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# Examining technology acceptance of pre-service mathematics teachers in Turkey: A structural equation modeling approach

**Melih Derya Gurer**[1]

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## Abstract

Among teacher beliefs, technology acceptance has a crucial role in effective technology integration into teaching. There is a need to examine the factors affecting future teachers' acceptance of technology in Turkey, where great investments have been made on the dissemination of technology in schools, and great emphasis has been put on the effective use of technology. The purpose of this study was to investigate Turkey's pre-service mathematics teachers' intentions to use technology in their future teaching. Technology Acceptance Model (TAM) was used as a framework and was expanded with different variables, including facilitating conditions, subjective norms, and technology self-efficacy. In this study, the relationships between these variables were examined. Data were collected from 530 pre-service mathematics teachers using a self-reported questionnaire, which explained their intentions to use technology. To test the model, a structural equation modeling approach was used. The results indicated that facilitating conditions, subjective norms, and attitudes toward technology were significant predictors of intention to use technology. Technology self-efficacy significantly determined the perceived ease of use. Perceived ease of use and perceived usefulness of technology significantly influenced pre-service teachers' attitudes toward technology. Not only technical infrastructure but also technical and design support would be provided in schools to increase pre-service teachers' intention to use technology. In addition, teacher educators would provide learning environments where pre-service teachers experience more with current technology.


**Keywords** Pre-service mathematics teachers · Intention to use technology · Technology acceptance model · Structural equation modeling

✉ Melih Derya Gurer
mdgurer@gmail.com

[1] Department of Computer Education and Instructional Technology, Faculty of Education, Bolu Abant Izzet Baysal University, 14030 Bolu, Turkey

## 1 Introduction

Information and communication technology (ICT) has become popular at all levels of education, and it has been used in many learning environments. In mathematics education, specifically, the National Council of Teachers of Mathematics (NCTM) (2000) has focused on the importance of using technology in mathematics education and asserted that technology may enhance students' learning of mathematics. Barak (2014) states that ICT in mathematics education supports students' visualization, active knowledge construction, and higher-order thinking. ICT can extend students' quality of mathematical investigations and provide authentic environments to learn mathematics. Simulations, calculators, Web applications, mathematical software, and other technologies support students in collecting, recording, organizing, and analyzing data. Digital tools have the potential to facilitate realistic problem-solving and collaborative approaches in mathematics through modeling, visualization, manipulation, and the introduction of more complex scenarios (Bray & Tangney, 2017; ter Vrugte et al., 2015). Additionally, Tan and Hew (2019) indicated that students' use of technology at home, especially its use for learning, is a strong predictor of their math performance.

Many countries and organizations have invested in equipping schools with current technologies, training their teachers, and providing digital learning tools. However, teachers have not yet integrated technology into their teaching successfully (Tondeur et al., 2017). Notably, it was found that mathematics teachers have used technology less frequently than science and language teachers (Tas & Balgalmis, 2016). Joubert (2013) claimed that teachers' attitudes, their learning of the uptake of technology, and changes in mathematics education due to technology have led to the underuse of technology in mathematics classrooms.

Teo & Milutinovic (2015) claimed that teachers' technology acceptance determines the degree of technology uptake for teaching. Researchers identified different models to explain the factors influencing individuals' technology acceptance. One of the most well-known and strong theoretical frameworks used to predict the antecedents of information systems (Davis, 1989) is the Technology Acceptance Model (TAM). Although it has roots in the information systems field, it has been tested in education research and proved to an effective model for ascertaining the acceptance of technology among teachers (Teo, 2015). The TAM has often been tested without considering teachers' academic discipline and in developed nations. However, the culture of a nation, the emphasis of organizational policy (McCoy et al., 2007), and nature of the subject-matter influence the uptake or rejection of technology (Mishra & Koehler, 2006). More studies focusing on developing countries, such as Turkey, and subject-matters, such as mathematics education, will deepen the understanding of teachers' technology-related behavior.

Because teachers' skills, knowledge, and beliefs are shaped during their pre-service teacher training, pre-service teachers deserve special attention. To make predictions for future use of technology in classrooms, it is necessary to examine the technology acceptance of pre-service teachers who will work in the Turkish educational context in which great emphasis has been given to technology integration over the last decade. Understanding the factors influencing pre-service teachers' acceptance of technology would also guide teacher educators to foster positive experiences and attitudes to their students.

### 1.1 Aim of the study

Turkey, as a developing country, has made a significant investment in technology in education. Although technology integration studies in the Turkish education system have roots in the 1980s, it has gained great importance with the Movement of Enhancing Opportunities and Improving Technology (FATiH Project) started in 2010 by the Ministry of National Education (MoNE) (Ministry of National Education, 2010). The project includes the distribution of technological tools to classrooms, the delivery of broadband Internet to all classrooms, the development of e-content, the training of teachers in terms of integrating technology into teaching, the creation of web platforms, and project support for content development.

