



# The role of TPACK in affecting pre-service language teachers' ICT integration during teaching practices: Indonesian context

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## Abstract

This study examined Indonesian pre-service language teachers' use of information and communication technology (UICT) during teaching practices. We used technological pedagogical and content knowledge (TPACK) framework to predict the UICT. The objective of the study is to determine if the TPACK is a valid model to explain Indonesian pre-service language teachers' UICT during teaching practices. 287 pre-service language teachers from three Indonesian universities completed a 38-item survey instruments based on the TPACK and UICT. The development of the survey instruments was done mainly through content validity index (CVI) and exploratory factor analysis (EFA). Findings of the study that were obtained through partial least squares structural equation modeling (PLS-SEM) informed 13 hypotheses. Overall, the TPACK components are interconnected and also reported to be a valid model to help explain Indonesian pre-service language teachers' UICT during teaching practices.

**Keywords** TPACK · Pre-service language teachers · UICT · Teaching practices

## 1 Introduction

Research on educational technology conducted in different contexts and settings have produced a common consensus that technology integration in education is a complex process (Mishra and Koehler 2006). One of many theoretical frameworks elaborated in educational technology research is TPACK that emerges as a framework combining

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fundamental dynamics of instructional activities using technology (Archambault and Barnett 2010). TPACK has recently been applied in either technology-based teaching activities or evaluation of teachers' technology integration (Agyei and Voogt 2012; Chai et al. 2012; Özgün-Koca et al. 2010; Valtonen et al. 2019). Although some research instruments on TPACK have been developed and examined for their interconnection (e.g. Archambault and Barnett 2010; Koh et al. 2010; Mumcu and Usluel 2010; Schmidt et al. 2009) that applied in various settings, a close investigation of the relationship between TPACK and UICT is still limited (Aslan and Zhu 2017; Reyes et al. 2017). As we were working on this study, the importance of interaction between some TPACK components and technology integration was also reported namely between pedagogical knowledge (PK) and ICT integration (Aslan and Zhu 2017), TPACK and intention to use Web 2.0 (Teo et al. 2018), and PK, technological knowledge (TK) and technology integration (Taimalu and Luik 2019).

However, those studies only summarized certain TPACK components' influences towards technology integration in education. Therefore, this study aimed at elaborating all TPACK components' interconnection and their roles in predicting UICT from the perspective of pre-service language teachers. To achieve the goals of the study, we first discussed the development and validation of research instruments designed specifically to measure teachers' technology integration knowledge and experiences as described in the TPACK framework and UICT.

## 2 Literature review

### 2.1 TPACK

The origin of TPACK was actually based on Shulman's pedagogical content knowledge (PCK) concept (Mishra and Koehler 2006). PCK is basically about the development of the most suitable teaching practices as well as the components. In the discussion about PCK, Shulman (1986) addressed a contrast idea of teaching content with general pedagogical approaches as well as teaching with content-specific pedagogy. The discussion on this was based on the historical development of teaching that argued content and pedagogy were included as "one indistinguishable body of understanding" (p.6). Regarding these meaningful principles of PCK, TPACK was introduced as a framework describing the components of effective integration of technology in instructional activities (Mishra and Koehler 2006; Schmidt et al. 2009). The appropriate way for technology integration within this framework needs teachers to possess a conceptualization formed by considering the interactions among the components; technology, content, and pedagogy" (Angeli and Valanides 2009). Although technology, content, and pedagogy are likely becoming a representation of different knowledge bases, interactions and link among the core concepts comprise the basic essence of the whole framework (Archambault and Barnett 2010). TPACK consists of seven knowledge bases, three of which are core knowledge bases; TK, PK, and content knowledge (CK). Meanwhile, other four components are established from the interactions among the core bases comprising technological content knowledge (TCK), PCK, technological pedagogical knowledge (TPK), and TPACK. The area, definition, and example of the seven TPACK components can be seen in Table 1.

**Table 1** TPACK area, definition, and example (Valtonen et al. 2019)

| TPACK area | Definition   | Example  |
|------------|--|--|
| TK         | Knowledge of how to use different technologies   | Knowledge of how to use ICT  |
| PK         | Knowledge of different teaching and learning approaches and theories of learning   | Knowledge of how to use inquiry-based learning method  |
| CK         | Knowledge of subject matter  | Knowledge of language teaching   |
| PCK        | Knowledge of how to combine the CK and PK in order to make the content understandable  | Knowledge of analogies to teach English as a foreign language  |
| TCK        | Knowledge of how to utilize appropriate technology to support teaching and learning approaches without considering the subject matter  | Knowledge of <i>Kahoot</i> -application in teaching language   |
| TPK        | Knowledge of how ICT is used by content experts  | Knowing how to use content-specific simulations, CALL  |
| TPACK      | Knowledge of how to combine different areas and how to use appropriate pedagogical approaches for certain content with appropriate ICT | Knowledge of how to use the application for supporting students' brainstorming and sharing of ideas in language learning |

## 2.2 Technology integration in language teaching

In nowadays' classrooms, the existence of technologies in educational settings has become a usual thing and a norm for many schools around the world (Castro 2012). In fact, according to Niemelä et al. (2016), digital tools such as tablets, computers, tablets, digital projection systems, digital cameras, and Internet have been considered among compulsory facilities not only for higher education institutions but also K-12 schools. Many K-12 schools are now in the race to use 1:1 technology program to ensure students and teachers have access to ICT (Keane and Keane 2019). This situation causes an expectation of cultural change in society in which technology-integrated teaching is consider fostering better learning for students (Prasojo et al. 2019). In fact, ability to integrate technologies into teaching has been listed as one of the requirements of recruiting new teachers including language teachers.

Specific technology integration is important in language teaching. Habibi et al. (2018) and Kabilan et al. (2010) reported that social media can help students practice their language meaningfully. Computer-based communication tools can improve students' language skills by facilitating interaction between students and native English-speakers (Golonka et al. 2014). Students have visual and auditory sources of learning language (Bernhardt 2010). Augmented reality was reported to help language learners coordinate and engage in the virtual world during problem solving tasks (Liu et al. 2016). In addition, Chen (2018) reported factors affecting the use of mobile learning among English learners. Regarding TPACK, language teachers enhanced second language (L2) interaction in form of TPACK by drawing students' attention for grammar through animation, supporting vocabulary use with image-based exercises and assessing the use of sentence patterns with a Chatbot (Tseng 2018). However, the use of more

general technology like ICT for L2 teaching is also suggested to investigate including from the perspectives of pre-service language teachers (Arrosagaray et al. 2019). In terms of TPACK, Mei et al. (2018) reported that pre-service teachers’ knowledge of technology in a teacher education program is positively related to the use of technology in the classroom. While Tai (2015) informed that TPACK-in-Action workshops positively impacted on the 24 language teachers’ teaching performance. In addition, Bustamante’s (2019) qualitative study on Spanish teaching indicated positive learning experiences for technology, pedagogy, and content within technology integration.

