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Possible links between Indonesian science teacher's TPACK perception and demographic factors: Self-reported survey

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Abstract

TPACK is a trending teacher expertise framework for teaching using digital technology. However, not many studies have revealed the relationship of the seven TPACK factors with demographic factors. This study aimed to determine the effect of gender, teaching experience, place of teaching, and level of education on the perception of TPACK for science teachers. A total of 1,357 high school science teachers were involved in this research. The survey data were analyzed using the Mann-Whitney U and Kruskal-Wallis tests. Overall results show that gender influences the perception of TPACK. On the teaching experience factor, teachers with less than five years of teaching experience have higher perceptions of TK, TPK, TCK, and TPACK. The teacher's workplace significantly differs in perceptions of TK and TCK. Regarding education level, teachers with a master's degree education have a higher and significantly higher TPACK perception than teachers with a bachelor's degree.

Keywords: gender, place of work, teacher degree, teaching experience, TPACK

INTRODUCTION

Science is a subject taught almost all over the world (Huang et al., 2010; Sbhatu, 2021), also in Indonesia (Faisal & Martin, 2019). Science learning aims to provide a unique experience for students to do science (Johnson, 1962; Shafer, 1990). In addition, science learning has an essential role in developing student competencies (Letina, 2020). However, the progress of science learning in Indonesia has not been seen. The PISA 2018 results in the sciences field show that Indonesian students are ranked 71 out of 79 countries that took part in the survey (OECD, 2018).

The 2018 PISA results confirm that science teaching in Indonesia still has several obstacles. One of the main obstacles in learning science is the low skill of teachers in teaching science (Baran, 2019). Teachers' teaching skills will affect students' science learning outcomes. On the other hand, training for science teachers in Indonesia is often carried out to equip teachers with adequate skills and competencies (Faisal & Martin, 2019). Adequate teacher skills make the meaning of science can be conveyed appropriately and accepted by students (Lederman & Lederman, 2019).

To investigate the competence of teachers and improve the quality of teacher training is necessary to examine several factors that will affect the effectiveness of the training carried out. Mishra and Koehler (2008) explained that the TPACK model could be used as a framework in the investigation. Despite many studies on Teacher TPACK, there is a lack of knowledge about the demographic factors influencing science teacher

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Contribution to the literature

- This study uses demographic factors that are rarely studied in relation to TPACK. The demographic factors we use are gender, teaching experience, teaching place, and education level.
- Our subjects are in-service teachers, while previous studies looking for the relationship between demographic factors and TPACK were conducted on pre-service teachers.
- The results of this study indicate that demographic factors have a relationship with the TPACK of science teachers. The government and stakeholders can use these results in education for planning effective teacher training programs based on demographic factors.

TPACK. Therefore, this study aims to explore this area by answering the research question of the extent to which TPACK is related to the demographic factors of science teachers in Indonesia. Demographic factors studied in this study include gender, teaching experience, teaching place, and education level. The perception of TPACK gained will be very important for science teacher training programs in Indonesia.

The government can use the relationship between demographic aspects and perceptions of TPACK to formulate an appropriate training system for teacher training. The grouping of training participants based on the obtained demographic factors is also essential so that the training can be carried out optimally. A survey conducted by Cowman and McCarthy (2016) show that demographic factors play a role in the effectiveness of knowledge transfer in training. Another study by Sa'adatu (2013) shows that demographic factors affect teacher performance in teaching.

Theoretical Framework

One of the frameworks that model teacher knowledge is TPACK (Koehler et al., 2007; Schmid et al., 2021). Technological pedagogical content knowledge (TPACK) is the most popular teacher professionalism framework globally (Mishra & Koehler, 2006, 2008). The TPACK framework is mainly used to assess teacher competency levels and design teacher professional development activities (Chai et al., 2013). TPACK is an extension of the pedagogical content knowledge framework proposed by Shulman (1986, 1987), teachers must combine different knowledge dimensions with teaching effectively using technology.

TPACK consists of three main components, namely pedagogical knowledge (PK), content knowledge (CK), and technological knowledge (TK). Furthermore, three first-level hybrid components are pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), and technological content knowledge (TCK). The first-level hybrid components are combined into a second level, TPACK, the most complex type of knowledge.