Before the FATiH project, with the 2007 Pre-Service Teacher Education Programmes, two compulsory courses on technology literacy and one compulsory course on instructional design and material development were placed into curriculum of all teacher education programs. In addition, pre-service mathematics teacher education programs offer elective courses on using technology in teaching mathematics. However, the importance given to the technology education and integration has decreased with the 2018 Pre-Service Teacher Education Programmes. With this programme, pre-service mathematics teachers are offered one information technology and one instructional technology courses. In addition, one elective course on computer-based mathematics teaching is presented (Council of Higher Education, 2018). Teachers' knowledge, skills, and beliefs are expected to be shaped at the pre-service teacher education stage. Understanding the factors affecting pre-service teachers' behavioral intention to use technology in a developing country that gives great emphasis on technology integration in recent years would help to make predictions for future use of technology in classrooms. Moreover, understanding the factors influencing the intention to use technology would guide teacher educators and policymakers in designing their courses and the teacher education curriculum.

There are studies explaining pre-service teachers' behavioral intention to use technology in Turkey context (e.g., Baydaş & Yılmaz, 2017; Ibili et al., 2019; Teo et al., 2012). However, some of them focused on specific technologies such as interactive whiteboards (Baydaş & Yılmaz, 2017) and augmented reality (Ibili et al., 2019). Some investigated pre-service teachers' technology integration intentions neglecting the effects of external variables such as subjective norms (Teo et al., 2012). In addition, they have not considered previous literature's findings that nature of subject-matter influences the adoption of technology such as computers and the Internet in schools (Fraillon et al., 2014; Liu et al., 2017). To address this knowledge gap, this study aimed to investigate the antecedents of intention to use technology of Turkey's pre-service mathematics teachers in their future teaching. The aim of the study was guided with the following research questions:

- What is the level of technology acceptance of pre-service mathematics teachers in Turkey?
- To what extent does the proposed model explain pre-service mathematics teachers' intention to use technology in their future teaching?
- Which are the significant antecedents of pre-service mathematics teachers' intention to use technology in their future teaching?

## 2 Literature review and hypothesis testing

### 2.1 Technology acceptance model

An extensive body of literature has interested in the factors related to the integration of technology into teaching from teachers' perspectives. Such theoretical frameworks explaining how individuals perceive and use technology are Theory of Planned Behavior (TPB), Theory of Reasoned Action (TRA), Unified Theory of Acceptance and Use of Technology (UTAUT), and Technology Acceptance Model (TAM). These models have been justified to have good exploratory powers with less number of variables in multiple studies. However, there is a debate about the superiority of the models over each other, and researchers compared the effectiveness of the models to predict user behaviors in similar contexts.

The two most frequently compared models, both theoretically and empirically, in literature regarding technology acceptance are TAM and UTAUT. Both TAM and UTAUT have been used extensively in Management Information Systems (MIS) and education (e.g. Baydas & Goktas, 2017; Rejón-Guardia et al., 2020; Šumak et al., 2011), and many modifications and adaptations of these theories have been proposed over the years. TAM was criticized as having few constructs to explain technology use behavior and lower explanatory power. Experiencing this limitation and basing on the TAM, the UTAUT incorporated additional constructs such as social influence, facilitating conditions, and habit, as well as mediating individual characteristics (age, gender, and experience) (Venkatesh et al., 2003). Although UTAUT has more predictive power than TAM in MIS studies (Venkatesh et al., 2003), its application in the field of education seems not as widespread (Ifenthaler & Schweinbenz, 2016). Limited number of studies (e.g. Birch & Irvine, 2009) have found lower predictive power of UTAUT in education contexts. On the other hand, after investigating 42 studies, Šumak et al. (2011) found the TAM is the most widely-applied theory in e-learning research and asserted that the TAM is a powerful and robust predictive model. Hence, the TAM was taken as the theoretical framework in the present study to determine pre-service mathematics teachers' intentions to use technology.

The TAM originated in the Theory of Reasoned Action (TRA) by Ajzen and Fishbein (1980). It focuses on the relationship between attitudes and behaviors within human action. It also suggests that an individual's behavior is determined by intention to perform the given behavior and this intention is a function of the attitude toward the behavior and subjective norms. According to TRA, there is a high correlation of attitudes and subjective norms to behavioral intention and to behavior. Basing on this notion, to investigate how users come to accept and use a given technology, the TAM was introduced by Davis (1986) and developed further by Davis et al. (1989). The TAM hypothesizes that psychological factors, perceived usefulness and perceived ease of use, are key determinants of user acceptance of technology. It aims to explain the causal relationships among users' perceived usefulness, perceived ease of use, attitude towards, and intention to use technology. Davis et al. (1989, p. 320) described perceived usefulness as "the degree to which a person believes that using a particular system would enhance his or her job performance," and perceived ease of use as "the degree to which a person believes that using a particular system would be free of effort." Behavioral intention to use technology is proposed to be a crucial factor in determining whether technology is actually being used. They claimed that the behavioral intention to use technology is directly affected by the attitude towards technology and indirectly influenced by perceived ease of use and perceived usefulness. In addition, perceived ease of use and perceived usefulness directly and jointly influence attitude towards technology. Finally, the perceived ease of use has a direct effect on perceived usefulness, and perceived usefulness and perceived ease of use can be affected by various external variables (Fig. 1).

From an educational research perspective, perceived usefulness covers teacher beliefs about the contribution of technology to the teaching process. Perceived ease of use refers to the extent to which pre-service teachers are able to use technology free of effort. When teachers perceive that using a specific technology is free of effort, they would perceive it to be useful for teaching and have positive perceptions of using technology. If pre-service teachers think that using technology for teaching enhances student learning and supports their professional development, their benefit from using technology in the classroom will be high. Finally, when teachers have positive perceptions of technology, they tend to use it for teaching.

