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# Beliefs and Knowledge for Pre-Service Teachers' Technology Integration during Teaching Practice: An Extended Theory of Planned Behavior

Akhmad Habibi[a], Yasir Riady[b], Ahmad Samed Al-Adwan[c] and Nour Awni Albelbisi[d]

[a]Faculty of Education and Teacher Training, Universitas Jambi, Jambi City, Indonesia; [b]Faculty of Law, Social Sciences, and Political Science, Universitas Terbuka, Banten, Indonesia; [c]Electronic Business and Commerce Department, Al-Ahliyya Amman University, Amman, Jordan; [d]Department of Curriculum and Instructional Technology, Faculty of Education, University of Malaya, Kuala Lumpur, Malaysia

**ABSTRACT**

The main purpose of the current research was to explore the relationships between beliefs/knowledge and technology integration (TI) during teaching practice (i.e., placement or practicum) among Indonesian pre-service teachers. Five core variables of the theory of planned behavior or TPB (subjective norms, attitudes, perceived behavioral control, behavioral intention, and behavior) and one extended variable, technological pedagogical and content knowledge or TPACK, were included in the proposed model. Data from 1,181 respondents were analyzed through the systematic steps of partial least square structural equation modeling (PLS-SEM) and importance-performance analysis (IPMA). The main findings support all hypotheses; the strongest relationship emerges between behavioral intention and behavior, while the weakest correlation was between TPACK and behavioral intention. All variable performances were satisfactory. The highest performance was attitudes (71.734); the lowest was TPACK (65.027). Broadly, the results indicate the greater importance of beliefs as opposed to knowledge in influencing behavior in relation to TI.

**KEYWORDS**
TPB; TPACK; technology integration; pre-service teachers; PLS-SEM

## Introduction

Today's young people, including pre-service teachers and their students, are digital natives. They are individuals born between 1980 and 2005 who have higher educational degrees than the previous generation (Kurz et al., 2019). These digital natives have grown up with the convenience of using technology and always count on technological devices to gather information and knowledge, communicate, and seek entertainment. For millennial

**CONTACT** Akhmad Habibi akhmad.habibi@unja.ac.id Faculty of Education and Teacher Training, Universitas Jambi, Jambi City, Indonesia.
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teachers (Generation Y), technology integration (TI) challenges are probably more pronounced when they start to teach due to high and sometimes unrealistic expectations from their students, coworkers, and school administrators (Gilakjani, 2013).

Today's pre-service teachers are digitally savvy, yet must learn to integrate technology for teaching. As new teachers become practicing teachers, how TI is portrayed in teacher education significantly impacts their attitudes toward technology (Taimalu & Luik, 2019). In Indonesia, universities prepare pre-service teachers to have beliefs and knowledge to suit changes in society and needs in teaching. More schools require teacher candidates to integrate technology into teaching, and technology has become an integral part of education (Wentworth, 2006). Therefore, it can be argued that pre-service teachers should have positive beliefs and be knowledgeable about integrating technology into teaching, initially during their teaching practice. Thus, it is important to examine their beliefs about and knowledge of TI.

Pre-service teachers' TI during teaching practice is likely influenced by attitudinal, social/normative, control, and other factors. However, these factors can be categorized into two main factors, beliefs, and knowledge (Taimalu & Luik, 2019). Studies reporting the relationship between teachers' beliefs/knowledge and TI are still limited, especially regarding pre-service teachers' TI during teaching practice in developing countries (Ifinedo et al., 2020). Therefore, this study elaborates on the determinants (beliefs and knowledge) in predicting TI (behavioral intention and behavior) during teaching practice. Five core variables of the theory of planned behavior (TPB) for beliefs are included: subjective norms, attitudes, perceived behavioral control, behavioral intention, and behavior). Technological pedagogical and content knowledge (TPACK), which represents knowledge, is used to extend the TPB.

## Literature review

### *Preparing teachers and technology integration*

Learning how to integrate technology into pedagogy might best be described as a process requiring time and effort (Falloon, 2020; Khlaif, 2018). Technology integration challenges change from time to time because new technologies are continually being established or adapted for educational purposes (Broadbent et al., 2020).

Technology integration is defined in this study as teaching preparation, activities, and assessment that utilize technology during teaching (and for pre-service teachers, during teaching practice); for example, using search engines to look for information on the Internet for teaching preparation, utilizing the Internet for teaching, and doing assessments using technology. There are always new things for teachers to learn regarding TI in education. In terms of teacher education programs in higher education, previous researchers have indicated that pre-service teachers are no worse or better at integrating technology than in-service teachers (Ertmer et al., 2007; Yong et al., 2016).

Pre-service teachers' perspectives on using technology in teaching practice can be seen as a complex and ongoing process (Rutherford et al., 2015). Pre-service teachers are considered knowledgeable and skillful in using technology for communication, pleasure, and information (List, 2019). However, they have constrained beliefs about and limited knowledge of TI during teaching (Anderson & Maninger, 2007). They might have challenges regarding the use of technologies for specific curriculum requirements and effective classroom management (Gilakjani, 2013). This is particularly the case as new advanced complex technologies are continually introduced to the market and schools, and skills to integrate technology during teaching require appropriate beliefs and specific knowledge (Rowston et al., 2021). Studies indicate in particular the importance of developing beliefs and knowledge for pre-service teachers for TI during teaching practicums (Kirschner, 2015). Thus, this study investigated students' technology-related beliefs, knowledge, and integration during such practicums.

### *The study*

Many models have been proposed to assist teachers and educators in better integrating technology into teaching activities by evaluating TI in educational contexts. Additionally, certain combination models for evaluating TI in education have been documented (Cheng, 2019; Habibi et al., 2020; Mohammadi, 2015; Sánchez-Prieto et al., 2019; Thongsri et al., 2018). For instance, the TPB and the technology acceptance model were modified to assess the variables influencing students' intention to utilize wikis (Cheng, 2019). The study demonstrated a favorable relationship between attitudes, subjective norms, perceived behavioral control, and students' intention to utilize wikis. Another study on mobile learning use among Thai students combined the unified theory of acceptance and use of technology with the use-and-gratification theory (Thongsri et al., 2018). In the present study, we merged together TPB and TPACK in order to give a more solid theoretical and educational foundation and thus a better understanding of pre-service teacher beliefs and knowledge about TI and the factors influencing these.