The TPACK framework is primarily used to assess teacher competency levels and design professional development activities. Much literature has reviewed the TPACK intervention in teacher professional development (Abbitt, 2011; Mouza et al., 2014; Qian & Lehman, 2018; Wang et al., 2018). However, many studies still try to examine the effect of TPACK on learning. For example, the effect of TPACK on student achievement (Farrell & Hamed, 2017), the effect of TPACK on the use of technology in teacher lesson plans (Schmid et al., 2021), use of technology in class (Joo et al., 2016), collaborative teacher discourse (Yeh et al., 2021), pre-service science teachers' performances (Aktas & Ozmen, 2020), TPACK effect in developing digital pedagogies (Maor, 2017), TPACK relationship with teacher's beliefs (Smith et al., 2016), perceived of TPACK on teacher professional development (Nazari et al., 2019).

Recent developments have shown many ways to measure TPACK: self-report rating scales, interviews, open-ended questionnaires, and hands-on assessments (performance, standardized tests, lesson plans, learning observations) (Abbitt, 2011; Willermark, 2018). The self-report method is currently one of the most frequently used because it is the most efficient and inexpensive way to obtain extensive quantitative data.

Previous researchers have developed various questionnaire scales to measure the seven areas of TPACK in the form of a survey (Alrwaished et al., 2017; Archambault & Crippen, 2009; Kadioglu-Akbulut et al., 2020; Schmid et al., 2020; Schmidt et al., 2009; Valtonen et al., 2017; Yurdakul et al., 2012). The instrument has demonstrated the expected factor structure of the seven knowledge dimensions in TPACK, which can be distinguished (Archambault & Barnett, 2010; Scherer et al., 2017).

METHODS

Research Design

This study adopted a cross-sectional survey design (Creswell, 2012). The purpose of the cross-sectional survey was to measure science teachers' perceptions of TPACK. The cross-sectional design was chosen because researchers can take samples from the population with good generalization, and survey results can be obtained quickly (Wang & Cheng, 2020). A cross-sectional design is usually used to find the relationship between demographic factors and perceptions (Berry et al., 2010; Parmenter et al., 2021).

Table 1. Demographic characteristics of participants

Criteria	Group	Total	Percentage (%)
Gender	Male	388	28.59
	Female	969	71.41
Teaching experience	x<=5	144	10.61
	5<x<=10	151	11.13
	10<x<=15	263	19.38
	15<x<=20	326	24.02
	20<x<=25	220	16.21
	25<x<=30	159	11.72
	x>30	94	6.93
Workplace	Public school	1071	78.92
	Private school	286	21.08
Educational degree	Bachelor's degree	1011	74.50
	Master's degree	346	25.50

Participants

This survey was taken in East Java Province, the second largest population in Indonesia. A total of 1,357 science teachers participated in the research. The science teachers are High school teachers and have varied teaching experience, with the majority having teaching experience for 15-20 years. More than three-quarters of participants were female (78%). Complete demographic characteristics of the participants can be seen in **Table 1**.

Instrument and Data Collection

The survey was carried out for two months from September until October 2020. Previously, we sent an approval letter to the East Java Education Office to conduct survey research on science teachers. Along with the letter, we also explain the research and the research objectives to be carried out. Once approved, we coordinated with the head of the Science Teacher Community in each district/city in East Java to help distribute the questionnaires.

