *Ann Rev Psychol.*, 53(1), 605–634.
- Brown, C., & Czerniewicz, L. (2010). Debunking the 'digital native': Beyond digital apartheid, towards digital democracy. *Journal of Computer Assisted Learning*, 26(5), 357–369.
- Cameron, D. (2005). The net generation goes to university? Online Submission. Retrieved from <http://files.eric.ed.gov/fulltext/ED496135.pdf>.
- Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2010). Facilitating preservice teachers' development of technological, pedagogical, and content knowledge (TPACK). *Educational Technology & Society*, 13(4), 63–73.
- Chai, C. S., Koh, J. H. L., Tsai, C., & Tan, L. L. W. (2011). Modeling primary school pre-service teachers' technological pedagogical content knowledge (TPACK) for meaningful learning with information and communication technology (ICT). *Computers & Education*, 57(1), 1184–1193.
- Chai, C. S., Ng, E. M. W., Li, W., Hong, H. Y., & Koh, J. H. L. (2013). Validating and modelling technological pedagogical content knowledge framework among Asian preservice teachers. *Australasian Journal of Educational Technology*, 29(1), 41–53.
- Eynon, R. (2010). Supporting the "Digital Natives": What is the role of schools? In L. Dirckinck-Holmfeld (Ed.), 7th International Conference on Networked Learning, pp. 851–858.
- Habowski, T., & Mouza, C. (2014). Pre-service teachers' development of technological pedagogical content knowledge (TPACK) in the context of a secondary science teacher education program. *Journal of Technology and Teacher Education*, 22(4), 471–495.
- Hargittai, E. (2010). Digital Na(t)ives? Variation in internet skills and uses among members of the 'net generation'. *Sociological Inquiry*, 80, 92–113.
- Helsper, E., & Eynon, R. (2010). Digital natives: where is the evidence? *British Educational Research Journal*, 36(3), 503–520.
- Hughes, J. E. (2013). Descriptive indicators of future teachers' technology integration in the PK-12 classroom: Trends from a laptop-infused teacher education program. *Journal of Educational Computing Research*, 48(4), 491–516.
- Jimoyiannis, A. (2010). Designing and implementing an integrated technological pedagogical science knowledge framework for science teachers' professional development. *Computers & Education*, 55(3), 1259–1269.
- Jones, C., & Healing, G. (2010). Net generation students: agency and choice and the new technologies. *Journal of Computer Assisted Learning*, 26(5), 344–356.
- Jones, C., Ramanau, R., Cross, S., & Healing, G. (2010). Net generation or digital natives: Is there a distinct new generation entering university? *Computers & Education*, 54(3), 722–732.
- Kabakçı Yurdakul, I. (2011). Examining techno pedagogical knowledge competencies of preservice teachers based on ICT usage. *Hacettepe University Journal of Education*, 40, 397–408.
- Kabakci Yurdakul, I., & Çoklar, A. N. (2014). Modeling preservice teachers' TPACK competencies based on ICT usage. *Journal of Computer Assisted Learning*, 30(4), 363–376.
- Kabakci Yurdakul, I., Odabasi, H. F., Kilicer, K., Coklar, A. N., Birinci, G., & Kurt, A. A. (2012). The development, validity and reliability of TPACK-deep: A Technological Pedagogical Content Knowledge scale. *Computers & Education*, 58(3), 964–977.

- Kavanoz, S., Yüksel, H. G., & Özcan, E. (2015). Pre-service teachers' self-efficacy perceptions on Web Pedagogical Content Knowledge. *Computers & Education*, 85, 94–101.
- Kennedy, G. E., Judd, T. S., Churchward, A., Gray, K., & Krause, K.-L. (2008). First year students' experiences with technology: are they really digital natives? *Australasian Journal of Educational Technology*, 24(1), 108–122.
- Kirschner, P. A., & van Merriënboer, J. J. G. (2013). Do learners really know best? *Urban Legends in Education. Educational Psychologist*, 48(3), 169–183.