### TPB

Ajzen (1991) introduced Theory of Planned Behavior, which is defined as a theoretical framework to understand someone's beliefs in things or objects or ways of doing things. The TPB posits that beliefs contribute to behavioral intentions. In turn, intentions influence behavior (Ajzen, 1991). Three sorts of salient beliefs represent indirect measurements of willingness or intentions. These are subjective norms, attitudes, and perceived behavioral control.

To date, the TPB has been widely applied in measuring perceptions to elaborate on people's intentions to become involved in a given behavior (Alzahrani et al., 2017; Cheng, 2019; Fatima et al., 2019; Lung-Guang, 2019; Mohammadi, 2015; Salleh, 2016; Sánchez-Prieto et al., 2019). It represents an individual's motivation in planning specific behavior performances (Conner & Sparks, 2005). The stronger the intention, the more likely the individual will perform the behavior. Attitude toward a behavior is the degree to which a person has either positive or negative feelings about the behavior; it is the evaluation of self-performance of a certain behavior (Ajzen, 1991). Further, in the context of this study, the foundation of subjective norms is between the salient normative beliefs of social support and the pressure to adopt technologies into teaching practice. The belief strength of subjective norms is measured by pre-service teachers' willingness to fit the perceived prescriptions of others for the use of technology during teaching practice (Ajzen, 1991).

Ajzen (1991) added the concept of "perceived behavioral control" into his theory as a factor influencing both behavioral intention and actual behavior. Conceptually, perceived behavioral control refers to the individual's perception that the relevant behavior is within his or her control. Operationally, perceived behavioral control is frequently measured by the ease or difficulty of the relevant behavior (Ajzen, 1991).

In this study, the TPB aided the researchers in analyzing, examining, and investigating the beliefs underlying pre-service teachers' intentions to adopt technology during teaching practice. Many previous studies reported on the relationships among TPB variables (Alzahrani et al., 2017; Cheng, 2019; Fatima et al., 2019; Kreijns et al., 2013; Lung-Guang, 2019; Mohammadi, 2015; Salleh, 2016; Sánchez-Prieto et al., 2019; Teo & van Schaik, 2012). Alzahrani et al. (2017) investigated the predictors of online games' actual use among 1,584 Malaysian students; games in their study were played on computers or smartphones, incorporating web-based programs to combine broadband Internet services with other networked gaming systems. Alzahrani et al. (2017), extending TPB with three external variables (human-computer interaction, social interaction, and flow experience), reported that subjective norms had the strongest correlation ($\beta$ =

.248; $p < .001$) with the actual use of online games. Further, attitude ($\beta = .115$; $p < .001$) and perceived behavioral control ($\beta = .235$; $p < .001$) have also shown significant relationships with the use of online games (Alzahrani et al., 2017). In another study, Kreijns et al. (2013) indicated that attitudes significantly predicted intention to use digital learning materials. Subjective norms with $\beta = .490$ at $p < .001$ were significantly related to the intention to adopt digital learning materials (Kreijns et al., 2013).

Lung-Guang (2019) examined the correlation between university students' self-regulated learning and planning for their participation in massive open online courses, and found that attitudes were not positively correlated with behavioral intention ($\beta = .064$; $p > .05$); meanwhile, subjective norms ($\beta = .149$; $p < .001$) and perceived behavioral control ($\beta = .561$; $p < .001$) were significant in predicting behavioral intention. Another study indicated that subjective norms ($\beta = .580$; $p < .001$) significantly predict the intention to use mobile learning (Mohammadi, 2015). Sánchez-Prieto et al. (2019) used subjective norms and attitudes as part of TPB to determine mobile learning use; subjective norms were reported to have a significant correlation with behavioral intention ($\beta = .175$; $p < .001$), while the relationship between attitudes and behavioral intention were insignificant ($\beta = .020$; $p > .05$).

Table 1 shows prior studies on correlations within the TPB framework on TI in education. However, these studies were mostly conducted in developed countries. Thus, the current study enriches the literature in the context of a developing country. As for the main framework proposed within this study, all TPB variables were included in relation to behavioral intention, i.e., subjective norms, attitudes, perceived behavioral control, behavioral intention, and behavior. Five hypotheses were noted in relation to the model in this study:

H2: Subjective norms will have a significant relationship with behavioral intention.

H3: Attitudes will have a significant relationship with behavioral intention.

H4: Perceived behavioral control will have a significant relationship with behavioral intention.

H6: Perceived behavioral control will have a significant positive relationship with behavior.

H7: Behavioral intention is a significant predictor of behavior.

## *TPACK*

Technological pedagogical content knowledge (TPACK) is probably the most prominent model of teacher expertise regarding the educational use