The instrument used in this study was a questionnaire. The questionnaire used in this study contained 47 questions (TK=seven questions, PK=11 questions, CK=five questions, PCK=five questions, TCK=five questions, TPK=six questions, and TPACK=six questions). The instrument was developed regarding the criteria in the questionnaire developed by (Schmid et al., 2009, 2020; Yurdakul et al., 2012), so theoretically, the dimensions of the TPACK are known. Thus, it only needs to be confirmed using confirmatory factor analysis (CFA). Before taking data, the instrument has been tested for validity and reliability. Instrument validity was measured using the corrected item discrimination (r) value. The value of r ranges from 0.19 to 0.88, with a p-value <0.05, then all items are declared valid—reliability analysis using Cronbach's alpha (α). Cronbach's alpha was chosen because it is considered the best for calculating item reliability (Schmid et al., 2020), the questionnaire will be reliable if it has a value above 0.08 (Schmid et al., 2020). The results of the reliability test are, as follows: TK (α=0.88), PK (α=0.97), CK (α=0.86), PCK (α=0.94), TCK (α=0.84), TPK (α=0.84), TPACK (α =0.93). and the whole instrument (3.98). The measurement results with CFA showed that several parameters such as RMSEA (0.062), IFI (0.914), TLI (0.907), CFI (0.913), RMR (0.42), and CMIN (2.237) met the criteria determined by (McCoach et al., 2013; Schumacker & Lomax, 2015; Tabachnick & Fidell, 2013). The results of a complete analysis of the validity and reliability of the questionnaire can be seen in **Appendix A**. Validation is also carried out by testing the correlation between the seven aspects in the TPACK to ensure the instrument used has an intact TPACK framework. The results of the correlation test are shown in **Appendix B**.

The valid questionnaire is then made in the form of a Google Form. The links created are distributed to the science teacher community coordinators in each district/city through Whatsapp (WA) social media. WA was chosen because each teacher has a WA group at the district/city level, so the questionnaire distribution becomes easier. Teachers also have the right not to fill out the questionnaire as an ethical consideration. The filling of the questionnaire is based on the volunteerism of the teacher. The data that has been provided is also kept confidential and anonymized. Thus, the selection of respondents in this study was carried out using snowball sampling (Frey, 2018).

Data Analysis

The data that has been obtained will be checked first, sorted, and discarded if there are two or more identical identities. In addition, participant data will also be issued if the teacher is from another region, or the teacher is from non-science subjects. Data were analyzed using descriptive and inferential analysis. The descriptive analysis describes the TPACK value for each component and demographics data. Mann-Whitney test was used to determine difference in the mean between the two groups (gender, workplace education level). Kruskal-Wallis test was used to determine difference between more than two groups (teaching experience).

Table 2. Results of the analysis of the effect of gender on the science teachers' TPACK

Variable	TK		PK		CK		PCK		TCK		TPK		TPACK	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Gender														
Male	3.55	0.91	3.89	0.82	3.95	0.71	3.96	0.74	3.81	0.78	3.81	0.76	3.81	0.80
Female	3.34	0.89	3.82	0.78	3.81	0.68	3.83	0.72	3.59	0.76	3.72	0.72	3.67	0.78
z-score	-4.070		-2.038		-3.776		-3.154		-4.983		-2.089		-3.378	
Sig.	.000**		.042*		.000**		.002**		.000**		.037*		.001**	

Table 3. Results of the analysis of the effect of teaching experience on science teachers' TPACK

Variable	TK		PK		CK		PCK		TCK		TPK		TPACK	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Teaching experience														
x<=5	3.82	0.73	3.97	0.67	3.95	0.58	3.95	0.66	3.83	0.73	3.91	0.68	3.83	0.69
5<x<=10	3.64	0.93	3.80	0.73	3.78	0.67	3.79	0.73	3.76	0.75	3.79	0.77	3.71	0.77
10<x<=15	3.52	0.84	3.90	0.72	3.87	0.64	3.92	0.69	3.66	0.70	3.78	0.73	3.82	0.74
15<x<=20	3.29	0.89	3.78	0.85	3.80	0.74	3.79	0.78	3.60	0.81	3.69	0.74	3.60	0.85
20<x<=25	3.34	0.87	3.86	0.80	3.87	0.66	3.90	0.68	3.64	0.76	3.78	0.70	3.75	0.71
25<x<=30	3.21	0.96	3.79	0.84	3.89	0.75	3.92	0.75	3.64	0.80	3.67	0.73	3.66	0.80
x>30	2.97	0.91	3.79	0.90	3.82	0.78	3.88	0.77	3.49	0.84	3.59	0.80	3.57	0.94
Kruskal-Wallis H	83.472		5.909		7.123		8.932		13.920		16.184		14.042	
Sig.	.000**		.433		.310		.177		.031*		.013*		.029*	

Table 4. Results of the analysis of the effect of workplace on science teachers' TPACK

Variable	TK		PK		CK		PCK		TCK		TPK		TPACK	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Workplace														
Public school	3.36	0.90	3.82	0.81	3.84	0.70	3.87	0.73	3.63	0.78	3.74	0.73	3.70	0.80
Private school	3.55	0.87	3.90	0.74	3.90	0.63	3.89	0.69	3.76	0.74	3.76	0.74	3.75	0.74
z-score	-3.006		-1.099		-.976		-.219		-2.221		-.206		-.702	
Sig.	.003**		.272		.329		.826		.026*		.837		.482	

Ethical Statement

This research has received approval from the Education Office of East Java Province. The respondents in this study participated voluntarily and anonymously, so the ethical statement is not applicable.