- Kline, R. B. (2005). *Principles and practice of structural equation modeling* (2nd ed.). New York: The Guilford Press.
- Koehler, M. J., & Mishra, P. (2005). What happens when teachers design educational technology? The development of technological pedagogical content knowledge. *Journal of Educational Computing Research*, 32(2), 131–152.
- Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education*, 9(1), 60–70.
- Koh, J. H. L., Chai, C. S., & Tay, L. Y. (2014). TPACK-in-action: Unpacking the contextual influences of teachers' construction of technological pedagogical content knowledge (TPACK). *Computers & Education*, 78, 20–29.
- Koh, J. H. L., Chai, C. S., & Tsai, C. C. (2013). Examining practicing teachers' perceptions of technological pedagogical content knowledge (TPACK) pathways: A structural equation modeling approach. *Instructional Science*, 41(4), 793–809.
- Kohen, Z., & Kramarski, B. (2012). Developing a TPCK-SRL assessment scheme for conceptually advancing technology in education. *Studies in Educational Evaluation*, 38(1), 1–8.
- Kumar, S., & Vigil, K. (2011). The net generation as preservice teachers: Transferring familiarity with new technologies to educational environments. *Journal of Digital Learning in Teacher Education*, 27(4), 144–153.
- Lee, M. H., & Tsai, C. C. (2010). Exploring teachers' perceived self-efficacy and technological pedagogical content knowledge with respect to educational use of the World Wide Web. *Instructional Science*, 38(1), 1–21.
- Lei, J. (2009). Digital natives as preservice teachers: what technology preparation is needed? *Journal of Computing in Teacher Education*, 25(3), 87–97.
- Li, Y., & Ranieri, M. (2010). Are 'digital natives' really digitally competent? A study on Chinese teenagers. *British Journal of Educational Technology*, 41(6), 1029–1042.
- Li, L., Worch, E., Zhou, Y., & Aguiton, R. (2015). How and why digital generation teachers use technology in the classroom: An explanatory sequential mixed methods study. *International Journal for the Scholarship of Teaching and Learning*, 9(2), 9.
- Maeng, J. L., Mulvey, B. K., Smetana, L. K., & Bell, R. L. (2013). Preservice teachers' TPACK: Using technology to support inquiry instruction. *Journal of Science Education and Technology*, 22(6), 838–857.
- Margaryan, A., Littlejohn, A., & Vojt, G. (2011). Are digital natives a myth or reality? University students' use of digital technologies. *Computers & Education*, 56(2), 429–440.
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017–1054.
- Nagler, W., & Ebner, M. (2009). Is your university ready for the ne (x) t-generation? In EdMedia: World Conference on Educational Media and Technology. Association for the Advancement of Computing in Education (AACE), pp. 4344–4351.
- Ng, W. (2012). Can we teach digital natives digital literacy? *Computers & Education*, 59(3), 1065–1078.
- Oh, E., & Reeves, T. C. (2014a). Generational differences and the integration of technology in learning, instruction, and performance. In D. H. Jonassen (Ed.), *Handbook of research on educational communications and technology*. New York: Springer.
- Oh, E., & Reeves, T. C. (2014b). Generational differences and the integration of technology in learning, instruction, and performance. In D. H. Jonassen (Ed.), *Handbook of research on educational communications and technology* (pp. 819–828). New York: Springer.
- Ottenbreit-Leftwich, A. T. (2012). The importance of using subject-specific technology uses to teach TPACK: a case study. In D. Polly, C. Mims, & K. Perschitte (Eds.), *Creating technology-rich teacher education programs: Key issues* (pp. 152–169). Hershey, PA: IGI Global.
- Pierson, M. E., & Cozart, A. (2004). Case studies of future teachers: Learning to teach with technology. *Journal of Computing in Teacher Education*, 21(2), 59–63.
- Polly, D., Mims, C., Shepherd, C. E., & Inan, F. (2010). Evidence of impact: Transforming teacher education with preparing tomorrow's teachers to teach with technology (PT3) grants. *Teaching and Teacher Education*, 26(4), 863–870.