**Table 1.** Prior studies TPB and TPACK on technology integration.

| Author | Method | Predictors | Dependent variables | Correlation |
|---|---|---|---|---|
| Alzahrani et al. (2017) | Path analysis (PLS-SEM) 1584 students | Attitudes, subjective norms, and perceived behavioral control | Actual use of online gaming | Attitudes -> actual use (β = .115)*<br>Subjective norms -> actual use (β = .248)**<br>Perceived behavioral control -> actual use (β = .235)** |
| Cheng (2019) | Path analysis (PLS-SEM) 174 students from a university in Hong Kong | Attitudes, subjective norms, perceived behavioral control, and intention to use | Intention to use wiki, behavior | Attitudes -> intention to use (β = .090)<br>Subjective norm -> intention to use wiki (β = .335)**<br>Perceived behavioral control -> intention to use wiki (β = .482)**<br>Perceived behavioral control -> behavior (β = .170)**<br>Intention to use wiki -> behavior (β = .329)** |
| Fatima et al. (2019) | Path analysis (PLS-SEM)<br>176 respondents | Attitudes, perceived behavioral control | Intention toward m-learning | Perceived behavioral control -> attitudes toward m-learning (β = .239)**<br>Subjective norms -> attitudes toward m-learning (β = .348)**<br>Attitudes toward m-learning -> intention for m-learning adoption (β = .330) |
| Kreijns et al. (2013) | Bivariate correlation<br>1209 teachers in Dutch | Attitudes, subjective norms, | Intention to use digital learning materials | Attitudes -> intention to use (β = .49)**<br>Subjective norm -> intention to use (β = .10)** |
| Lung-Guang (2019) | Path analysis (CB-SEM)<br>224 respondents | Attitudes, subjective norms, perceived behavioral control | Behavioral intention | Attitudes -> behavioral intention (β = .064)<br>Subjective norms -> behavioral intention (β = .149)**<br>Perceived behavioral control -> behavioral intention (β = .561)** |
| Mohammadi (2015) | Path analysis (PLS-SEM)<br>390 students | Subjective norms | Intention | Subjective norms -> intention (β = .58)** |
| Salleh (2016) | Path analysis (CB-SEM)<br>1040 respondents | Attitudes, subjective norms, perceived behavioral control, intention | Intention, actual behavior | Attitudes -> intention (β = .675)**<br>Subjective norms -> intention (β = .30)**<br>Perceived behavioral control -> intention (β = .27)**<br>Perceived behavioral control -> actual behavior (β = .16)**<br>Intention -> actual behavior (β = .29)** |
| Sánchez-Prieto et al. (2019) | Path analysis (PLS-SEM)<br>222 respondents | Subjective norms, attitudes | Behavioral intention | Subjective norms -> behavioral intention (β = .175)**<br>Attitudes -> behavioral intention (β = .020) |
| Habibi et al. (2020) | Path analysis (PLS-SEM)<br>287 pre-service language teachers | TPACK | Use of ICT | TPACK -> use of ICT (β = .345)** |
| Joo et al. (2018) | Path analysis (CB SEM)<br>296 Korean pre-service teachers | TPACK | Intention to use technology | TPACK -> Intention to use ICT (β = .000) |
| Santos and Castro (2021) | Pearson product-moment correlations (*r*)<br>67 pre-service teachers | TPACK | Education Technology tools (EdTech tools) | TPACK and EdTEch tools (*r* = .302)** |
| Teo et al. (2019) | Path analysis (CB SEM)<br>464 Chinese pre-service teachers | TPACK | Intention to use technology | TPACK -> Intention to use technology (β = .260)** |
| Raygan and Moradkhani (2020) | Path analysis (CB SEM)<br>209 Iranian EFL teachers | TPACK | Technology integration | TPACK -> Technology integration (β = .262)** |

*Note*. * $p< .05$; ** $p< .01$.

of digital technologies (Schmid et al., 2021). TPACK, an extension of the pedagogical content knowledge (PCK) framework (Shulman, 1986), combines pedagogy, content, and technology (Blocher et al., 2011). The TPACK framework includes three main components: pedagogical knowledge, content knowledge, and technological knowledge. The three main components form four combined domains: pedagogical content knowledge, technological pedagogical knowledge, technological content knowledge, and TPACK.

The relationship between TPACK and behavioral intention or actual behavior regarding TI in education has been discussed in the literature (Habibi et al., 2020; Joo et al., 2018; Raygan & Moradkhani, 2020; Santos & Castro, 2020; Teo et al., 2019). For instance, in one study an insignificant relationship ($\beta = .000$; $p > .05$) emerged between TPACK and intention to use information and communication technology (ICT) (Joo et al., 2018). However, most reports confirmed a significant relationship between TPACK and technology use in teaching and learning activities (Habibi et al., 2020; Raygan & Moradkhani, 2020; Santos & Castro, 2020; Teo et al., 2019). Habibi et al. (2020) noted a significant correlation between Indonesian language teachers' TPACK and ICT use ($\beta = .345$; $p < .01$) during teaching practice. The relationship between TPACK and ICT use in education was also significant at $p < .01$ (Santos & Castro, 2020). TPACK in this study is defined as knowledge to integrate appropriate pedagogical procedures for content mastery through technology use during teaching practice. Two hypotheses were proposed based on the prior studies and the context of this study, behavioral intention and behavior of technology use during practicum (Figures 1 and 2):