RESULTS

The Effect of Gender on the Perception of Science Teachers' TPACK

The effect of gender on each aspect is shown in **Table 2**. The results in **Table 2** show that gender affects the perception of TPACK for science teachers. The male has a higher perception in every aspect (TK, PK, CK, TPK, TCK, PCK, and TPACK).

The Effect of Teaching Experience on the Perceptions of Science Teachers' TPACK

The effect of Teaching Experience on each aspect is shown in **Table 3**. The results in **Table 3** show that teaching experience has varying effects on perceptions of TPACK. Teaching experience affects perceptions of TK (Sig. 0.000), TCK (0.031), TPK (0.013), and TPACK (0.029. Meanwhile, teaching experience does not affect PK (Sig. 0.433), CK (Sig. 0.310), and PCK (Sig. 0.177). In aspects that have significant differences, teachers with <five years of teaching experience have the highest scores (TK, TCK, TPK, TPACK).

The Influence of the Workplace on the Perceptions of Science Teachers' TPACK

The influence of the teaching place on each aspect is shown in **Table 4**. Based on **Table 4**, teaching places affect the perception of TK (Sig. 0.03) and TCK (Sig. 0.026), where private schools have a higher perception of this aspect, while other aspects of teaching places have no effect. Place of teaching does not affect aspects of PK (Sig. 0.272), CK (Sig. 0.329), PCK (Sig. 0.826), TPK (Sig. 0.837), and TPACK (Sig. 0.482).

The Influence of Education Level on the Perceptions of Science Teachers' TPACK

The effect of education level on each aspect is shown in **Table 5**. Based on **Table 5**, educational level affects the perception of TPACK obtained by teachers in every aspect (TK, PK, CK, PCK, TCK, TPK, and TPACK). Teachers who take postgraduate education (master's degree) have a higher perception in every aspect.

Table 5. Results of the analysis of the effect of educational level on science teachers' TPACK

Variable	TK		PK		CK		PCK		TCK		TPK		TPACK	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Educational level														
Bachelor	3.32	0.91	3.78	0.80	3.80	0.70	3.82	0.73	3.61	0.77	3.70	0.75	3.64	0.81
Master	3.65	0.84	4.03	0.73	4.01	0.64	4.02	0.68	3.79	0.75	3.89	0.66	3.92	0.69
z-score	-5.932		-5.568		-5.195		-4.737		-3.821		-4.336		-5.693	
Sig.	.000**		.000**		.000**		.000**		.000**		.000**		.000**	

DISCUSSION

This study aimed to explore the relationship between demographic factors and the perception of science teachers. Information on the relationship of demographic factors with the perception of science teacher TPACK can be used by the government or related parties to create appropriate training programs. Demographic factors explored in this study are gender, teaching experience, place of work, and educational level. Demographic factors influence effectiveness and motivation during training (Cowman & McCarthy, 2016; Heidarian et al., 2015). The results showed that gender influenced the perception of TPACK. Teaching experience and teacher's place of teaching also affect the perception of TPACK, but only by several factors. Educational level significantly influences the perception of TPACK; teachers with a master's degree have a higher TPACK perception in every aspect.

The Effect of Gender on the TPACK Perception

Chai et al. (2016) suggested examining the effect of gender on teacher TPACK. The findings of this study indicate that gender influences every aspect of TPACK. This study also shows that men have a higher perception of TPACK than women. The result of this study aligns with the meta-analysis conducted by Ergen et al. (2019), which shows that the total perception of TPACK in males is higher than in females. However, it is different from the results of research in general. Research by Koh et al. (2010) showed that male teacher candidates rated themselves higher in the TK, CK, and TPK aspects as the first-year pre-service teacher. Another study by Cetin-Berber and Erdem (2015) showed that male teacher candidates had higher TK than females. In contrast, studies show that gender does not affect TPACK (Arslan, 2015; Hosseini & Kamal, 2013; Karaca, 2015).

