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Indonesian Pre-service and In-service Science Teachers' TPACK Level

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Abstract

This current study aimed to examine the levels of TPACK among pre-service and in-service science teachers, including several influencing factors such as gender, status, and age. Through a study of TPACK dimensions of the 211 pre-service and in-service biology teachers in junior high school and science teachers in senior high schools were identified. The results depicted that pre-service and in-service science teachers dominate the understanding and application of non-technological dimensions. Otherwise, it was found that technological dimensions needed to be more knowledgeable for pre-service and in-service science teachers. The analysis of the variance test demonstrates significant differences were identified regarding status and age. However, no dimension was found to be significantly different regarding age level. To sum up, pre-service and in-service science teachers have different understandings and applications of ICT integration in science classrooms. Professional teaching can be developed by improving knowledge and skills of technology, pedagogy, content, and their integration.

Kata Kunci: TPACK, Pre-service Biology Teachers, Pre-service Science Teachers, In-service Biology Teachers, In-service Science Teachers

INTRUDUCTION

The advancement of technology in education has shed light on the use of information and communication technology (ICT) to develop effective teaching and learning. Every teachers or teacher candidates, including science teachers, are expected to be acknowledgeable with technology for language teaching. The goal is that ICT is provided to enhance language teaching quality (Hew & Cheung, 2014), increase learners' understanding, and motivate learning in science classrooms (Kessler & Bikowski, 2010). Science teachers can integrate ICT into their teaching courses. To do this, science teachers must understand how to operate a computer, surf the internet, and utilize technological media for effective teaching. This understanding of how biology and teachers integrate ICT into their teaching refers to technological pedagogical content knowledge (TPACK).

TPACK is paramount for in-service and pre-service teachers in science classrooms. TPACK leads in-service and pre-service science teachers to be acknowledgeable for the innovative integration of ICT, lesson, and teaching methods (Kurt, Mishra & Kocoglu, 2013; Rosenberg & Koehler, 2015). Teachers should deal with the seven dimensions of TPACK (Baser, Theodore & Ozden, 2016). The first dimension is technological knowledge (TK), which leads science teachers to understand how to utilize ICT in their teaching. The second dimension is pedagogical knowledge (PK), which allows science teachers to deal with pedagogical competence. The third one is content knowledge (CK), which allows science teachers to prepare

their lesson plans. The fourth is technological content knowledge (TCK), which combines lessons and ICT in science classrooms. The fifth one is technological pedagogical knowledge (TPK), which integrates how science teachers manage their classrooms and the use of ICT for effective teaching. The sixth is pedagogical content knowledge (PCK), which describes knowledge for various teaching methods. These dimensions are integrated into the last dimension, called technological pedagogical content knowledge (TPACK) (Baser et al., 2016).

Several studies on the integration of technology into teaching content, however, have shown that there are several important findings to notice, such as low technological practices in the science teaching (Peeraer & Van Petegem, 2014), and lack of technological skills in the science classrooms (Hockly, 2012). These different findings imply that a group of science teachers have either high or low ability on TPACK. Meanwhile, in Indonesia, recent studies on TPACK focus on benefits of TPACK for pre-service science teachers (Limbong, 2017), science teachers' perceptions and beliefs on TPACK, and implementation of TPACK in teaching science in high schools (Wulandari, 2019; Putri, 2019).

However, little study has been conducted in terms of the level of TPACK between in-service and pre-service science teachers in Indonesia. This study aims to measure the TPACK comparison between in-service and pre-service science teachers in Indonesia. This current study is different from the previous studies. First, it tends to compare both in-service and pre-service teachers' levels of TPACK, which has not been investigated in previous studies. Second, a higher number of both in-service and pre-service science teachers took part in the study. Third, it investigates the level between in-service and pre-service science teachers in general, gender difference, age, and status level. To focus on the study, two research questions were addressed, as follows: 1) What is the level of TPACK among pre-service and in-service science teachers? and 2) To what extent does the level vary depending on demographic variables (i.e, gender, status and age)?

METHOD

This research used the survey research method. Survey research was chosen because it provides the ability to collect data from respondents quickly and efficiently. Surveys also allow for feedback from respondents on things like their knowledge, opinions, and attitudes towards the researched topic. In this case, survey research can help to measure the TPACK (Technological Pedagogical and Content Knowledge) of novice and experienced science education teachers. Surveys can be an appropriate method to achieve the goals of this research (Niess, 2005; Swan & Shi, 2010; Fang & Chen, 2013; Li & Liu, 2017).