H1: TPACK will have a significant relationship with behavioral intention

H5: TPACK will have a substantial role in predicting behavior

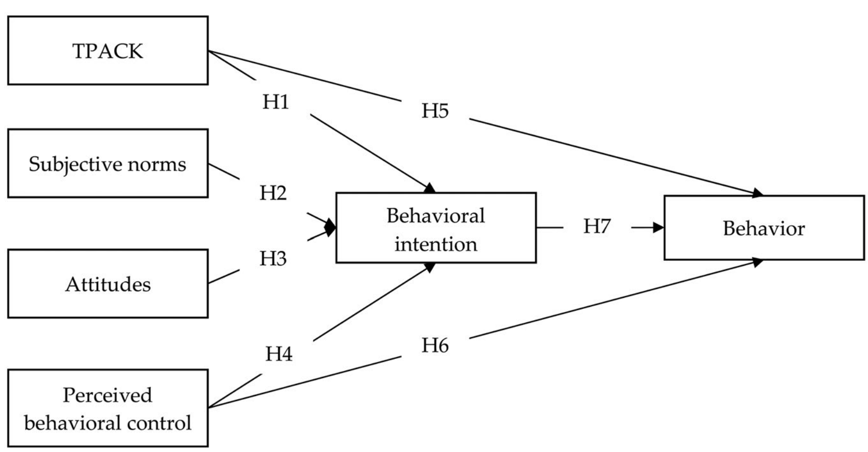


**Figure 1.** Proposed model, TPB on technology integration during teaching practices.

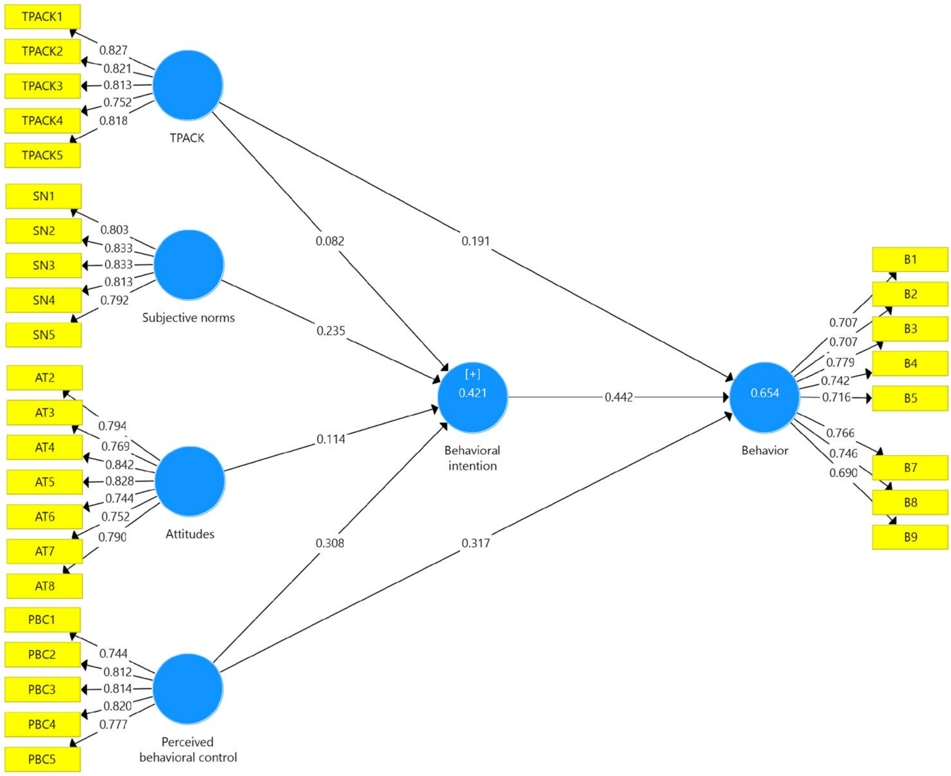


**Figure 2.** Measurement model, reflective indicator loadings.

## Method

### *Instrumentation process*

This study implemented a survey design as a research approach (Stimson, 2014). The instrumentation process began with the adaptation and construction of the survey items. These are centered on six key domains: TPACK, subjective norms, attitudes, perceived behavioral control, intention to use, and behavior. In addition to the main survey, demographic information was also included. The instrument was adapted from prior studies of TPB (Ajzen, 1991; Aslan & Zhu, 2017; Sadaf et al., 2012) and TPACK (Schmidt et al., 2009). For behavior or actual use of technology during teaching practice, the survey instrument was adapted from Aslan and Zhu (2017) and Habibi et al. (2020). A 5-point Likert scale with anchors from 1 (strongly disagree) to 5 (strongly agree) was employed. The instrument was translated from English to Indonesian and vice versa, using a back-translation procedure (Behr, 2017). For that purpose, two experts in translation were involved. The questionnaire was compared to see the suitability of the translation in the context of pre-service teachers through a face and content validity process to discuss the clarity and simplicity of the wording (Connell et al., 2018). Five pre-service teachers with similar characteristics to the main respondents evaluated the clarity and simplicity of the statements. The process involved two group discussions as part of assuring face validity.

Further, the scale was discussed with five educational technology experts for content validity. From the face and content validity processes, 11 items were dropped; some others were revised based on the pre-service teachers' and experts' suggestions for reasons such as lack of clarity, bias, and out-of-context statements. The instrument was then distributed to ten experts for the calculation of a content validity index (CVI). Each item was presented for relevance, simplicity, and clarity evaluation. The items were evaluated on a 4-point scale, ranging from such as 1 (not relevant, not simple, not clear) to 4 (very relevant, very simple, very clear) (Lynn, 1986). We requested the experts evaluate the item level (I-CVI - scoring 3 or 4 divided by the number of experts) and scale level (S-CVI - scoring from the average agreement by experts = S-CVI/AVE). With ten experts, the I-CVI should be >.780, and the S-CVI should be above .800 (Gilbert & Prion, 2016). All indicators of I-CVI and S-CVI met the criteria with values over .780 and .800.

### *Pilot study through the exploratory factor analysis (EFA)*

One of the essential steps in survey research is ensuring that the instruments used are developed to reflect the conceptual framework's intended variables. One of the steps is the pilot study; a pilot study is an initial testing process or protocol that will be applied in a bigger study (Hertzog, 2008). Exploratory factor analysis (EFA) was done with the pilot data (Hair et al., 2011). The instrument was distributed to 310 pre-service teachers or respondents in one university; the respondents were recruited by contacting their practicum supervisors. Two hundred and eighty-seven responses were usable, while 23 were not completed or missed. The respondents' characteristics in the pilot study were similar to the primarily targeted respondents in the main study (n. 1,181), i.e., pre-service teachers who were doing or have done their teaching practicum.

Because the research adapted indicators from previous studies, EFA was needed to determine the validity of the underpinning structure of the proposed variables. The data's suitability was assessed using the EFA process by assessing the data's normality using skewness and kurtosis. Q-Q plots and histograms were also used to verify the linearity (Hair et al., 2011). Visual inspection of the Q-Q plots and histograms indicate that the data were normally distributed. The variance inflating factor (VIF) was also used to check multicollinearity, indicating that multicollinearity is not an issue (VIF values are less than 10) (Hair et al., 1995). Most items met the threshold values of the EFA through Varimax rotation (James, 2009), namely Sphericity Bartlett Test ($p$ < .500), factor loading, Kaiser-Meyer-Olkin (>.800), Factor Loading (≥ .500), Communalities (≥.300), and Eigenvalue (≥1.00) (Harerimana & Mtshali, 2020; Luo et al., 2019). One item (AT1) was dropped since AT1 in attitudes (.4530) had cross-loading with perceived behavioral control (.4710). The details of the instrumentation processes from the adaptation to the pilot study are exhibited in Table 2.

### *Population and target population*

This study's total potential population is about 1.2 million Indonesian pre-service teachers studying in 374 pre-service teacher training programs based on Indonesian higher education data (IHED, 2021). However, the target population includes Indonesian pre-service teachers in Jambi, one of the Indonesian provinces located across the southern part of Sumatra Island. The target population of this study are 2,417 pre-service teachers (IHED, 2021) across three universities (A, B, and C).