### 2.3 The study and hypotheses

Adopting technology in teaching requires knowledge of technology, pedagogy, and content. TPACK can play a very important role in language teaching within the integration of ICT. Many studies have addressed the relationship among all TPACK components. In addition, some studies explored some TPACK components in relation to technology integration. However, a comprehensive TPACK interconnection and their influences towards technology integration have not much informed. Therefore, this study aimed at elaborating the interconnection and relationship with technology integration from the perspective of pre-service language teachers in teaching English. To achieve the aims of the study, 13 hypotheses were formulated (Fig. 1) that involve 8 variables; TK, CK, PK, TCK, PCK, TPK, TPACK, and IUCT.

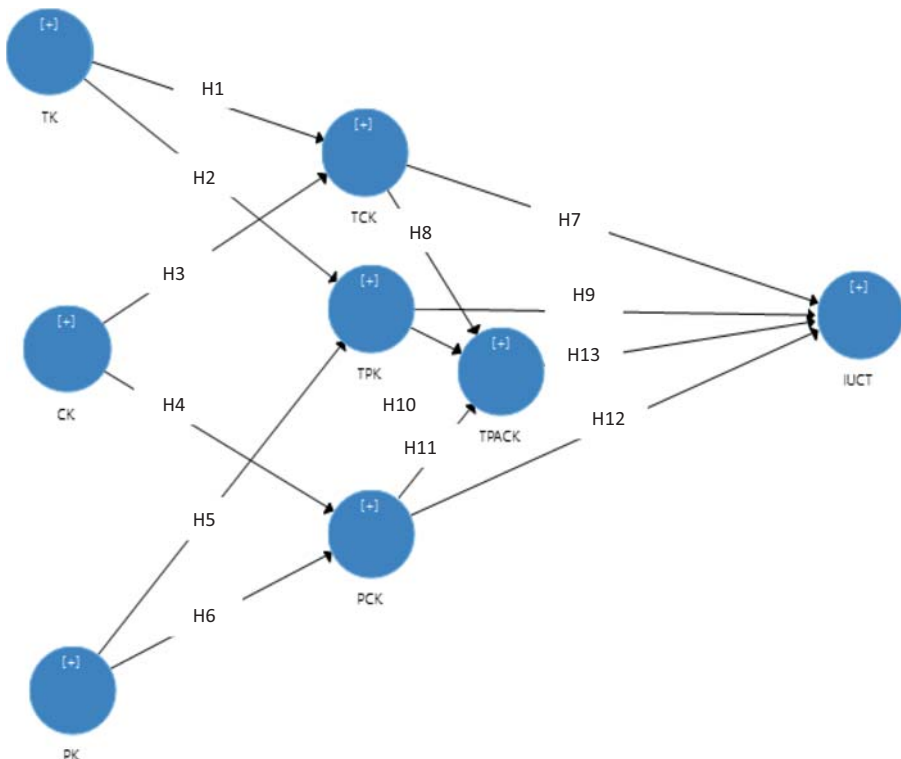


Fig. 1 Initial structural model

## 2.4 TK, CK, and PK

TK in this study is defined as knowledge of how to use different technologies perceived by Indonesian pre-service language teachers. TK has been proposed to have significant correlation with TCK and TPK (Chai et al. 2012; Dong et al. 2015; Pamuk et al. 2015; Scherer et al. 2017). Chai et al. (2012) failed to identify the relationship between TK and PCK or TPK. Meanwhile, Dong et al. (2015) reported that TK has significantly affected TCK ( $\beta = 0.630$ ;  $p < 0.01$ ) and TPK ( $\beta = 0.460$ ;  $p < 0.01$ ). Similarly, Pamuk et al. 2015 informed strong relationships between PK and TCK ( $\beta = 0.740$ ;  $p < 0.01$ ) as well as PK and TPK ( $\beta = 0.620$ ;  $p < 0.01$ ). Another report by Scherer et al. (2017) informed the influence of TK to TCK ( $\beta = 0.860$ ;  $p < 0.01$ ) and TK to TPK ( $\beta = 0.810$ ;  $p < 0.01$ ). Due to the roles of TK in predicting TCK and TPK, two hypotheses were proposed in this study;

H1: TK will positively and significantly predict TPK.

H2: TK will positively and significantly predict TCK.

CK in this study is knowledge of subject matter that was also considered important in predicting two second-level knowledge bases, TCK and PCK (Chai et al. 2012; Dong et al. 2015; Pamuk et al. 2015). Even though Chai et al. (2012) found that CK was not a predictor for both TCK and PCK, Dong et al. (2015) reported that CK significantly affected TCK ( $\beta = 0.130$ ;  $p < 0.05$ ). Meanwhile, Pamuk et al. (2015) revealed TCK ( $\beta = 0.860$ ;  $p < 0.01$ ) and PCK ( $\beta = .860$ ;  $p < 0.01$ ) was statistically related to CK. 2 hypotheses were made regarding the role of CK;

H3: TK will positively and significantly predict TCK.

H4: TK will positively and significantly predict PCK.

Similar to TK and CK, PK which is defined as knowledge of different teaching and learning approaches has been reported to significantly influence TPK and/or PCK (Chai et al. 2012; Dong et al. 2015; Pamuk et al. 2015; Valtonen et al. 2017). Chai et al. (2012) only reported the relationship between PK and TPK ( $\beta = 0.520$ ;  $p < 0.01$ ). Likewise, PK was also reported to be significant for TPK ( $\beta = 0.280$ ;  $p < 0.01$ ) in a study conducted by Pamuk et al. (2015). However, Dong et al. (2015) informed both TPK ( $\beta = 0.350$ ;  $p < 0.01$ ) and PCK ( $\beta = 0.640$ ;  $p < 0.01$ ) were significantly affected by PK.

H3: PK will positively and significantly predict TPK.