The results with the TAM have been consistent, and the relationships between the factors have been significant. Legris et al. (2003) concluded that the TAM is an effective model in predicting the determinants of information technology or information system use. The TAM has also been supported in educational environments and shown predictive validity in studies conducted with both in-service (Cigdem & Topcu, 2015; Mac Callum et al., 2014) and pre-service teachers (Teo, 2009; Wong, 2015). Ibili et al. (2019) investigated mathematics teachers' acceptance of augmented reality (AR) application developed to improve secondary school students' 3D geometric thinking skills. After implementing

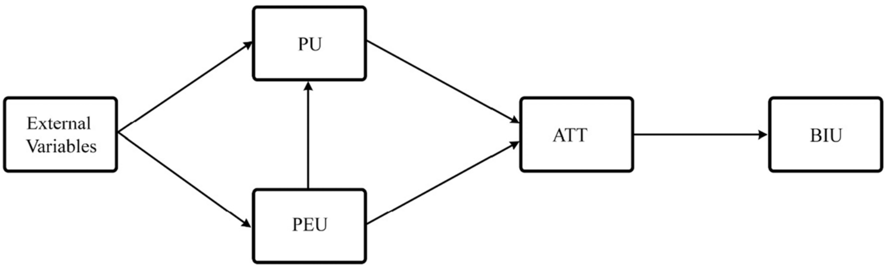


**Fig. 1** Technology acceptance model (Davis et al., 1989)

the AR application in the classroom, 148 mathematics teachers in Turkey stated that they have a high intention to use the application for teaching. Mathematics teachers' intention of using AR in teaching mathematics was significantly influenced by their attitudes towards AR. Moreover, their attitudes towards AR were predicted by perceived usefulness of AR and satisfaction. Teo & Milutinovic (2015) used the TAM to investigate pre-service mathematics teachers' intention to use technology for teaching mathematics. They concluded that pre-service teachers' attitudes towards computers were found to have a direct influence on the intention to use technology. Perceived ease of use and perceived usefulness had direct effects on attitude towards computers. Studying factors that affect mathematics teachers' intentions to use interactive whiteboards in mathematics lessons, DeVita et al. (2012) found that perceived usefulness and attitude towards use have a direct effect on mathematics teachers' behavioral intention to use interactive whiteboards.

Adopting the hypotheses of the TAM for this study, the following hypotheses were constructed:

- H1: Pre-service teachers' perception of easy use will significantly influence their perception of the usefulness of technology for teaching mathematics.
- H2: Pre-service teachers' perception of easy use will significantly influence their attitudes toward technology usage in mathematics teaching.
- H3: Pre-service teachers' perception of the usefulness of technology for teaching will significantly influence their attitudes toward technology usage in mathematics teaching.
- H4: Pre-service teachers' attitudes toward technology usage in teaching mathematics will significantly influence their behavioral intention to use technology in future classrooms.

Although there is evidence of its theoretical and empirical validity, TAM has been criticized for being unable to explain the technology acceptance of individuals more broadly (Legris et al., 2003). According to Venkatesh & Davis (2000), the TAM explains at almost 40% of the variance in individual use intention for new technologies. Moreover, TAM ignored the interpersonal influence as subjective norms on adoption of technology, so it has limitations in being applied beyond the workplace. This criticism stressed the expand of the model by adding variables to increase its predictive validity and understand technology acceptance better. From the literature, the underuse of technology for teaching may be attributed to individual, environmental, and technological factors. Among these are facilitating conditions (FC) (Wong, 2015), subjective norms (SN) (Teo, 2010), and technology self-efficacy (TSE) (Sadaf et al., 2012; Teo et al., 2012).

### 2.2 Facilitating conditions

Facilitating conditions (FC) are defined as the beliefs about the existence of an organizational or technical infrastructure to support the use of a system (Venkatesh et al., 2003). These include the environmental factors that affect a person's desire to perform a task, including access to hardware and software, time and money needed, administrative support, skills training, and technical support. Poor facilitating conditions act as barriers to the effective integration of technology into teaching. Fathi &

Ebadi (2020) found that technical support is the highest-ranked factor influencing teachers' technology use. Hence, facilitating conditions are important predictors of the intention to use a system when performance and effort expectancy is not present (Venkatesh et al., 2003). In several studies, it has been found that facilitating conditions have a significant positive influence on the intention to use technology for teaching (Ngai et al., 2007; Wong, 2015). Accordingly, the following hypothesis was proposed:

- H5: Pre-service teachers' perception of facilitating conditions will significantly influence their behavioral intention to use technology in future classrooms.