### *Sampling*

We used partial least square structural equation modeling (PLS-SEM) for the statistical analysis. Theoretically, PLS-SEM can be applied to small sample sizes (<100) when models consist of significant constructs and many indicators (Hair et al., 2017). This study, however, involved a relatively large sample size (>1,000). Stratified sampling was implemented, in which we stratified the sampling based on the universities (A, B, and C). We distributed the questionnaire to 1,219 pre-service teachers (50% of the target population, n. 2,417). However, 1,181 responses

**Table 2.** Instrumentation process, pilot study, and measurement model.

| Domain | Adaptation and construction | Face and content validity | CVI (Indicators' code) | Pilot study with EFA analysis (dropped item) |
|---|---|---|---|---|
| TPACK | 10 | 5 | 5 (TPACK 1-TPACK5) | 5 |
| Attitude | 9 | 8 | 8 (AT1-AT8) | 7 (AT1) |
| Subjective norm | 7 | 5 | 5 (SN1-SN5) | 5 |
| Perceived behavioral control | 7 | 5 | 5 (PBC1-PBC5) | 5 |
| Behavioral intention | 3 | 3 | 3 (BI1-BI3) | 3 |
| Behavior | 10 | 9 | 9 (B1-B9) | 9 |
| Total | 46 | 35 | 35 | 34 |

(Table 2) were measurable after data cleaning in the SPSS (96.9% response rate).

## Analysis and findings

Data gained from this study were computed through PLS-SEM with measurement model, structural model, and importance-performance analysis (IPMA).

### *Measurement model*

A measurement model is a procedure to examine a model's construct validity and reliability (Jarvis et al., 2003). Loadings, internal consistency reliability (ICR), convergent validity, and discriminant validity were reported in this step. For loadings, indicators with loading values lower than .500 should be dropped, while the loading of >.500 should be retained (Noor et al., 2019; Ogbeibu et al., 2021). The measurement model computation was done after the data normality assessment in the SPSS. We computed the data through the PLS algorithm in the SmartPLS 3.3.3, resulting in most items having loading values more than .708; however, one item (B6 from the behavior variable) was dropped since the loading is below .50. ICR is described as an effort to evaluate the steadiness or consistency of computational scores across indicators (Ogbeibu et al., 2021); ICR values are computed from 0 to 1; the greater the value, the higher the reliability. Cronbach's alpha, Rho_A, and composite reliability are suggested to have values over .700 (Hair et al., 2021) for a good ICR. The reports, shown in Table 3 and Figure 2, confirm that all values meet the required values; all measurements for ICR score more than .70. The lowest Cronbach's alpha value was obtained by behavioral intention (.8110), while the highest alpha emerged for attitudes (.8990). Rho_A ranged between .8180 and .8990, while CR values were .8880 to .9200. Convergent validity, part of construct validity, defines that tests having the same or similar constructs should be highly correlated; convergent validity is reported through average extracted variance (AVE) (Manley et al., 2021). The most negligible value

**Table 3.** Measurement model; internal consistency reliability and convergent validity.

| | Cronbach's alpha | rho_A | CR | AVE |
|---|---|---|---|---|
| Attitudes | .8990 | .8990 | .9200 | .6230 |
| Behavior | .8760 | .8770 | .9020 | .5360 |
| Behavioral intention | .8110 | .8180 | .8880 | .7250 |
| Perceived behavioral control | .8530 | .8550 | .8950 | .6300 |
| Subjective norms | .8730 | .8740 | .9080 | .6640 |
| TPACK | .8650 | .8680 | .9030 | .6510 |

of a variable's AVE must be .500 (Hair et al., 2021), which informs 50% of the indicators' variance. All variables had AVE values of more than .500, ranging from .5360 (behavior) to .6640 (subjective norms).

Discriminant validity examines whether constructs that should not be related are actually unrelated (Gaskin et al., 2018). We elaborated the discriminant validity through the heterotrait-monotrait (HTMT) ratio of correlations as the primary measurement. This study's threshold value for HTMT was <.900 (Gaskin et al., 2018). When the value is higher than .900, discriminant validity emerges as an issue (Gaskin et al., 2018). Thus, the values should be less than .900; all HTMT values were lower than .900, ranging from .584 to .800. Therefore, no discriminant validity issues appear on the measurement model assessment. Based on the measurement model assessments (loadings, ICR, convergent and discriminant validity), the survey instrument of the current study was valid and reliable. The final instrument is included in the Appendix.

### Structural model

A structural model focuses on assessing the inter-correlation between the involved variables, allowing academics to analyze the relationships simultaneously. The study applied PLS bootstrapping selection (5000 samples) in estimating the structural model; bootstrapping is a recommended PLS-SEM procedure for producing sub-samples of observations chosen at random from the original dataset (with replacement) (Lowry & Gaskin, 2014). It is a nonparametric approach to testing statistical significances of PLS-SEM results such as path coefficient (β), t value, and *p*-value through the SmartPLS application. Before reporting the structural model, it is recommended to report the model fit indices (Benitez et al., 2020; Henseler et al., 2016). The standardized root mean square residual (SRMR) is recommended to determine the model fit in PLS-SEM-based studies; the SRMR maximum value should be .08 (Bentler & Bonett, 1980). The squared euclidean distance (d_ULS) and the geodesic distance (d_G) are

**Table 4.** HTMT and model fit.

| | Attitudes | Behavior | Behavioral intention | Perceived behavioral control | Subjective norms | Model fit | |
|---|---|---|---|---|---|---|---|
| Behavior | .7900 | | | | | SRMR | .0510 |
| Behavioral intention | .6380 | .8540 | | | | d_ULS | 1.4510 |
| Perceived behavioral control | .8170 | .8000 | .7100 | | | d_G | .4760 |
| Subjective norms | .7680 | .7850 | .6770 | .7740 | | | |
| TPACK | .7290 | .6810 | .5840 | .6800 | .7630 | | |

also included in this process. As shown in Table 4, the SRMR value met the criteria; the value was below .08, and d_ULS and d_G are also satisfactory at 1.450 and .4760, respectively (Bentler & Bonett, 1980).