H4: TK will positively and significantly predict PCK.

## 2.5 TPK, TCK, PCK, TPACK

TPK in this study is defined as knowledge of how ICT is used by content experts perceived by the respondents. Some previous studies have been addressing the interconnection between TPK and TPACK (Chai et al. 2012; Dong et al. 2015; Pamuk et al. 2015; Scherer et al. 2017). Pamuk et al. (2015) found and reported that TPK was correlated with TPACK ( $\beta = 0.350$ ;  $p < 0.01$ ). Scherer et al. (2017) also revealed that TPK strongly affect TPACK ( $\beta = 0.980$ ;

$p < 0.01$ ). On the other hand, Chai et al. (2012) and Dong et al. (2015) reported that TCK was not related to TPACK in their study findings. Regarding UICT, not many studies addressed TPK relationships with UICT. Graham (2011) quantitatively addressed that TPK has a great contribution to technology integration. To investigate comprehensively TPACK interconnection and their relationship with UICT, we addressed two hypotheses in regard to TPK;

H7: TPK will positively and significantly predict TPACK.

H8: TPK will positively and significantly predict UICT.

TCK in this study refers to knowledge of how to utilize appropriate technology to support English teaching and learning approaches without the subject matter. Similar to TPK, not many TCK studies focused on the correlation between TCK and UICT. However, some researchers reported TCK as a strong predictor for TPACK (Chai et al. 2012; Dong et al. 2015; Pamuk et al. 2015). Pamuk et al. (2015) reported a strong correlation between TCK and TPACK ( $\beta = 0.580$ ;  $p < 0.01$ ) while Chai et al. (2012) found no relationship between TCK and TPACK. Similarly, Dong et al. (2015) reported that TCK positively predicted TPACK ( $\beta = 0.490$ ;  $p < 0.01$ ). Based on these backgrounds, we proposed 2 hypotheses regarding TCK as predictors of TPACK and UICT;

H9: TPK will positively and significantly predict TPACK.

H10: TPK will positively and significantly predict UICT.

PCK is described as the knowledge of how to combine the CK and PK in order to make the content more understandable in English teaching. Some researchers have examined statistical correlation between PCK and TPACK (Chai et al. 2012; Dong et al. 2015; Pamuk et al. 2015; Scherer et al. 2017). Chai et al. (2012), Dong et al. 2015, and Pamuk et al. (2015) reported that no correlation emerged between PCK and TPACK. However, Scherer et al. (2017) informed that PCK was a strong predictor for TPACK ( $\beta = 0.980$ ;  $p < 0.01$ ). We proposed 2 hypotheses in relation to the role of PCK in predicting TPACK and UICT;

H11: TPK will positively and significantly predict TPACK.

H12: TPK will positively and significantly predict UICT.

TPACK in this study refers to knowledge of how to combine different areas and how to use appropriate pedagogical approaches for certain content with appropriate ICT. TPACK has been reported to fit predicting technology integration (Joo et al. 2018; Teo et al. 2018; Tondeur et al. 2017). Teo et al. (2018) informed TPACK's significance for intention to use Web 2.0 in China ( $\beta = 0.260$ ;  $p < 0.01$ ). Similarly Tondeur et al. (2017) also reported the positive relationship between TPACK and intention to integrate technology. However, TPACK was not significant predicting intention to use technology reported by Joo et al. (2018). To anticipate the relationship, a hypothesis was proposed for this study;

H13: TPACK will positively and significantly predict UICT.

## 3 Method

### 3.1 Conceptual model of the study

This study was conducted from October 2018 to July 2019 utilizing survey as the data collection method. Review of previous studies and the assessment of validity and reliability of the instruments were done before the data collection. The assessment of the model was conducted through partial least squares structural equation model (PLS-SEM). This study used a predictive approach to estimate the model for causality since the process of the study is not interfered by the assumption of data distribution (Hair et al. 2019).

### 3.2 Instrumentation

The review of literature helps a researcher define and analyse the theories and concepts of the theoretical framework of the research, as well as determine appropriate methods and instruments to be adapted in order to elaborate the research objectives (Hair et al. 2016). We adapted and constructed survey instruments from previous related studies; TPACK (Koh et al. 2010; Luik et al. 2018; Schmidt et al. 2009) and UICT (Aslan and Zhu 2017). As a result 44 items were generated in this stage. Afterward, the instruments were examined through face and content validity through discussion and content validity index (CVI) for social and cultural as well as setting differences (Lynn 1986).

For face validity, a panel of five users (three pre-service teachers, a program staff, and a teacher educator) was involved in discussing the adapted instruments. The process was done through interactive group discussion. For content validity, we discussed the instruments with five Indonesian experts. The experts were professors in the fields of educational technology and educational policy. After the discussion, some items were revised and 4 items were eliminated since they could not be used in the educational context of Indonesia resulting 40 items for further validation process.

We distributed the instruments to ten experts in educational technology and Indonesian educational policy. Twenty-seven experts were contacted; fifteen experts did not reply the call and 2 experts refused to participate. Each item of the survey instruments was evaluated by rating its relevance, clarity, and simplicity. The attributes of the items were rated on a 4-point scale (1 = not relevant/ not clear/ not simple to 4 = very relevant/ very clear/ very simple (Halek et al. 2017; Lynn 1986). The experts' panel was requested to evaluate if the items covered all related aspects or if there were something missing in the components. The CVI was measured both at the item level (I-CVI) and scale level (S-CVI) for the three instruments' attributes. The I-CVI was measured by providing a score of 3 or 4 to the experts that were divided by the total number of experts. The score of 3 or 4 in the CVI theory represents positive responses (Lynn 1986). With a total of ten experts, the I-CVI should not be less than 0.780 (Polit and Beck 2009). In calculating the S-CVI (Polit and Beck 2009; Fleiss et al. 2004), the average portion of the items on one scale rated 3 or 4 (average agreement by experts = S-CVI/AVE) where the



threshold value is 0.800 (Halek et al. 2017; Polit and Beck 2009). Most items' values were above the threshold values of 0.780 for I-CVI and 0.800 for S-CVI. However, PK4 was dropped because its I-CVI and S-CVI value was lower than the threshold. Additionally, a modified kappa ( $k^*$ ) and the probability of chance occurrence ( $P_c$ ) were also calculated.