Regarding ICT use, many studies show that men have a higher perception of using ICT. Gebhardt et al. (2019) research results show that male teachers outperform female teachers in assessing their ICT skills. This result is similar to a similar study on the case of students. The results of the same study by Mahdi and Al-Dera (2013), his research on EFL teachers in Saudi Arabia showed significant differences between male and female teachers in the use of ICT in teaching and learning. This study indicates that men are more confident in using ICT and applying it in learning.

The result of this study show that men have a higher perception of TPACK in every aspect. This result is influenced by social culture in Indonesia. In Indonesia, women have a more significant role in managing the family, for example, raising children, cleaning the house, making food, and others. Most Indonesians do not have household assistants, so they do their homework independently. This condition makes female teachers in Indonesia less able to develop themselves, especially developing their TPACK. According to Werang et al. (2016), the socio-economic conditions of teachers also affect the development of their competencies. Other research by Koh et al. (2014) indicates that women lack confidence in their perception of TPACK.

Effect of Teaching Experience on TPACK Perception

The research findings show that teaching experience influences teachers' perceptions of TPACK. Teachers with less than five years of teaching experience have higher perceptions of TK, TPK, TCK, and TPACK. Research on teacher teaching experience on professionalism has had mixed results. However, at a certain level, many people assume that the experience of teachers tends to have a linear relationship with the quality of their teaching (Brandenburg et al., 2016). On the other hand, there is a complex relationship between a teacher's teaching experience and the quality of teaching. Several other factors build the quality of teaching, one of which is teaching experience (Brandenburg et al., 2016; Klassen & Chiu, 2010). Several researchers have investigated this complex relationship and have yielded mixed findings (Chingos & Peterson, 2011).

The findings show that the initial teacher has a high perception of aspects that contain technology elements. Initial teachers with <five years of teaching experience are Generation Z familiar with technology and quickly adapt to technology. Research results from Elias et al. (2012) showing age have a positive relationship with attitude towards technology. Fleming et al. (2018) describe parents as relatively low in digital literacy, and as a result, they are less able to participate in a more digital society and economy. Furthermore, Guner and Acarturk (2020) explained that older people usually stated that they wanted to learn and use ICT but had some obstacles. In addition, the gap between young and old is also a barrier for them when learning technology.

The Effect of Workplace on TPACK Perception

This study's findings indicate an influence between the teaching place and the perception of TK and TCK. Perceptions of TK and TCK teachers who teach in private schools are higher than teachers in public schools. The age distribution influences this in private and public schools. Teachers in private schools are usually fresh graduates who understand more about technology. Meanwhile, teachers in public schools are generally senior teachers who have become civil servants. Calafato and Paran (2019), in their research, found that the age of teachers affected their attitudes toward literacy. Another research by Elias et al. (2012) also shows that age affects technology attitudes in the workplace. In their research, Morris and Venkatesh (2000) revealed that the adaptation of technology by older people requires social pressure. Their studies implicated that leaders' pressure dominates their self-awareness to learn technology. In addition to the age factor, the competition factor between private and public schools also causes differences in competence between private and public teachers.

In Indonesia, private schools have a high challenge competing with public schools. This competition causes private schools to develop their human resources and infrastructure to attract parents' attention. Although not all private schools are more advanced than public schools, some private schools are (Martono et al., 2020). The effect of competition between public and private schools also occurs in several countries (Epple et al., 2004; Greene & Kang, 2004; McKinnon et al., 2013). Perie et al.'s (2005) research result shows that private schools outperform public schools in all major subjects, including science. Private schools can better articulate the most suitable strategies for teaching science and support specific professional development for their teachers (McKinnon et al., 2013). This condition is related to the development of their teacher's TPACK.