### 2.3 Subjective norm

The subjective norm (SN) refers to a person's perception of social pressure to use a technology or not (Ajzen, 1991). According to Venkatesh et al. (2003), those who are important to a person affect the intention to make use of a particular system. Thus, people's positive thoughts influence other individuals' behaviors. Within an educational environment, a teacher's decision to use instructional technology might be affected by colleagues, administrators, and students. Pierce and Ball (2009) stated that the views of colleagues might make the acceptance of technology more difficult or easier in secondary school mathematics classes. Ibili et al. (2019), Teo (2010), and Baydas & Goktas (2017) supported the view that subjective norms had a significant positive influence on their intention to use technology for teaching. In addition to the direct effect of subjective norms on intention to make a behavior, Venkatesh & Bala (2008) asserted that subjective norms have direct effects on usefulness of a system. This influence actualized through internalization and/or identification influence mechanisms. Internalization occurs when an important person for a teacher thinks that technology should be used, and one incorporates the referent's belief system. On the other hand, the belief that using technology will improve the individual's status and power within a group is defined as identification (Venkatesh & Davis, 2000). It was claimed and justified that SN has direct effects on perceived usefulness (Chang et al., 2017; Ibili et al., 2019; Rejón-Guardia et al., 2020) and perceived ease of use (Rejón-Guardia et al., 2020; Verma & Sinha, 2018). Therefore, the following hypothesis was formulated:

- H6: Pre-service teachers' subjective norms will significantly influence their behavioral intention to use technology in their future classrooms.
- H7: Pre-service teachers' subjective norms will significantly influence their perceived usefulness.
- H8: Pre-service teachers' subjective norms will significantly influence their perceived ease of use.

### 2.4 Technology self-efficacy

Bandura (1982) defined self-efficacy as a belief in one's own ability to perform an action to achieve specific goals. Self-efficacy is not concerned with skills, but rather with beliefs about what one can do with the skills he or she has. Technology self-efficacy (TSE) is the perception of the ability to use technology. Teachers with high technology self-efficacy are more likely to integrate technology into their classrooms than teachers with low technology self-efficacy. Previous research has provided evidence that teachers' belief in their capacity to work effectively with technology may be a significant factor in using technology in the classroom (Chen, 2010; Li et al., 2019; Sadaf et al., 2012). Moreover, self-efficacy is effective in reducing anxiety, which negatively influences PEU. Buchanan et al. (2013) and Teo et al. (2012) have reported that self-efficacy is associated with perceived ease of use. Thus, individuals with high technology self-efficacy have a higher perception that technology is easy to use. Therefore, the following hypotheses were claimed:

- H9: Pre-service teachers' self-perception of technology efficacy will significantly influence their intention to use technology in their future classrooms.
- H10: Pre-service teachers' self-perception of technology efficacy will significantly influence their perception of ease of technology use.

In an effort to understand pre-service teachers' intentions to use technology in their classrooms, different variables were added to the TAM and used as the theoretical framework for the study. A research model was proposed (Fig. 2), and it was hypothesized that pre-service mathematics teachers' intention to use technology could be predicted directly by their attitudes towards technology, facilitating conditions, subjective norms, technology self-efficacy beliefs, and indirectly by perceived ease of use and perceived usefulness.

## 3 Methodology

### 3.1 Participants and data collection

The participants of this study were 530 pre-service mathematics teachers in four large-scale universities in Turkey. Westland (2010) offered the lower bonds on sample size in structural equation modelling (SEM) as a function of the number of observed and latent variables, minimum effect, power, and significance. The practical application of Westland's computation is also available through (https://www.danielsoper.com/statcalc/calculator.aspx?id=89). With 0.2 effect size, 0.8 statistical power, and 0.05 probability level, the minimum sample size for this study is calculated as 425. Hence, it could be considered that the sample of 530 participants was adequate for this study. Of the participants, 78.4% were female (N = 415), and 21.6% were male (N = 115). Among the participants, 75.8% and 24.2% were trained to be primary and secondary school mathematics teachers, respectively. They were aged from 18 to 31, with a mean age of 22.85. Whereas pre-service mathematics

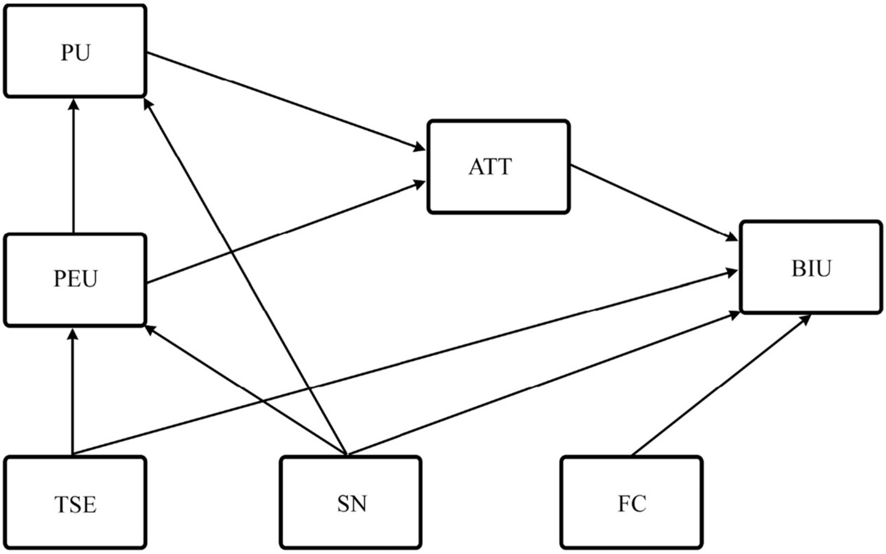


**Fig. 2** The model proposed and tested in the study. Note: (BIU = behavioral intention to use; PEU = perceived ease of use; PU = perceived usefulness; ATT = attitude toward technology; SN = subjective norm [adopted from Venkatesh et al. (2003)]; FC = facilitating conditions [adopted from Venkatesh et al. (2003)]; TSE = technology self-efficacy [adopted from Teo et al. (2012)])

teachers for primary level in Turkey attend a four-year undergraduate study, pre-service secondary school mathematics teachers attend a five-year study. The pre-service teachers in the current study were in their third (N = 197), fourth (N = 183) or fifth (N = 100) grade. Pre-service mathematics teachers take compulsory courses on core mathematics, pedagogy, and teaching mathematics. Moreover, until the end of their 3rd grade, they take compulsory courses on computer literacy, technology integration into teaching, and instructional technologies and material development. They also take elective courses about technology in teaching mathematics depending on the expertise of the teacher educators.