In assessing whether the relationships are significant, we conducted the bootstrapping procedure in the SmartPLS 3.3.3. Assuming a 5% significance level, we reported significances through β, t value, and *p*-value (Hair et al., 2014; Ogbeibu et al., 2018). All correlations informed in the structural model are significant (Table 5 and Figure 3). The PLS-SEM computation shows the significance of all hypotheses (H1, H2, H3, H4, H5, H6, and H7. The strongest predictor for behavioral intention was perceived behavioral control ($\beta$ = .3080; $p < .01$; t=7.76) followed by subjective norms ($\beta$ = .2350; $p < .01$; t=6.18). Meanwhile, the weakest correlation appeared between TPACK and behavioral intention ($\beta$ = .2350; $p < .05$; t=6.18).

**Table 5.** Structural model; path coefficient (β), *p*-value, significance, $f^2$.

| H | Path | β | *p*-Value | Sig. | $f^2$ |
|---|---|---|---|---|---|
| H1 | TPACK -> Behavioral intention | .0820 | <.05 | Yes | .0060 |
| H2 | Subjective norms -> Behavioral intention | .2350 | <.001 | Yes | .0390 |
| H3 | Attitudes -> Behavioral intention | .1140 | <.05 | Yes | .0090 |
| H4 | Perceived behavioral control -> Behavioral intention | .3080 | <.001 | Yes | .0700 |
| H5 | TPACK -> Behavior | .1910 | <.001 | Yes | .0660 |
| H6 | Perceived behavioral control -> Behavior | .3170 | <.001 | Yes | .1550 |
| H7 | Behavioral intention -> Behavior | .4420 | <.001 | Yes | .3460 |

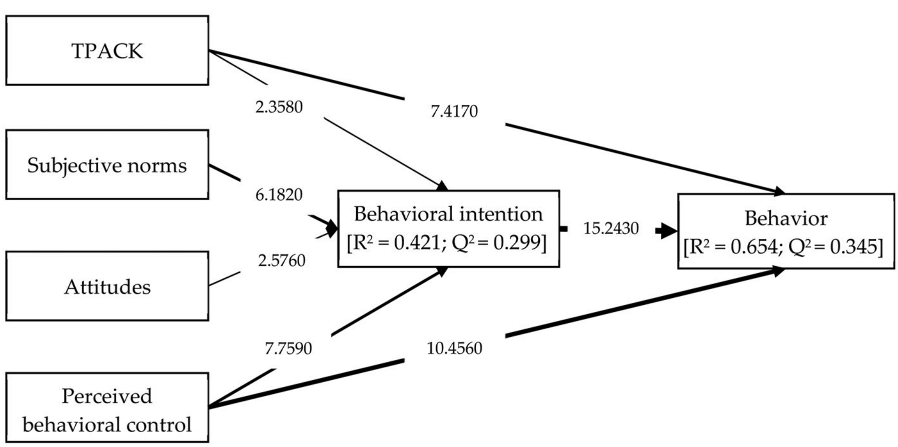


**Figure 3.** Final model; t value, R2, and $Q^2$.

Behavioral intention was the most significant predictor of behavior using technology during teaching practice (β = .4420; $p$ < .01; t = 15.24). It was followed by the relationship between perceived behavioral control and behavior (β = .3170; $p$ < .01; t = 1.46). TPACK is the least strong predictor for behavior (β = .3170; $p$ < .01; t = 1.46).

In addition to the significance test results, we also performed coefficient determination ($R^2$), effect sizes ($f^2$), and predictive relevance ($Q^2$) as statistical approaches for PLS-SEM-based research. $R^2$is defined as the values measuring the model's predictive accuracy (Piepho, 2019). $R^2$ values are from 0 and 1. The values of .75, .50, and .25 are respectively defined as substantial, moderate, and weak (Henseler et al., 2012). Figure 3 shows the result of $R^2$; Behavioral intention (.421, weak) and behavior (.654, medium). Further, $f^2$or effect sizes compute the impact of predictors on dependent variables. The $f^2$ value of .02 has a small effect, .15 has a medium effect, and .35 has a large effect (Henseler et al., 2012). Table 4 shows that the strongest effect size emerged on the predicting power of behavioral intention on behavior ($f^2$ = .3460), while the smallest $f^2$ was between TPACK and behavioral intention ($f^2$ = .0060). Results for the predictive relevance are reported through the Stone-Geisser's $Q^2$ values (Götz et al., 2010); predictive relevance with $Q^2$is a computational procedure to assess predictive accuracy in PLS-SEM (Hair et al., 2019). When the model shows predictive relevance, it accurately predicts the data points of indicators in the model. The procedure was done through blindfolding in the SmartPLS (Hair et al., 2019). Values larger than 0 indicate that the $Q^2$ for the construct is achieved; 0.02 (small), 0.15 (medium), and 0.35 (large). $Q^2$ values for behavioral intention and behavior were above 0, facilitating the model's predictive relevance.

### *Importance performance analysis (IPMA)*

To support the structural model examination, IPMA was performed to disclose the potential area of improvement in behavioral intention and behavior of TI during teaching practice. This is to understand the improvement priority among exogenous constructs for the selected endogenous constructs (behavioral intention and behavior). IPMA extends the results of PLS-SEM by considering the construct's performance. Thus, conclusions can be elaborated on two dimensions (importance and performance), essential for the managerial actions of the relationship tests. IPMA could help researchers facilitate the contribution and recommendation of research by recognizing the performance and importance of related variables in examining the model (Ringle & Sarstedt, 2016; Streukens et al., 2017).