Besides face and content validity, the instruments have also been examined through exploratory factor analysis (EFA) using some measurements; Sphericity Bartlett Test ( $p < 0.500$ ), factor loading, Kaiser-Meyer-Olkin ( $> 0.800$ ), Factor Loading  $\geq (0.500)$ , Communalities ( $\geq 0.300$ ), and Eigenvalue ( $\geq 1.00$ ) which were proposed by Hair et al. (2010) and Pallant (2011). The survey instruments were piloted to 98 pre-service language teachers. 1 item (TPK4) was dropped due to its low loading value. Other items included in the EFA meet the measurements. Because PK4 and TPK4 were dropped, 38 indicators in eight constructs were included after the assessment of CVI and EFA (Table 2). The CVI and EFA data process can be accessed at Mendeley dataset repository.

### 3.3 Data collection

As face and content validity were done, we distributed the instruments to the respondents. The data were obtained from three Indonesian universities that have schools of education. To date, the letters of permission of the data collection were achieved and signed by each dean of the schools of education of each university. The distribution of the data was done using printed materials as it is recommended by the funder of this research. We spent a-three month time in collecting the data. All responses were compiled into Microsoft Excel and SPSS.

The population of this study is approximately 1.2 million student teachers in Indonesian PTTs centered in 374 teacher training institutes or programs or PTTs (Ministry of research, technology, and higher education, MoRTHE 2018). Meanwhile, the target population of this study covered all Indonesian pre-service language teachers. Through stratified sampling (Creswell 2014), we divided the target population from their universities. As a result, 310 instruments were distributed. However, only 287 data were measurable; University A (142), University B (67), and University C (78).

**Table 2** The indicators after CVI and EFA

| No | Construct | Indicators   | No of items |
|----|-----------|--|-------------|
| 1  | TK        | TK1, TK2, TK3  | 3           |
| 2  | PK        | PK1, PK2, PK3, PK5, PK6, PK7   | 6           |
| 3  | CK        | CK1, CK2, CK3  | 3           |
| 4  | TCK       | TCK1, TCK2, TCK3   | 3           |
| 5  | PCK       | PCK1, PCK2, PCK3   | 3           |
| 6  | TPK       | TPK2, TPK3, TPK4   | 3           |
| 7  | TPACK     | TPACK1, TPACK2, TPACK3, TPACK4, TPACK5   | 5           |
| 8  | UICT      | UICT1, UICT2, UICT3, UICT4, UICT5, UICT6,<br>UICT7, UICT8, UICT9, UICT10, UICT11, UICT12 | 12          |



### 3.4 Data preparation

The process of data conversion so that they can be processed by the computer was known as data preparation. The data preparation in this study was done to ensure the completeness and accuracy of the data as well as assurance that the data had no problems with outliers, missing values, non-normal distributions, and/or errors inputting the data (Hair et al. 2010). The assessment of skewness and kurtosis as well as Q-Q plot and histogram was carried out for the normality of the data.

### 3.5 Measurement models in the study

Measurement model was the examination process of the reliability and validity of the construct measures. Four reflective measurement models (reflective indicator loadings, internal consistency reliability, convergent validity, and discriminant validity) were examined in this process.

#### 3.5.1 Reflective indicator loadings

We used PLS-SEM result format in reporting the reflective indicator. Table 3 informs the detail final results of all eleven constructs' reflective measurement model assessments. Details of the assessment and the results of reflective indicator show that some loadings were lower than the threshold or recommended values. From the result of the final PLS-SEM process, most indicators achieved the recommended value of  $\geq 0.700$  (Hair et al. 2019). However, few indicators show values below the threshold. All indicators having the value below 0.708 emerged from the construct of UICT namely UICT12 (0.653), UICT1 (0.656), UICT2 (0.674), UICT9 (0.690). The weak indicators were subsequently dropped from the process (Hair et al. 2016).

#### 3.5.2 Internal consistency reliability

Internal consistency reliability was utilized for the evaluation of the consistency of results across items. In PLS-SEM method for this study, both Cronbach's alpha and composite reliability were tested (Hair et al. 2019). The values for internal consistency reliability are measured between 0 and 1, where the higher the value indicates a higher level of validity. The values of and Cronbach's alpha and composite reliability should be higher than 0.700 (Hair et al. 2019).

Table 3 performs the detail of Cronbach's alpha and composite reliability values. The Cronbach's alpha and the composite reliability values for most construct were stable, equivalent, and have good internal consistency reliability which exceeded the recommended value of 0.708 and were below the maximum value of 0.950. However, two constructs had values of greater than 0.950. PCK achieved 0.952 while TCK's value of composite reliability was 0.958. We deleted indicators (PCK3 and TCK3) that have semantically redundant items since the items measure very different aspects of the construct domain within a strong argument then the concerns of very high reliability are not assured (Hayduk and Littvay 2012).

### 3.5.3 Convergent validity

For the convergent validity, AVE values should be reported as suggested as the metric to measure (Hair et al. 2019). To calculate the AVE, we used PLS-SEM algorithm. The minimum acceptable AVE is 0.500 or higher, explaining 50% or more of the variance of the items for the construct. All constructs in this study had AVE values that are greater than 0.500 or explaining 50% or more about the variance of the items for the construct (Table 3).

**Table 3** Outer loading, Cronbach's alpha, composite reliability, and AVE

|        | Outer loading | Cronbach's Alpha | Composite reliability | Average Variance Extracted (AVE) |
|--------|---------------|------------------|-----------------------|----------------------------------|
| CK1    | 0.846         | 0.783            | 0.873                 | 0.696                            |
| CK2    | 0.773         |                  |                       |                                  |
| CK3    | 0.879         |                  |                       |                                  |
| PCK1   | 0.951         | 0.859            | 0.933                 | 0.875                            |
| PCK2   | 0.919         |                  |                       |                                  |
| PK1    | 0.719         | 0.844            | 0.885                 | 0.563                            |
| PK2    | 0.741         |                  |                       |                                  |
| PK3    | 0.745         |                  |                       |                                  |
| PK5    | 0.775         |                  |                       |                                  |
| PK6    | 0.788         |                  |                       |                                  |
| PK7    | 0.730         |                  |                       |                                  |
| TCK1   | 0.955         | 0.870            | 0.938                 | 0.884                            |
| TCK2   | 0.925         |                  |                       |                                  |
| TK1    | 0.834         | 0.758            | 0.861                 | 0.676                            |
| TK2    | 0.897         |                  |                       |                                  |
| TK3    | 0.726         |                  |                       |                                  |
| TPACK1 | 0.788         | 0.798            | 0.868                 | 0.623                            |
| TPACK2 | 0.822         |                  |                       |                                  |
| TPACK3 | 0.759         |                  |                       |                                  |
| TPACK5 | 0.787         |                  |                       |                                  |
| TPK2   | 0.844         | 0.751            | 0.858                 | 0.668                            |
| TPK3   | 0.794         |                  |                       |                                  |
| TPK4   | 0.814         |                  |                       |                                  |
| UICT10 | 0.760         | 0.878            | 0.905                 | 0.578                            |
| UICT11 | 0.698         |                  |                       |                                  |
| UICT5  | 0.772         |                  |                       |                                  |
| UICT6  | 0.788         |                  |                       |                                  |
| UICT7  | 0.782         |                  |                       |                                  |
| UICT8  | 0.815         |                  |                       |                                  |
| UICT9  | 0.698         |                  |                       |                                  |