A paper-based questionnaire was designed by the researcher and distributed to the pre-service teachers through the end of the spring semester, and it took around 20 min to complete the survey. The participants were given informed consent about the aim of the study, and the privacy and security of data was ensured by the researcher. Additionally, they were told that they were free to withdraw from the study in any time of the study.

### 3.2 Instruments

The questionnaire used in this study contained items adapted from Teo (2009), Ursavaş et al. (2014), and Li et al. (2016), which were adapted from Davis (1989) and Venkatesh et al. (2003). These questionnaires were used in several studies to evaluate students', teachers', and pre-service teachers' technology acceptance in different educational contexts, and they were validated. After writing the items, a pilot questionnaire was created with 32 items, and 170 pre-service mathematics teachers participated to the scale development. With the exploratory factor analysis (EFA), five items were deleted from the pilot questionnaire and the EFA yielded 27 items under seven constructs: perceived usefulness (five items), perceived ease of use (three items), attitude toward technology (two items), behavioral intention to use (three items), facilitating conditions (four items), subjective norms (five items), and technology self-efficacy (five items). Sample items for each construct were presented in Table 1. The items were measured on a 5-point Likert scale from 1 = strongly disagree to 5 = strongly agree. The Cronbach's alpha coefficients of the constructs were computed as 0.90 for perceived usefulness, 0.87 for perceived ease of use, 0.79 for attitude toward technology, 0.90 for behavioral intention to use, 0.91 for facilitating conditions, 0.91 for subjective norms, and 0.92 for technology self-efficacy.

### 3.3 Convergent validity

Convergent validity of the scale was assessed with the (1) item reliability, (2) composite reliability, and (3) average variance extracted. Table 2 shows the measurement scores for each construct. The item reliability was computed by its factor loading onto the underlying construct. The factor loadings of each item in seven constructs ranged from 0.510 to 0.833, which exceeded the value recommended by Hair et al. (2010). According to Hair et al. (2010), a value of 0.50 or bigger is appropriate. Additionally, the composite reliability values of all the constructs were computed between 0.72 and 0.85, which showed good reliability (Hair et al., 2010). Finally, the average variance extracted index values were computed to test the amount of variance captured by the constructs (Hair et al., 2010). A value of 0.50 or higher is considered to be adequate for convergent validity. As Table 2 indicates, the convergent validity for all constructs was satisfied.

**Table 1** Sample items for each construct

| Construct | Sample item |
|---|---|
| Perceived usefulness | Using technology enhances my effectiveness |
| Perceived ease of use | I find technology easy to use |
| Attitude toward technology | Working with technology is fun |
| Behavioral intention to use | I indent to use technology in the future |
| Facilitating conditions | When I encounter difficulties in using technology, I know where to seek assistance |
| Subjective norms | I will be expected to use technology by my students |
| Technology self-efficacy | Using new technologies has always been complicated for me (Reversed) |

**Table 2** Results of convergent validity

| Construct | Item | Factor loading | Average variance extracted * | Composite reliability |
|---|---|---|---|---|
| PU | PU1 | 0.802 | 0.54 | 0.85 |
| | PU2 | 0.786 | | |
| | PU3 | 0.753 | | |
| | PU4 | 0.713 | | |
| | PU5 | 0.614 | | |
| SN | SN1 | 0.788 | 0.51 | 0.84 |
| | SN2 | 0.765 | | |
| | SN3 | 0.743 | | |
| | SN4 | 0.667 | | |
| | SN5 | 0.580 | | |
| TSE | TSE1 | 0.846 | 0.53 | 0.84 |
| | TSE2 | 0.826 | | |
| | TSE3 | 0.812 | | |
| | TSE4 | 0.534 | | |
| | TSE5 | 0.533 | | |
| FC | FC1 | 0.814 | 0.58 | 0.85 |
| | FC2 | 0.777 | | |
| | FC3 | 0.743 | | |
| | FC4 | 0.710 | | |
| ATT | ATT1 | 0.751 | 0.56 | 0.72 |
| | ATT2 | 0.749 | | |
| PEU | PEU1 | 0.778 | 0.50 | 0.75 |
| | PEU2 | 0.751 | | |
| | PEU3 | 0.577 | | |
| BIU | BIU1 | 0.784 | 0.54 | 0.78 |
| | BIU2 | 0.750 | | |
| | BIU3 | 0.658 | | |

* Average variance extracted was computed by using the division of the sum of the squares of factor loading by the number of items in each construct

### 3.4 Discriminant validity

Discriminant validity is used to measure the extent to which constructs differ from one another (Hair et al., 2010). Discriminant validity is satisfied if the square root of the average variance extracted is greater than the correlation coefficients (Fornell & Larcker, 1981). In addition, discriminant validity was also achieved as the correlation between the constructs is lower than 0.85 (Awang, 2014). In the model, it is expected that the correlation of a construct with its indicators is higher than its correlation with the other constructs. Table 3 shows that a satisfactory level of discriminant validity at the construct level was established.