The Effect of Education Level on TPACK Perception

The findings in this study indicate an influence between the level of education and the teacher's perception of TPACK. The TPACK perception of teachers with a master's level of education has higher scores in all aspects. During the master's degree educational program, teachers have gained more experience in developing every aspect of their professionalism, both in content, creativity, and learning technology. In his research, Greenwald et al. (1996) show that teacher education level affects student learning outcomes. The learning outcomes obtained by students are also influenced by the effectiveness of the teacher's learning (Baroody, 2017). Furthermore, Baroody (2017) explained that besides being influenced by learning effectiveness, student learning outcomes are also influenced by the class format. The TPACK owned by the teacher also influences the teacher's ability to format the class directly.

Several studies have shown a positive relationship between teachers holding high degrees and student performance (Greenwald et al., 1996; Lee & Lee, 2020). Lee and Lee (2020), in his research by analyzing 30 years of data and a sample of 6,000 students, showed that students taught by science teachers who have advanced degrees have a positive and significant relationship with the achievement of higher education degrees. Another research by Harris and Sass (2011) shows the same. They found that attaining a teacher's master's degree was positively related to mathematics achievement gain among students in grades six through eight in North Carolina, United States.

CONCLUSION

Our research provides an overview of the TPACK profile of teachers in East Java Province, Indonesia. East Java province represents the condition of education in Indonesia because it has a medium-quality education. This study shows four main results:

1. gender influences the perception of TPACK of science teachers, male science teachers have higher perceptions in every aspect;
2. dependence on teaching experience and TPACK where teachers with <five years of teaching experience have a higher perception of TK and TPACK and have a significant difference;
3. significant differences in perceptions of TPACK of private and public teachers where teachers who teach in private schools have higher perceptions of TK and TCK; and
4. the degree level has a significant difference in every aspect of the TPACK profile, teachers with a master's degree have a higher perception.

Although the province of East Java has a moderate quality of education, it is considered to provide an overview of the TPACK profile of teachers. It represents the condition of education in Indonesia. These results must be re-confirmed with national-scale research to obtain more representative findings. A large number of samples in this study will contribute to stakeholders in formulating policies regarding teacher/pre-service teacher training. Stakeholders also need to pay attention to the distribution of science teacher educational qualifications to distribute education quality evenly. In addition, the results of this study also illustrate the importance of a balanced gender ratio in teacher recruitment. Based on our research findings, where age significantly influences the technology aspect, teacher training needs to pay attention to the age distribution of the teacher so that senior teachers have more opportunities to develop their ICT skills.

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Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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APPENDIX A

Table A1. Corrected item discrimination (r) and reliabilities (α) of the initial TPACK questionnaire (47 items)