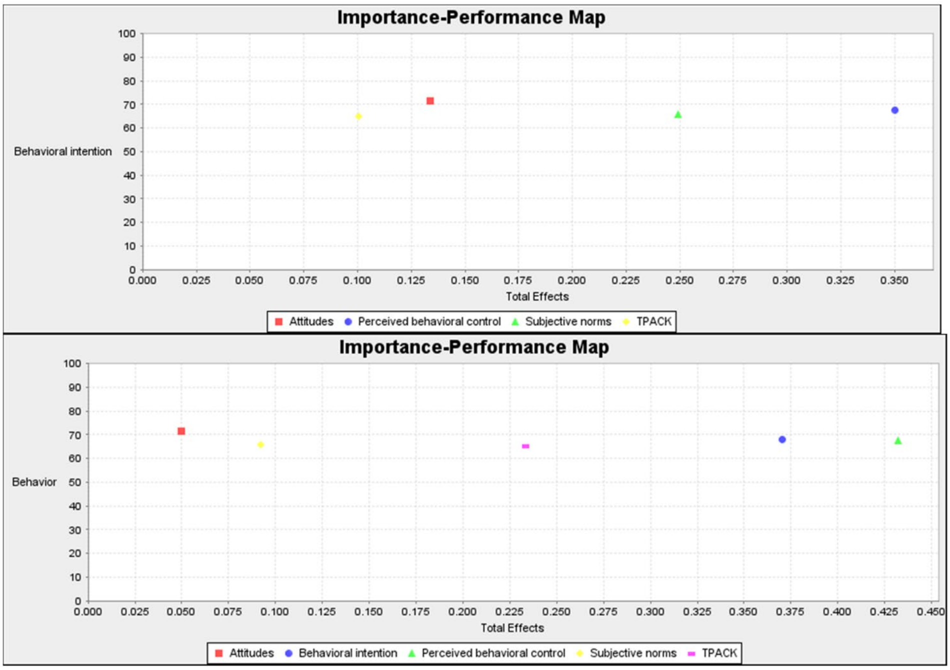


**Figure 4.** IPMA unstandardized maps; behavioral intention and behavior.

**Table 6.** IPMA results; importance-performance.

| | Importance | | Performance |
|---|---|---|---|
| | Behavioral intention | Behavior | |
| Attitudes | .1340 | .0500 | 71.374 |
| Behavior | | | 7.722 |
| Behavioral intention | | .3700 | 67.944 |
| Perceived behavioral control | .3500 | .4320 | 67.668 |
| Subjective norms | .2490 | .0920 | 65.807 |
| TPACK | .1010 | .2340 | 65.027 |

IPMA in PLS-SEM has more advantages than regular IPMA, which relies on multiple regression analysis (Streukens et al., 2017).

Figure 4 and Table 6 show the computational results of IPMA in the SmartPLS for factors predicting behavioral intention and behavior regarding TI during teaching practice among Indonesian pre-service teachers. Slightly different from the effects of path coefficients in the structural model, the importance in IPMA refers to the standardized regression coefficients between related variables, computed in the SmartPLS of the IPMA menu, which represent the priority of importance of affecting factors in improving the selected dependent variables. In predicting behavioral intention, perceived behavioral intention possessed the highest importance (.3500), followed by subjective norms (.2490), attitudes (.1340), and TPACK (.1010). Perceived behavioral control was also the most performed variable in affecting behavior regarding technology integration during practicum (.4320); this was followed by behavioral intention (.3700), TPACK (.2340), subjective norms (.0920), and attitudes (.0500). Further, greater values of performance for a construct (1 to 100) refer to higher performance. The results for IPMA values range from 65.027 to 71.374 for performance. Attitudes obtained the highest performance (71.374), followed by behavior (70.722), behavioral intention (67.944), perceived behavioral control (67.668), subjective norms (65.807), and TPACK (65.027). The performance covers significant areas for improving the critical factors among related variables within a model (Streukens et al., 2017).

## Discussion

Following the measurement model, the structural model and IPMA were assessed. Perceived behavioral control, which represents pre-service teachers' perception of their ability to integrate technology during their teaching practicum, was the most significant factor in predicting the pre-service teachers' behavioral intention and behavior regarding TI during teaching practice. Previous researchers also made similar reports (Fatima et al., 2019). Lung-Guang (2019) reported perceived behavioral control as the strongest predictor of behavioral intention. However, in other studies such as Teo and van Schaik (2012), no relationship between perceived behavioral control and behavioral intention emerged.

Subjective norms, which reflect pre-service teachers' perception that their peers, teachers, and family support TI during teaching practice, were the second decisive and important factor in predicting behavioral intention. This finding could be led by the assumption that cultural and social factors significantly contribute to behavioral intention regarding technology in teaching practice. Compared to Western culture, which also revealed the important role of subjective norms in predicting TI (e.g., Kreijns et al., 2013; Sánchez-Prieto et al., 2019), Asian people are more recognized as a collective community, highly respecting other people's opinions (Garcia et al., 2014). Perhaps unsurprisingly then, Indonesian pre-service teachers' TI was significantly predicted by the influence of their surroundings. The finding mirrored previous studies reporting subjective norms as a strong predictor of the intention or actual use of technology in the TPB framework's teaching and learning process (Cheng, 2019; Fatima et al., 2019; Kreijns et al., 2013; Mohammadi, 2015; Salleh, 2016; Sánchez-Prieto et al., 2019; Teo & van Schaik, 2012).

Furthermore, the findings also showed that attitudes were significantly related to behavioral intention regarding Indonesian pre-service teachers' TI during teaching practice. Similar results were reported by Fatima et al.

(2019) and Kreijns et al. (2013). Moreover, Teo and van Schaik (2012) and Salleh (2016) reported that favorable attitudes were the most strongly predictors of TI in teaching for TPB frameworks. However, other studies indicated that attitudes do not significantly correlate to behavioral intention and behavior (Cheng, 2019; Lung-Guang, 2019; Sánchez-Prieto et al., 2019).

TPACK was also essential in predicting behavioral intention and behavior regarding TI during teaching practice. With *p*-values of less than 0.5, both behavioral intention (β = .0820) and behavior (β =.1910) were significantly predicted by TPACK in this study. The finding supports prior studies that showed the roles of TPACK in predicting behavioral intention or behavior regarding TI (Habibi et al., 2020; Joo et al., 2018; Tondeur et al., 2017). Even though TPACK, which represents knowledge, is significantly related to behavioral intention and behavior, the statistical values were lower than subjective norms, attitudes, and perceived behavioral control, representing beliefs in predicting behavioral intention and behavior. These results might be because pre-service teachers lack knowledge in combining technology, pedagogy, and content in teaching.