**Table 3** Results of discriminant validity

| | BIU | PU | TSE | SN | FC | PEU | ATT |
|---|---|---|---|---|---|---|---|
| BIU | (0.74) | | | | | | |
| PU | 0.48 | (0.72) | | | | | |
| TSE | 0.24 | 0.30 | (0.73) | | | | |
| SN | 0.37 | 0.34 | 0.40 | (0.77) | | | |
| FC | 0.56 | 0.49 | 0.19 | 0.30 | (0.75) | | |
| PEU | 0.31 | 0.39 | 0.50 | 0.27 | 0.27 | (0.71) | |
| ATT | 0.46 | 0.48 | 0.20 | 0.31 | 0.45 | 0.29 | (0.74) |

Diagonal values are the square root of the average variances extracted from observed variables; off-diagonal values are the correlation coefficients between constructs

It was also determined that no correlations among the constructs are greater than 0.85 (Awang, 2014).

## 4 Results

### 4.1 Descriptive statistics

Table 4 indicates the descriptive statistics of the scale constructs. While the mean scores of PEU, SN, TSE, and BIU were at moderately high level, the pre-service teachers' PU, ATT, and FC were at high level. The standard deviation of the scores ranged between 0.45 and 0.58, which indicates a narrow variation around the mean. Moreover, the skewness and kurtosis values showed an acceptable degree of univariate normality for model testing (Kline, 2005).

### 4.2 Test of the proposed model

To test the proposed model, fit indices were computed by performing a path analysis with SPSS AMOS 24.0. There is no specification among researchers on

**Table 4** Descriptive statistics of the model constructs

| Construct | Items | Mean | SD | Skewness | Kurtosis |
|---|---|---|---|---|---|
| PU | 5 | 4.24 | 0.45 | 0.38 | -0.63 |
| PEU | 3 | 4.10 | 0.52 | -0.13 | -0.39 |
| ATT | 2 | 4.23 | 0.51 | 0.06 | -0.61 |
| FC | 4 | 4.32 | 0.47 | 0.05 | -0.68 |
| SN | 5 | 3.91 | 0.49 | 0.26 | -0.11 |
| TSE | 5 | 3.73 | 0.58 | 0.30 | -0.52 |
| BIU | 3 | 4.16 | 0.49 | -0.11 | -0.10 |

which fit indices can be presented. Hence, several indices were computed. Kline (2005) recommended presenting at least four indices. Chi-square value which should be insignificant was computed as $\chi^2$=1192.1 (df = 395, p < 0.05). Scholars criticized it due to its sensitivity to sample size more than 200 (Hair et al., 2010). The chi-square value was significant because the number of participants was 530. For this reason, the ratio of $\chi^2$ to df was used, with a value less than 5 indicating an acceptable fit. In addition, the values of the root mean square error of approximation (RMSEA), the comparative fit index (CFI), the goodness of fit (GFI), the normed fit index (NFI), and root mean residual (RMR) indicated that the model was acceptable. Table 5 indicates the acceptable fit indices based on Kline (2005) and Raykov and Marcoulides (2006) and the fit indices obtained from the model test.

### 4.3 Hypothesis testing

The nine out of ten hypotheses proposed with the model were confirmed by the SEM (Table 6). In addition, the hypotheses regarding the TAM variables were supported. The results showed that PEU was significantly influenced by TSE (β = 0.59, p < 0.01) and SN (β = 0.21, p < 0.01), and PU was significantly influenced by PEU (β = 0.40, p < 0.01) and SN (β = 0.27, p < 0.01). ATT was significantly influenced by both PEU (β = 0.18, p < 0.01) and PU (β = 0.57, p < 0.01). Moreover, SN (β = 0.21, p < 0.01), FC (β = 0.49, p < 0.01) and ATT (β = 0.46, p < 0.01) were found to be significant in influencing BIU. Among the external variables, TSE did not have a significant effect on BIU (β = 0.01, p > 0.01).

### 4.4 Path analysis

With path analysis, the direct, indirect, and total effects of each exogenous on the endogenous variables were computed. While direct effect refers to the linking of one construct to another with an arrow, indirect effect is the impact of one variable on another variable through other variables. A total effect is the sum of the direct and indirect effects of one determinant on a variable. Cohen (1988) stated that the effect size values less than 0.1 are small, that are around 0.3 are medium, and equal to 0.5

**Table 5** Fit indices of the proposed model

| Fit index | Level of acceptance | Fit values of the proposed model |
|---|---|---|
| χ2 | - | p < 0.05 (significant) |
| χ2/df | ≤ 5 | 3.017 |
| RMSEA | ≤ 0.08 | 0.062 |
| RMR | ≤ 0.05 | 0.046 |
| GFI | ≥ 0.90 | 0.909 |
| NFI | ≥ 0.90 | 0.928 |
| CFI | ≥ 0.90 | 0.928 |