### 3.5.4 Discriminant validity

Discriminant validity is “the extent to which a construct is empirically distinct from other constructs in the structural model (Hair et al. 2019, p.13). When using the Fornell-Larcker criterion (traditional metric), “the shared variance for all model constructs should not be larger than their AVEs” (Fornell & Larcker, 1981 as cited in Hair et al. 2019, p. 14). It can be seen that the AVE of every construct in this study is higher than its shared variance (Table 4). From the criterion of Fornell-Larcker, it can be concluded that the discriminant validity for the quantitative data of this study was established.

Discriminant validity can be established when an indicator loading on a construct is higher than that of all of its cross-loadings on the other constructs (Hair et al. 2016). Table 5 exhibits all indicators’ outer loadings as well as their cross-loadings for other indicators. It can be seen that the outer loadings (in bold and italic) for every construct was higher than the entire cross-loadings on the other constructs, for instance, the indicator CK1 has the highest loading value (0.846) compared to its cross loading on the other constructs (e.g. PCK = 0.375, PK = 0.531, and TCK = 0.333). Based on the finding of cross-loading assessment, it can be summarized that the discriminant validity was established through the assessment of outer loadings.

Discriminant validity issues emerge when the values of HTMT (the main consideration for the discriminant validity) are higher than the threshold. The threshold values for HTMT in this study (< 0.90) due to the reason that the constructs were conceptually similar; “an HTMT value above 0.90 suggests a lack of discriminant validity” (Hair et al. 2016, p. 141). Shown in Table 6, all values are below 0.90. The results indicate that all HTMT values were significantly different from 1 which is, therefore, establishing discriminant validity of the active constructs. After this process, 30 indicators were included for the assessment of the structural model.

## 4 Findings

The assessment of the structural model involved the examination of the model’s predictive capabilities. There were six systematic approaches (Hair et al. 2016). As elaborated earlier, the examination process involved in this study was begun with the

**Table 4** Fornell-Larcker criterion

|       | CK_   | PCK   | PK    | TCK   | TK    | TPACK | TPK   | UICT  |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| CK_   | 0.834 |       |       |       |       |       |       |       |
| PCK   | 0.412 | 0.935 |       |       |       |       |       |       |
| PK    | 0.540 | 0.539 | 0.750 |       |       |       |       |       |
| TCK   | 0.372 | 0.330 | 0.360 | 0.940 |       |       |       |       |
| TK    | 0.428 | 0.316 | 0.370 | 0.488 | 0.822 |       |       |       |
| TPACK | 0.482 | 0.421 | 0.542 | 0.509 | 0.457 | 0.789 |       |       |
| TPK   | 0.380 | 0.370 | 0.452 | 0.515 | 0.474 | 0.696 | 0.817 |       |
| UICT  | 0.398 | 0.407 | 0.415 | 0.407 | 0.424 | 0.581 | 0.525 | 0.760 |

**Table 5** Cross-loadings

|        | CK_          | PCK          | PK           | TCK          | TK           | TPACK        | TPK          | UICT         |
|--------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| CK1    | <b>0.846</b> | 0.375        | 0.531        | 0.333        | 0.339        | 0.390        | 0.250        | 0.296        |
| CK2    | <b>0.773</b> | 0.278        | 0.328        | 0.222        | 0.318        | 0.335        | 0.297        | 0.284        |
| CK3    | <b>0.879</b> | 0.365        | 0.463        | 0.355        | 0.408        | 0.468        | 0.403        | 0.406        |
| PCK1   | 0.404        | <b>0.951</b> | 0.559        | 0.338        | 0.306        | 0.446        | 0.372        | 0.419        |
| PCK2   | 0.363        | <b>0.919</b> | 0.436        | 0.273        | 0.284        | 0.330        | 0.314        | 0.334        |
| PK1    | 0.444        | 0.416        | <b>0.719</b> | 0.273        | 0.358        | 0.380        | 0.328        | 0.269        |
| PK2    | 0.439        | 0.381        | <b>0.741</b> | 0.247        | 0.297        | 0.429        | 0.346        | 0.310        |
| PK3    | 0.476        | 0.410        | <b>0.745</b> | 0.181        | 0.260        | 0.405        | 0.332        | 0.346        |
| PK5    | 0.361        | 0.452        | <b>0.775</b> | 0.290        | 0.205        | 0.420        | 0.381        | 0.309        |
| PK6    | 0.299        | 0.411        | <b>0.788</b> | 0.283        | 0.278        | 0.395        | 0.324        | 0.272        |
| PK7    | 0.418        | 0.343        | <b>0.730</b> | 0.352        | 0.277        | 0.409        | 0.316        | 0.370        |
| TCK1   | 0.394        | 0.333        | 0.363        | <b>0.955</b> | 0.500        | 0.528        | 0.526        | 0.429        |
| TCK2   | 0.295        | 0.282        | 0.308        | <b>0.925</b> | 0.407        | 0.417        | 0.433        | 0.325        |
| TK1    | 0.378        | 0.335        | 0.348        | 0.410        | <b>0.834</b> | 0.448        | 0.449        | 0.410        |
| TK2    | 0.371        | 0.252        | 0.321        | 0.426        | <b>0.897</b> | 0.396        | 0.427        | 0.359        |
| TK3    | 0.299        | 0.176        | 0.229        | 0.364        | <b>0.726</b> | 0.261        | 0.270        | 0.259        |
| TPACK1 | 0.389        | 0.380        | 0.561        | 0.399        | 0.341        | 0.788        | 0.516        | 0.516        |
| TPACK2 | 0.351        | 0.353        | 0.422        | 0.395        | 0.379        | <b>0.822</b> | 0.578        | 0.493        |
| TPACK3 | 0.407        | 0.279        | 0.357        | 0.328        | 0.384        | <b>0.759</b> | 0.547        | 0.382        |
| TPACK5 | 0.380        | 0.313        | 0.361        | 0.480        | 0.344        | <b>0.787</b> | 0.559        | 0.433        |
| TPK2   | 0.332        | 0.350        | 0.431        | 0.459        | 0.378        | 0.551        | <b>0.844</b> | 0.428        |
| TPK3   | 0.360        | 0.290        | 0.229        | 0.439        | 0.478        | 0.552        | <b>0.794</b> | 0.413        |
| TPK4   | 0.244        | 0.267        | 0.440        | 0.368        | 0.313        | 0.603        | <b>0.814</b> | 0.446        |
| UICT10 | 0.220        | 0.306        | 0.264        | 0.368        | 0.359        | 0.481        | 0.429        | <b>0.760</b> |
| UICT11 | 0.316        | 0.302        | 0.229        | 0.341        | 0.327        | 0.409        | 0.341        | <b>0.730</b> |
| UICT5  | 0.374        | 0.313        | 0.357        | 0.265        | 0.312        | 0.473        | 0.416        | <b>0.772</b> |
| UICT6  | 0.323        | 0.306        | 0.356        | 0.323        | 0.394        | 0.485        | 0.462        | <b>0.788</b> |
| UICT7  | 0.289        | 0.327        | 0.338        | 0.303        | 0.274        | 0.442        | 0.380        | <b>0.782</b> |
| UICT8  | 0.306        | 0.311        | 0.326        | 0.323        | 0.306        | 0.441        | 0.426        | <b>0.815</b> |
| UICT9  | 0.294        | 0.308        | 0.343        | 0.234        | 0.267        | 0.337        | 0.320        | <b>0.702</b> |