Item		*r*	α
	TK		
A1	I can use word and number processing programs for making scripts, notes, and presentations.	0.76	
A2	I can use the internet to find various sources of information for developing my knowledge.	0.76	
A3	I can create a web or blog for communicating my ideas or scientific products.	0.73	
A4	I can use video conferencing applications for various purposes.	0.70	
A5	I can use various online application platforms.	0.50	
A6	I can create a simple animation program for visualizing an object.	0.57	
A7	I always try to update the latest technological developments.	0.70	
Initial TK-subscale			0.88
	PK		
B1	I understand the concept of pedagogies and didactics.	0.83	
B2	I understand the foundation and orientation of education in schools.	0.80	
B3	I understand the level of cognitive, social, personality, and moral development of students as a basis for consideration in learning.	0.85	
B4	I understand the concepts of curriculum changes.	0.86	
B5	I can design and arrange my learning support tools that follow the approach, model, method, and learning strategy.	0.86	
B6	I can develop teaching materials such as worksheets, handouts, or modules.	0.75	
B7	I can develop or choose learning media that are under the planned learning objectives and methods.	0.87	
B8	I understand and can use innovative learning models that accordance with the curriculum.	0.83	
B9	I understand and usually do classroom management so that learning activities become more active, interactive, and effective.	0.88	
B10	I understand and can choose the right technique and form of the instrument for assessing the achievement of learning objectives.	0.87	
B11	I understand and can help students facing learning difficulties and develop their potential.	0.86	
Initial PK-subscale			0.97
	CK		
C1	I understand the facts, concepts, principles, and procedures that are essential in my subjects.	0.75	
C2	I can use my subjects' scientific thinking (deductive and inductive) to explain (reason) various natural facts and phenomena.	0.80	
C3	I always try to describe the hierarchy and relationship between the concepts in my subjects.	0.75	
C4	I can provide illustrations and some examples of the application of my subjects in the context of everyday life.	0.76	
C5	I always follow the latest developments in science and technology in the field of science through various media.	0.38	
Initial CK-subscale			0.86
	PCK		
D1	I can determine approaches, methods, models, and learning strategies that are suitable for each material's characteristics.	0.82	
D2	I can choose important materials, concepts, and ideas that students must understand and allow students to think.	0.83	
D3	I can choose the right assignments and learning experiences for students related to learning topics.	0.85	
D4	I can choose appropriate media and learning resources to help students learn my subject.	0.84	
D5	I can choose right evaluation technique or method according to nature/character of learning material.	0.80	
Initial PCK-subscale			0.94
	TCK		
E1	I follow and understand the latest technological developments related to my subjects.	0.68	
E2	I still feel left behind in understanding the development of science and technology in my subjects which are growing rapidly.	0.44	
E3	I can develop content in my subjects that is based on or utilize technology.	0.76	
E4	I can download and explore the internet to get the latest information on my subjects.	0.73	
E5	I can create or download animations or games related to the material in my subject.	0.64	
Initial TCK-subscale			0.84
	TPK		
F1	I can choose technology that can support the implementation of learning approaches, methods, models, and strategies.	0.71	
F2	I can choose technology to develop media, materials, and learning resources that can support the achievement of learning objectives.	0.65	
F3	I can choose or develop technology that can be used to manage teaching materials, media, and learning resources so that they are easily accessible to students (learning management system).	0.77	

Table A1 (Continued). Corrected item discrimination (r) and reliabilities (α) of the initial TPACK questionnaire (47 items)

Item		*r*	α
	TK		
F4	I can choose and use technology to deliver teaching materials and assignments to students, either for face-to-face or online learning.	0.79	
F5	I can choose technology to carry out online assessments and process the results of face-to-face and online assessment.	0.77	
F6	I can do a good online assessment according to information technology facilities.	0.19	
Initial TPK-subscale			0.84
	TPACK		
G1	I can choose and apply suitable learning strategies to teach my subjects with certain characteristics by using the right technology to understand them easily.	0.81	
G2	I can apply innovative technology-based learning models to give students experience in designing and creating projects in my subjects.	0.80	
G3	I can use certain learning models with animation programs to experiment with my subjects.	0.81	
G4	I can use pictures or videos about my learning material to motivate students before starting the lesson.	0.79	
G5	I can use virtual labs/simulations in inquiry learning to help students understand concepts in subject.	0.80	
G6	I can choose the application to do the appropriate assessment even though there are many pictures, symbols, and terms in science subjects.	0.81	
Initial TPACK-subscale			0.93
Whole instrument			0.98

APPENDIX B

Relationship between each Component in TPACK

We also performed an analysis to find out the relationship between the TPACK components. This analysis was conducted to validate the developed survey items. The relationship of each TPACK component is shown in **Table A2**. Based on **Table A2**, each component in TPACK has a very strong correlation (Sig. 0.000). This result follows the theory, which states that each component in TPACK correlates (Koehler et al., 2013; Mishra & Koehler, 2008)

Table A2. Relationship between components in TPACK (n=1,357)

Relationship of the component	R	p-value
TK-PK	0.583	0.00
TK-CK	0.480	0.00
TK-PCK	0.489	0.00
TK-TCK	0.539	0.00
TK-TPK	0.536	0.00
TK-TPACK	0.504	0.00
PK-CK	0.668	0.00
PK-PCK	0.670	0.00
PK-TCK	0.534	0.00
PK-TPK	0.561	0.00
PK-TPACK	0.592	0.00
CK-PCK	0.672	0.00
CK-TCK	0.558	0.00
CK-TPK	0.537	0.00
CK-TPACK	0.542	0.00
PCK-TCK	0.560	0.00
PCK-TPK	0.624	0.00
PCK-TPACK	0.625	0.00
TCK-TPK	0.624	0.00
TCK-TPACK	0.602	0.00
TPK-TPACK	0.619	0.00