**Table 6** Hypothesis testing results

| Hypothesis | Path | Path coefficient | Result |
|---|---|---|---|
| H1 | PEU ➔ PU | 0.40 | Supported |
| H2 | PEU ➔ ATT | 0.18 | Supported |
| H3 | PU ➔ ATT | 0.57 | Supported |
| H4 | ATT ➔ BIU | 0.46 | Supported |
| H5 | FC ➔ BIU | 0.49 | Supported |
| H6 | SN ➔ BIU | 0.21 | Supported |
| H7 | SN ➔ PU | 0.27 | Supported |
| H8 | SN ➔ PEU | 0.21 | Supported |
| H9 | TSE ➔ BIU | 0.01 | Not Supported |
| H10 | TSE ➔ PEU | 0.59 | Supported |

or more are large. The standardized direct, indirect, and total effect size values are listed in Table 7.

The most prominent determinant of BIU is FC, with a total effect size of 0.492, which is high. Another strong determinant of BI is ATT, with a total effect size of 0.457. This is followed by PU (0.258), PEU (0.186), SN (0.317), and TSE (0.121). The six determinants accounted for approximately 54.3% of the variance in BIU. While PU (0.566) has high influence on ATT, PEU (0.408), TSE (0.238), and SN (0.231) have medium size influence on ATT. The PU is found to be the most

**Table 7** Direct, indirect, and total effects of determinants on variables

| Outcome | Determinant | Standardized estimates | | |
|---|---|---|---|---|
| | | Direct | Indirect | Total |
| Behavioral intention ($R^2=0.543$) | PU | - | 0.258 | 0.258 |
| | PEU | - | 0.186 | 0.186 |
| | ATT | 0.457 | - | 0.457 |
| | FC | 0.492 | - | 0.492 |
| | TSE | 0.012 | 0.109 | 0.121 |
| | SN | 0.211 | 0.106 | 0.317 |
| Attitude toward technology ($R^2=0.446$) | PU | 0.566 | - | 0.566 |
| | PEU | 0.182 | 0.226 | 0.408 |
| | TSE | - | 0.238 | 0.238 |
| | SN | - | 0.231 | 0.231 |
| Perceived usefulness ($R^2=0.273$) | PEU | 0.399 | - | 0.399 |
| | TSE | - | 0.233 | 0.233 |
| | SN | 0.269 | 0.078 | 0.347 |
| Perceived ease of use ($R^2=0.378$) | TSE | 0.583 | - | 0.583 |
| | SN | 0.194 | - | 0.194 |

dominant determinant of ATT. The PU, PEU, and TSE explained approximately 44.6% of the variance in ATT. PEU has a high total effect on PU (0.399), while the total effect size of TSE on PU is 0.233 and the effect size of SN on PU is 0.347. Together, PEU, TSE, and SN accounted for 27.3% of the variance in PU. Finally, TSE has total effect of 0.583, SN has total effect 0.194 on PEU, and they explain 37.8% of the variance in PEU.

## 5 Discussion

The purpose of this study is to test the efficacy of the TAM by investigating the factors influencing behavioral intention to use technology in the context of pre-service mathematics teachers of Turkey. The results from descriptive data analysis showed that pre-service teachers have a moderately high level of technology acceptance. Pre-service teachers' high level of technology acceptance might be related to the importance of the training of pre-service teachers on technology and technology integration. With the structuring of teacher education programmes started in 2007 by the Higher Education Council of Turkey, pre-service mathematics teachers take two compulsory courses on information and communication technology and one compulsory course on instructional technologies and material development. In addition, elective courses on mathematical software and technology integration are offered to pre-service mathematics teachers. The curriculum of such courses was designed to help prospective teachers gain technology competence and integration skills. Therefore, it is reasonable to expect pre-service mathematics teachers in Turkey to have high behavioral intention to use technology in their future teaching.

One of the contributions of this study is that the TAM was empirically validated among the pre-service mathematics teachers of Turkey. Consistent with previous findings (Huang & Teo, 2019), pre-service teachers' attitudes towards technology were influenced by perceived usefulness and ease of use together. In addition, the influence of perceived usefulness was stronger than the influence of perceived ease of use. This result showed that pre-service teachers' perception of the effectiveness of technology in teaching mathematics has more influence on attitude towards technology than effort involved in using technology. Furthermore, perceived ease of use has direct influence on perceived usefulness.

The path analysis indicated that the facilitating conditions, subjective norms, and attitude toward technology have direct influences on pre-service mathematics teachers' intention to use technology for teaching in their future classrooms. This result is consistent with previous studies indicating the positive effects of facilitating conditions, subjective norms, and attitude toward technology on technology use behaviors (Baydaş & Yılmaz, 2017; Teo et al., 2012). Although it was offered that technology self-efficacy has a significant effect on behavioral intention, the results did not confirm this hypothesis. In addition, technology self-efficacy, perceived ease of use, and perceived usefulness have indirect effects on behavioral intention to use technology. The direct effects on behavioral intention indicated that when pre-service teachers are encouraged by their future colleagues, superiors, and students, and when they think that working with technology is fun and make them more productive, they tend to use technology in their future classrooms. Furthermore, when administrative and technical support and technological tools are provided, they are likely to use technology.