Thus, this study provides support for the importance of beliefs in relation to TI in teaching. The study adds the existing literature on factors affecting TI in education, especially during teaching practicum. To enhance TI, teacher education must recognize the variations in pre-service teachers' TPACK and TPB areas. Teachers' strengths should be highlighted and exploited (Valtonen et al., 2018). Pre-service teachers with a high level of knowledge and beliefs for TI in the classroom should be encouraged to develop their strong points further and support their weaknesses.

## Conclusion

This paper extends the existing literature demonstrating the relationships between beliefs/knowledge variables and TI during teaching practice, behavioral intention, and behavior through PLS-SEM approaches, structural model and IPMA. In this study, beliefs (subjective norms, attitudes, and perceived behavioral control) had more significant relationships than knowledge (TPACK) with technology integration. Beliefs in the value of technology use are needed for pre-service teachers to support technology knowledge acquisition. Improved beliefs and knowledge enable pre-service teachers to improve instruction methods and personalize learning; teacher education can benefit from these factors to enhance the program's efficiency and effectiveness (Jamil et al., 2012). This result should be explored further to prepare new teachers for TI during teaching practice. Training new teachers should focus further on developing beliefs as well as knowledge in teacher education.

The findings provide further in-depth understanding of the discrepancies between beliefs and knowledge for pre-service teachers and may be helpful in considering the design of teacher education programmes. Policymakers developing such programmes may wish to consider appropriate guidelines or policies on TI in education regarding beliefs and knowledge for TI. For example, technology-based courses could be further improved with a focus on fostering both beliefs in relation to and knowledge about technology's benefits for teaching to improve learning (Bereczki & Kárpáti, 2021). Focusing in particular on bridging between beliefs and knowledge to improve pre-service teachers' use of technology during teaching practice (i.e., on practicum) could also be an important area of focus. Such belief/knowledge-based training could positively impact their teaching behavior, decision-making, and interactions, assisting in forming better planning, preparation, and decisions and identifying teaching activities in the classroom with effective use of technology.

Some limitations emerged from this study. The method used in this study only recognizes the existence of the relationships and the strength of a causal hypothesis, but it does not precisely report the causal direction. A self-reported questionnaire could also be a limitation; future researchers could extend the scale to give more insights regarding beliefs, knowledge, and educational TI. Other approaches such as observation, experiment, and interview are recommended to improve understanding of beliefs and knowledge. Contexts and settings could also be varied particularly to cover wider programme elements; the enrichment of future findings can enhance the quality of the research in TI. Demographic information should also be included to understand the differences in factors predicting TI. In addition, larger and more representative samples in the quantitative study could promote confidence in the generalizability of future research.

## Disclosure statement

No potential conflict of interest was reported by the authors.

## ORCID

Akhmad Habibi http://orcid.org/0000-0001-7687-2858
Ahmad Samed Al-Adwan http://orcid.org/0000-0001-5688-1503
Nour Awni Albelbisi http://orcid.org/0000-0002-7800-6483

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## Appendix: Survey instrument [English version]

Demographic Information

1. University
2. Gender
    a. Female
    b. Male
3. Age range
    a. 18–19
    b. 20–21
    c. >22
4. Major
    a. Social science education
    b. Science education
    c. Language education
    d. Preschool or elementary teacher education

Please tick in the provided column

1 = Strongly disagree
2 = Disagree
3 = Neutral
4 = Agree
5 = Strongly agree

### Technological pedagogical and content knowledge (TPACK)

| No. | Statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1. | I can teach lessons that combine my content area, technology, and teaching approaches appropriately. | | | | | |
| 2. | I can select technology to use in my classroom that enhances what I teach, how I teach, and what students learn. | | | | | |
| 3. | I can use strategies that combine content, technology, and teaching approaches that I learned about in my coursework. | | | | | |
| 4. | I can provide leadership in helping others coordinate content, technology, and teaching approaches at my school. | | | | | |
| 5 | I can choose technology that enhances the content for a lesson. | | | | | |

## Attitude

| No. | Statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 2. | I think that technology integration improves engagement with content and students | | | | | |
| 3. | Integrating technology during teaching practice is relevant with the 21st century teaching | | | | | |
| 4. | I think that technology integration enriches the learning experience through innovative tools | | | | | |
| 5. | I think that technology integration helps facilitate understanding of material/concepts | | | | | |
| 6. | I feel that technology is easy to use | | | | | |
| 7. | Technology integration caters to the needs of different learning styles | | | | | |
| 8. | I think that using technology improves students' evaluation in their learning | | | | | |

## Subjective norms

| No. | Statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1. | My colleagues expect me to use technology for teaching. | | | | | |
| 2. | The principal of my school expects me to use technology for teaching. | | | | | |
| 3. | My students assume that I can use technology for teaching. | | | | | |
| 4. | Parents of my students expect me to use technology for teaching. | | | | | |
| 5. | My professor expects me to integrate technology into teaching. | | | | | |

## Perceived behavioral control

| No. | Statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1. | I think that the advantages of using technology outweigh the disadvantages. | | | | | |
| 2. | I have high self-efficacy in personal use in teaching using technology. | | | | | |
| 3. | I think access to learning outside the classroom supports technology use. | | | | | |
| 4. | I think that access to technology is not a problem in technology integration. | | | | | |
| 5. | I think supporting human resources is not an issue for technology integration. | | | | | |

## Behavioral intention

| No. | Statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1. | I will use technology for simulation. | | | | | |
| 2. | I will use computers or smartphones application in my instructional activities. | | | | | |
| 3. | I will use technology to communicate with my students. | | | | | |

## Behavior

| No. | Statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1. | I use search engines (e.g., Google, Yahoo, etc.) to look for information on the Internet for teaching preparation. | | | | | |
| 2. | I do assessments using technology. | | | | | |
| 3. | Using technology, I create instructional materials (e.g., handouts, tests, etc.). | | | | | |
| 4. | I create lesson plans using technology. | | | | | |
| 5. | I use data-show projectors to present the subject matter. | | | | | |
| 6. | I use presentation programs (e.g., PowerPoint, etc.) to present the subject matter. | | | | | |
| 7. | I prepare visual effects to enhance learning concepts through technology. | | | | | |
| 8. | I prepare sound effects to enhance learning concepts through technology. | | | | | |
| 9. | I use the Internet for my teaching, e.g., social media, wiki, etc. | | | | | |