examination of collinearity, stage 1. The path coefficients ( $\beta$ ) were then examined in stage 2. Further, in stage 3, the coefficient of determination ( $R^2$ ) was examined. In stage 4, the effect size of  $f^2$  was reported to assess the relevance of the construct in explaining selected endogenous constructs. In line with the  $f^2$  effect size for the values of  $R^2$ , we also calculated the  $Q^2$  and its effect size in stage 5 and 6 (Hair et al. 2019).

#### 4.1 Collinearity issue

Specifically, the sets of predictors were assessed for collinearity: (1) PCK, TCK, TPK, and TPACK as predictors of UICT; (2) PCK, TCK, and TPK as predictors of TPACK;

**Table 6** HTMT

|       | CK_   | PCK   | PK    | TCK   | TK    | TPACK | TPK   | UICT |
|-------|-------|-------|-------|-------|-------|-------|-------|------|
| CK_   |       |       |       |       |       |       |       |      |
| PCK   | 0.493 |       |       |       |       |       |       |      |
| PK    | 0.651 | 0.621 |       |       |       |       |       |      |
| TCK   | 0.432 | 0.374 | 0.418 |       |       |       |       |      |
| TK    | 0.549 | 0.383 | 0.458 | 0.594 |       |       |       |      |
| TPACK | 0.605 | 0.498 | 0.657 | 0.601 | 0.578 |       |       |      |
| TPK   | 0.496 | 0.456 | 0.561 | 0.631 | 0.62  | 0.899 |       |      |
| UICT  | 0.476 | 0.465 | 0.485 | 0.457 | 0.509 | 0.686 | 0.642 |      |

(3) PK and TK as predictors of TPK; (4) CK and TK as predictors of TCK; and CK and PK as predictors of PCK (Table 7). All VIF values are below the threshold of three (<3) which suggested by Hair et al. (2019). Therefore, collinearity is not an issue for the model of this study.

#### 4.2 Structural model relationship

To assess whether the relationships in the current study are significant between independent variables and dependent variables, we did the bootstrapping samples of 5000. Assuming a 5% significance level, all relationships informed in the structural model are significant, except the relationship between TCK and UICT. In terms of interconnection between core bases of knowledge (PK, CK, and TK) and the second-level bases of knowledge (TPK, TCK, and PCK), the PLS-SEM results inform the significances on all proposed relationships that support H1, H2, H3, H4, H5, and H6. In detail, TK is reported to have significant effects on TPK ( $\beta = 0.286$ ;  $p < 0.01$ ) and TCK ( $\beta = 0.321$ ;  $p < 0.01$ ). In addition, CK significantly predicts TCK ( $\beta = 0.281$ ;  $p < 0.01$ ) and PCK ( $\beta = 0.224$ ;  $p < 0.01$ ). The last core base, PK, is informed to be significant in determining TPK ( $\beta = 0.377$ ;  $p < 0.01$ ) and PCK ( $\beta = 0.447$ ;  $p < 0.01$ ). For these three

**Table 7** Inner VIF values

|       | CK | PCK   | PK | TCK   | TK | TPACK | TPK   | UICT  |
|-------|----|-------|----|-------|----|-------|-------|-------|
| CK    |    | 1.741 |    | 1.306 |    |       |       |       |
| PCK   |    |       |    |       |    | 1.335 |       | 1.429 |
| PK    |    | 1.741 |    |       |    |       | 1.263 |       |
| TCK   |    |       |    |       |    | 1.575 |       | 1.625 |
| TK    |    |       |    | 1.306 |    |       | 1.263 |       |
| TPACK |    |       |    |       |    |       |       | 2.366 |
| TPK   |    |       |    |       |    | 1.528 |       | 2.258 |
| UICT  |    |       |    |       |    |       |       |       |

core base knowledge, the strongest relationship emerges between PK and PCK. In affecting TPACK, the second-level bases of knowledge (TPK, TCK, and PCK) are reported to be significant. Therefore, the three hypotheses (H7, H9, and H11) are statistically supported. TPACK is most strongly predicted by TPK ( $\beta=0.555$ ;  $p<0.01$ ) which is also the strongest correlation of all proposed hypotheses in this study. The weakest predictor affecting TPACK is TCK ( $\beta=0.144$ ;  $p<0.01$ ). Additionally, TPK is also significant predicting TPACK ( $\beta=0.199$ ;  $p<0.01$ ).