Pre-service teachers believed that their future students, colleagues, and superiors would influence their decisions to integrate technology. This quality of the subjective norm was found to be a significant predictor of behavioral intention, and this result is echoed in previous studies (Teo, 2010; Venkatesh et al., 2003). Sadaf et al. (2012) stated that the opinions and suggestions of others might affect teachers' use of technology for teaching. Administrators and colleagues might encourage or force teachers to integrate technology into teaching, or vice versa. Additionally, 21st-century students expect their teachers to use modern information and communication technologies in the classroom (Sadaf et al., 2012). This study also indicated that the social pressure and ambition of gaining power and status among the colleagues would promote their perceptions about the usefulness and ease of use of technology in the classroom. This result corroborates the findings of the previous studies reporting the positive effects of subjective norms on perceived usefulness and ease of use (Rejón-Guardia et al., 2020; Venkatesh & Bala, 2008). If pre-service teachers are asked, encouraged, and guided to use technology for educational purposes, they are likely to integrate it. This study has also justified that facilitating conditions have a significant influence on the behavioral intention to use technology. Similarly, Teo (2010) and Sadaf et al. (2012) found that facilitating conditions are significant predictors of the intention to use technology. Pre-service teachers believe that if technical facilities and instructional support are provided to them, they will use technology more in their classrooms.

Pre-service teachers perceived that they have high technology knowledge and skills. However, their technology self-efficacy did not have a direct influence on their behavioral intention. On the contrary, several researchers found that technology or computer self-efficacy is a significant determinant of behavioral intention (Teo, 2009; Teo et al., 2012; Wong, 2015). Similar to the result of this study, Wong (2016) indicated that technology self-efficacy was not a significant direct predictor of behavioral intention. Venkatesh et al. (2003) reported that technological complexity or anxiety does not have any influence on the intention to use it. Pre-service teachers might not intend to use technology simply because they have high technology self-efficacy beliefs. Technology self-efficacy alone might not be enough to encourage pre-service teachers to use technology. The mediating effect of technology self-efficacy through attitude toward technology supports this assumption.

### 5.1 Implications

This study has important implications for teacher educators, policymakers, and school administrators. The facilitating conditions has the highest influence among the other direct determinants on the intention to use technology. Although pre-service teachers trust in their technology skills, they need administrative, technological, and design support to use technology in their future classrooms. Continuous administrative, technological, and design support of teachers is extremely important to create technology-rich learning environments. Furthermore, an effective teacher education curriculum in terms of technology integration needs to address future teachers' experience with current digital tools such as dynamic mathematical software, dynamic geometry software, simulations, and virtual manipulatives that could be used in teaching mathematics. Instead of decreasing the number of courses on technology skills and integration, Higher Education Council of Turkey could more emphasize the critical role of these courses in technology integration. In addition, teacher educators may encourage and guide pre-service mathematics teachers to practice with the digital environment provided within the FATiH project. As Sadaf et al. (2012) showed, modern-day students are comfortable using technology, and they expect their teachers to use current technology in the classroom. If a culture encouraging technology use for teaching is created in schools by administrators, and continuous professional development of teachers on technology integration is provided, future teachers would use technology more in their classrooms.

### 5.2 Limitations

There are some limitations to this study. This study showed that 54.3% of the variance in the dependent variable could be explained by four endogenous variables, leaving 45.7% unexplained. This shows that other variables that were not included in the model may have the potential to influence pre-service teachers' intention to use technology. Therefore, future research should include other variables such as satisfaction, anxiety, image, pedagogical beliefs, pedagogical readiness that might have direct and indirect effects on behavioral intention. Moreover, the number of items under the factors in the questionnaire change between two and five. Having few items for each construct might influence the outcomes. Since this study was conducted only with pre-service mathematics teachers, their lack of experience in teaching and integrating technology into teaching may lead to poor representation of the actual teaching in the classroom. Additionally, future research could be performed by comparing in-service teachers to pre-service teachers to understand the gap between the actual and predicted experiences. Future research might also benefit from using participants from different departments, and then comparisons among the departments could be made. Finally, this study did not consider the effect of experience with technology for teaching on pre-service teachers' intention to use technology (Venkatesh et al., 2003). Further studies should consider the impact of experience on intention to use technology for teaching.

## 6 Conclusion

Previous studies stressed the importance of validating the TAM in different cultures and contexts (Teo et al., 2012, 2019). This study was aimed to investigate the factors influencing pre-service mathematics teachers in a Turkish context. The original TAM was enriched with added constructs, including technology self-efficacy, subjective norms, and facilitating conditions. In the current study, the proposed model has a good fit to the data, and the model was validated. The results indicate that facilitating conditions, subjective norms, and attitude toward technology have direct and significant effects on intention to use technology for teaching. Technology self-efficacy is important to enhance pre-service teachers' perception of the easy use of technology.

**Declarations**

**Ethical approval** This study was approved by the Bolu Abant Izzet Baysal University Human Research Ethics Committee and all procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Consent to participate/consent for publication** The following statement was included in the cover page of the questionnaire: "Responding to the questionnaire will not affect the respondents. So please give as accurate answer as possible. In this regard, the researcher will present the overall information only. If you are not comfortable with answering any questions, you may skip or cancel the participation at any time."

**Conflict of interest** The author certifies he has no conflict of interest influencing this study.

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