- Prensky, M. (2001). Digital natives, digital immigrants. *On the Horizon*, 9(5), 1–6.
- Rehmat, A. P., & Bailey, J. M. (2014). Technology integration in a science classroom: Preservice teachers' perceptions. *Journal of Science Education and Technology*, 23(6), 744–755.
- Saengbanchong, V., Wiratchai, N., & Bowarnkitiwong, S. (2014). Validating the technological pedagogical content knowledge appropriate for instructing students (TPACK-S) of pre-service teachers. *Procedia-Social and Behavioral Sciences*, 116, 524–530.
- Sánchez, J., Salinas, A., Contreras, D., & Meyer, E. (2011). Does the new digital generation of learners exist? A qualitative study. *British Journal of Educational Technology*, 42(4), 543–556.
- Schumacker, R. E., & Lomax, R. G. (2010). *A beginner's guide to structural equation modeling* (3rd ed.). New York: Routledge, Taylor & Francis Group.
- Shamir-Inbal, T., & Blau, I. (2016). Developing digital wisdom by students and teachers: the impact of integrating tablet computers on learning and pedagogy in an elementary school. *Journal of Educational Computing Research*, 54(7), 967–996.
- Shinas, V. H., Karchmer-Klein, R., Mouza, C., Yilmaz-Ozden, S., & Glutting, J. (2015). Analyzing pre-service teachers' technological pedagogical content knowledge development in the context of a multidimensional teacher preparation program. *Journal of Digital Learning in Teacher Education*, 31(2), 47–55.
- Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4–14.
- Southall, S. P. (2012). *Digital native preservice teachers: An examination of their self-efficacy beliefs regarding technology integration in classroom settings*. Richmond: Virginia Commonwealth University.
- Spaulding, M., & Martin, T. (2013). Preservice and in-service teachers' perceptions toward technology benefits and integration. *The Journal of Learning in Higher Education*, 9(1), 67–78.
- Tapscott, D. (1998). *Growing up digital: The rise of the net generation* (Vol. 352). New York: McGraw-Hill.
- Teo, T. (2013). An initial development and validation of a Digital Natives Assessment Scale (DNAS). *Computers & Education*, 67, 51–57.
- Teo, T., Kabakci Yurdakul, I., & Ursavaş, Ö. F. (2014). Exploring the digital natives among pre-service teachers in Turkey: A cross-cultural validation of the Digital Native Assessment scale. *Interactive Learning Environments*, 24(6), 1231–1244.
- Thinyan, H. (2010). Are digital natives a world-wide phenomenon? An investigation into South African first year students' use and experience with technology. *Computers & Education*, 55(1), 406–441.
- Thompson, P. (2013). The digital natives as learners: Technology use patterns and approaches to learning. *Computers & Education*, 65, 12–33.
- Toledo, C. A. (2007). Digital culture: immigrants and tourists responding to the natives' drumbeat. *International Journal of Teaching and Learning in Higher Education*, 19(1), 84–92.
- Weller, M. (2011). *The digital scholar: How technology is transforming scholarly practice*. A&C Black.
- Yeh, Y. F., Hsu, Y. S., Wu, H. K., Hwang, F. K., & Lin, T. C. (2014). Developing and validating technological pedagogical content knowledge-practical (TPACK-practical) through the Delphi survey technique. *British Journal of Educational Technology*, 45(4), 707–722.

**Isil Kabakci Yurdakul** is an associate professor in Computer and Instructional Technologies Education Department of Education Faculty, Anadolu University, Eskisehir, Turkey. She received her Ph.D. in Computer and Instructional Technologies Education from Anadolu University, Turkey in 2005. She has articles published in international and national journals, papers presented to international and national meetings, published national books and chapters in international and national books about her academic interest area. She served in various projects as executive and researcher. Her academic interest areas are professional development, information and communication technologies integration, instructional design, internet and the child.