Besides the interconnection among TPACK components, this study is also proposed to investigate the role of 4 TPACK's component in predicting Indonesian pre-service language teachers' UICT. Through the bootstrapping process in PLS-SEM, 3 of the predictors are reported to statically predict UICT while one of them, TCK is not significant predicting UICT ( $\beta=0.060$ ;  $p>0.05$ ). The strongest variable predicting UICT is TPACK ( $\beta=0.354$ ;  $p<0.01$ ) followed by TPK ( $\beta=0.153$ ;  $p<0.01$ ). The weakest significant correlation emerges between PCK and UICT ( $\beta=0.092$ ;  $p<0.01$ ). The results of the analysis support H10, H11, and H13; however, H8 is rejected. The complete exhibition of the bootstrapping results can be seen in Fig. 2 and Table 8.

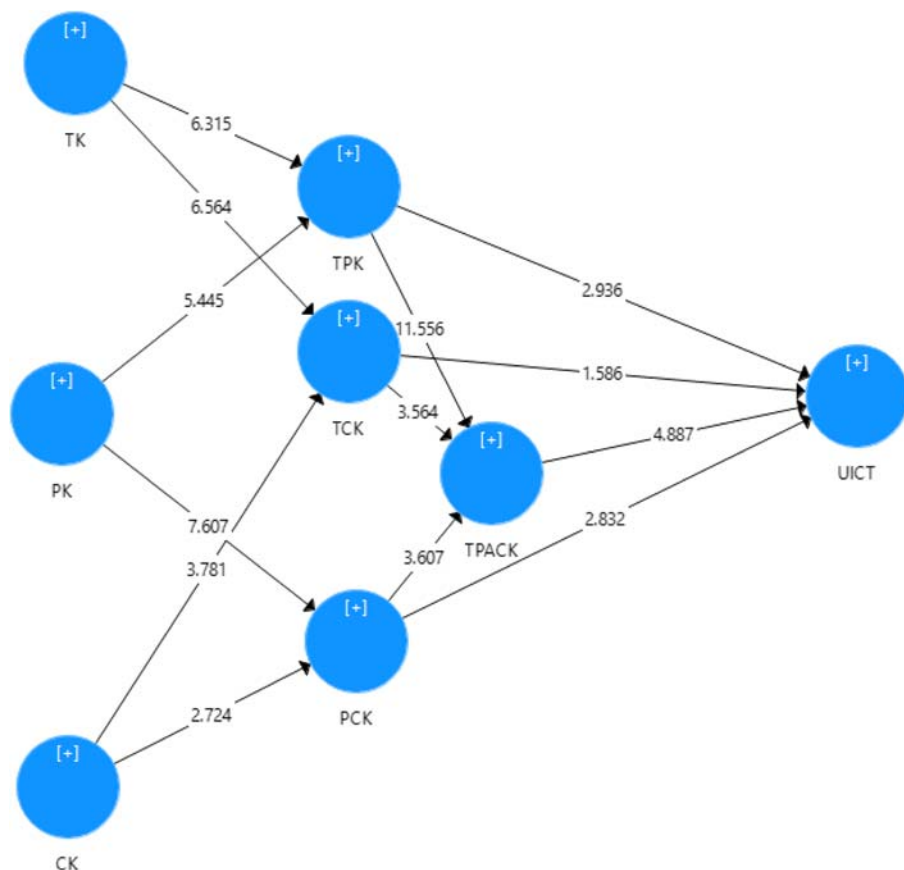


Fig. 2 The model and t value

**Table 8** Bootstrapping results

| Hypotheses | Path          | Path coefficient ( $\beta$ ) | $p$ value | Significance |
|------------|---------------|------------------------------|-----------|--------------|
| H1         | TK -> TCK     | 0.321                        | $p < .01$ | Yes          |
| H2         | TK -> TPK     | 0.286                        | $p < .01$ | Yes          |
| H3         | CK -> TCK     | 0.281                        | $p < .01$ | Yes          |
| H4         | CK -> PCK     | 0.224                        | $p < .01$ | Yes          |
| H5         | PK -> TPK     | 0.377                        | $p < .01$ | Yes          |
| H6         | PK -> PCK     | 0.447                        | $p < .01$ | Yes          |
| H7         | TCK -> TPACK  | 0.144                        | $p < .01$ | Yes          |
| H8         | TCK -> UICT   | 0.060                        | 0.065     | No           |
| H9         | TPK -> TPACK  | 0.555                        | $p < .01$ | Yes          |
| H10        | TPK -> UICT   | 0.153                        | $p < .01$ | Yes          |
| H11        | PCK -> TPACK  | 0.199                        | $p < .01$ | Yes          |
| H12        | PCK -> UICT   | 0.092                        | $p < .01$ | Yes          |
| H13        | TPACK -> UICT | 0.354                        | $p < .01$ | Yes          |

### 4.3 Level of $R^2$

Coefficient of determination ( $R^2$ ) is the value which measures the model's predictive accuracy and is calculated as the squares correlation between a specific endogenous construct's, or dependent variable's, actual and predicted values (Hair et al. 2016).  $R^2$  value ranges between 0 and 1, where a higher value indicates a higher level of predictive accuracy.  $R^2$  value of 0.75 is considered substantial, while 0.50 is moderate, and 0.25 is weak (Hair et al. 2016). Table 9 exhibits the result of  $R^2$ ; PCK (0.381, weak), TCK (0.262, weak), TPACK (0.577, moderate), TPK (0.322, weak), UICT (0.322, weak). It can be considered that the data of this study is in a good level of predictive accuracy.

### 5 $f^2$ effect size

The effect sizes, denoted as  $f^2$ , measures the impact of a predictor construct on an endogenous construct.  $f^2$  assesses the change in the values of  $R^2$  when a certain exogenous construct, is removed from the model. This is to measure the real impact

**Table 9**  $R^2$  Value

|       | $R^2$ | Consideration |
|-------|-------|---------------|
| PCK   | 0.381 | Weak          |
| TCK   | 0.269 | Weak          |
| TPACK | 0.577 | Moderate      |
| TPK   | 0.322 | Weak          |
| UICT  | 0.322 | Weak          |



of an exogenous construct to the endogenous construct. The value of 0.02 is considered a small effect, 0.15 (medium effect), and 0.35 (large effect) (Hair et al. 2016). All exogenous constructs or predictors have effect sizes to endogenous constructs except for PCK -> UICT, TCK -> UICT, and TPK -> UICT (Table 10).

### 5.1 Assessing predictive relevance, $Q^2$

The last stage of this study model data presentation was done involving the predictive relevance of the model through the Stone-Geisser's  $Q^2$  value. When the model shows predictive relevance, it is accurate to predict the data points of indicators in the model (Hair et al. 2016). In the structural model,  $Q^2$  value which is larger than 0 for the reflective construct has an indication that the model's predictive relevance for the construct is achieved (0.02 as small; 0.15 as medium 0.35 as large). The procedure to obtain the  $Q^2$  was done through blindfolding procedure using SmartPLS 3.0. (Hair et al. 2019). Results for the predictive relevance are reported in Table 11. From the table, it can be seen that all  $Q^2$  values were above 0. The results of  $Q^2$  facilitate support for the model's predictive relevance for all five endogenous constructs.

## 6 Discussion

The main goal of this study was to investigate interactions among TPACK components and examine their roles in predicting UICT from the perspectives of Indonesian pre-service language teachers. Firstly, we developed research instruments measuring TPACK and UICT through face and content validity (CVI), reliability (Cronbach's alpha) and factor analysis (EFA). While developing and validating the instruments, recommendations of previous studies for TPACK (Koh et al. 2010; Luik et al. 2018; Schmidt et al. 2009) and for UICT (Aslan and Zhu 2017) in the literature were considered. For this

**Table 10**  $f^2$  effect size

|               | Original $f^2$ | Effect size |
|---------------|----------------|-------------|
| CK -> PCK     | 0.047          | Small       |
| CK -> TCK     | 0.083          | Small       |
| PCK -> TPACK  | 0.070          | Small       |
| PCK -> UICT   | 0.009          | No effect   |
| PK -> PCK     | 0.185          | Medium      |
| PK -> TPK     | 0.166          | Medium      |
| TCK -> TPACK  | 0.031          | Small       |
| TCK -> UICT   | 0.003          | No effect   |
| TK -> TCK     | 0.108          | Small       |
| TK -> TPK     | 0.096          | Small       |
| TPACK -> UICT | 0.078          | Small       |
| TPK -> TPACK  | 0.477          | Large       |
| TPK -> UICT   | 0.015          | No effect   |

**Table 11** Results of predictive relevance.

|       | $Q^2$ | Predictive relevance |
|-------|-------|----------------------|
| CK    | –     | –                    |
| PCK   | 0.321 | Medium               |
| PK    | –     | –                    |
| TCK   | 0.227 | Medium               |
| TK    | –     | –                    |
| TPACK | 0.345 | Medium               |
| TPK   | 0.213 | Medium               |
| UICT  | 0.178 | Medium               |

study, thirty-eight indicators are valid and reliable after EFA process; TPACK (26 indicators) and UICT (12 indicators). After the data preparation process, we measured the model by examining the model reflective indicator loadings, internal consistency reliability, convergent validity, and discriminant validity (Hair et al. 2019). From this process, 8 indicators were dropped since they did not meet the threshold values. As a result, 30 indicators were included for the assessment of the structural model.

From the assessment process, TPACK was strongly predicted by TPK while PK was the main predictor of TPK. Similarly, PK also predicts PCK with the strongest coefficient. Meanwhile, TCK is mostly predicted by TK. There are some correlations that are similar to previous studies; however, some of them are different. For instance, Pamuk et al. (2015) found the different result on the factor affect TPACK with TCK as the strongest predictor of TPACK. In addition, they reported PK strongly predicted TPK. Similar to this study, TK was informed as the strongest predictor for TCK and PK for PCK. In contrast, Chai et al. (2012) informed that TPACK was not predicted by TPK, TCK, and PCK; however, PK and CK were found to be related to TPACK. Luik et al. (2018) published an article coding other constructs' term for the TPACK components; technology, pedagogy, and content in which they were reported to have a significant relationship among all constructs.

A very few studies informed the relationship between TPACK complete paths and technology integration. Therefore, we filled the gap by examining TPACK interconnection and their roles predicting UICT. In determining UICT during teaching practices, TPACK is reported to be the strongest predictor followed by TPK and PCK. However, TCK is confirmed to have no correlation with UICT. This finding is similar to the findings of Teo et al. (2018), Tondeur et al. 2017) and Joo et al. (2018) that mention TPACK as a significant predictor for intention to use technology in education. Likewise, Aslan and Zhu (2017) informed the significant relationship between PK and UICT during teaching practices. However, Joo et al. (2018) reported that TPACK was not related to intention to use technology.

## 7 Conclusion

The central elaboration of this study has been obtained to elaborate the roles of TPACK in UICT during Indonesian pre-service language teachers' teaching practices. Before

identifying the TPACK roles on UICT, the investigation among TPACK components' interconnection was done which aims to comprehensively examine TPACK's roles affecting UICT so that the bias could be minimized for the proposed model (Vinzi et al. 2010).

Based on the data analysis, we suppose even though current TPACK format represents, at least schematically, validated relationships among knowledge bases perceived from pre-service language teachers in Indonesia and indicates that they all achieved similar impact on the development of TPACK, findings of this study suggest that relationships among TPACK components are complex involving 9 hypotheses e. Regarding its roles on UICT during teaching practices, the model has also been statistically valid and reliable informing that TPACK as a component is the strongest predictor followed by TPK and PCK.

Some implications and limitations are informed in this study. A better comprehension of pre-service language teacher's perceptions on TPACK can help to increase the efficiency of the programs regarding technology integration during teaching practices. A key goal of teacher education programs should aim to help pre-service teachers develop their perception about the needs of the new educational system regarding the integration of technology into teaching. In addition, the results of the current study should be considered for some methodological limitations. First, quantitative approach is not the only method for this kind of study. Studies through qualitative strategy are recommended for further informing the relationships that facilitates in-depth understanding of the situation. Although the proposed model elaborated the direct effects among the variables, intervention study to investigate indirect effects is suggested in order to discover more relationships among involve variables. Lastly, the findings and the proposed model are valid and reliable for Indonesian education and language teachers' context. Therefore, future studies are suggested to compare regarding countries and majors in different contexts.

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**Data availability** The dataset can be accessed at Mendeley dataset repository <https://data.mendeley.com/datasets/s6brgxxkt/4>

## Compliance with ethical standards

**Competing interests** The author declares that there are no competing interests.

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