Participants

The participants of the current study were 211 pre-service and in-service biology and science teachers in Indonesia, then we called it science teachers because in Indonesia, the biology teachers taught in the senior high school and science teachers taught in the junior high school. It comprised 189 pre-service science teachers studying in the science education department at two different state universities in Indonesia and 22 in-service biology teachers teaching at senior high schools in Indonesia and in-service science teachers at junior high schools in Indonesia. The participants were selected through online purposive sampling (Barratt, Ferris & Lenton, 2014) due to massive and social distancing restrictions during Covid-19 outbreaks. To see the detailed information of the participants, we can see Table 1.

Table 1. Demographic Variables of the Participants

Variable		%	*N*
Gender	Male	23.2	49
	Female	76.8	162
Status	Pre-Service	89.5	189
	In-Service	10.4	22
Age	19-21 years old	89.5	189
	22-35 years old	4.2	9
	36-50 years old	6.1	13

Table 1 above shows that the participants were of various demographic variables. In terms of gender, female (n=162, 76.7%) participants were of higher number compared to males (n=49, 23.2%). Regarding the status level, 189 (89.5%) pre-service science teachers and 22 (10.4%) in-service science teachers participated in the study. As for the age, 189 (89.5%) pre-service science teachers were 19 – 21. On the other hand, the number of pre-service science teachers in the age of 22 – 35 was 9 (4.2%), while 13 (6.1%) in-service science teachers were 36-50 years old.

Data collection

This current study utilized Technological Pedagogical and Content Knowledge (TPACK) of science teachers for surveying science teachers. TPACK, developed by Hsu (2017), is used as a measurement tool that integrates science teachers as a course and the application of technology. TPACK consists of 28 items: 6 items for TK, 6 items for CK, 5 items for PK, 5 items for PCK, 3 items for TCK, 2 items for TPK and 1 item for TPACK. As for reliability, Cronbach's alpha of TPACK ranges from .81 to .92.

The data were collected in January 2021. To collect the data, we sent 223 TPACK questionnaires to science teachers to fill in and complete the questionnaire via E-mail, WhatsApp, Facebook, and Web Survey. However, only 211 science teachers returned and

responded to the questionnaire. The rest (n=12) have not responded to the request with any notice.

Data analysis

Having collected all of the questionnaires, the data were analyzed by SPSS 25.0. The application was performed to examine both descriptive and inferential statistics. As for descriptive statistics, the analysis was focused on the mean and standard deviation of each dimension of TPACK. This analysis was undertaken to answer the first research question about the TPACK level among pre-service and in-service science teachers.

Furthermore, inferential statistics were performed to determine variances of each demographic variable of the participants. In this case, an independent sample t-test was performed to analyze the mean significances among the independent samples. Furthermore, we utilized one-way ANOVA to analyze age level, which consists of more than two groups.

RESULTS AND DISCUSSION

RQ1: What is the level of TPACK among pre-service and in-service science teachers?

To answer the first question, the data were descriptively analyzed as shown in Table 2.

Table 2. The Level of TPACK of Pre-service and In-service Science Teachers

Groups		*n*	Range	*M*	*SD*
PST	TK	189	14-29	19.8	2.475
	CK	189	24-43	36.4	3.531
	PK	189	32-44	38.3	3.076
	PCK	189	29-40	35.1	2.223
	TCK	189	10-23	16.6	2.439
	TPK	189	7-13	9.5	1.174
	TPACK	189	1-5	3.5	1.137
	Valid N (listwise)	189			
IST	TK	22	17-23	19.7	1.393
	CK	22	28-42	36.5	3.474
	PK	22	36-44	41.4	2.128
	PCK	22	28-38	33.6	3.157
	TCK	22	13-16	15.1	.750
	TPK	22	8-15	9.5	1.566
	TPACK	22	1-5	2.6	1.008
	Valid N (listwise)	22			

Table 2 compares the TPACK of pre-service and in-service science teachers regarding the descriptive calculation. Non-technological dimensions such as PK, CK, and PCK have

higher scores. However, lower levels of pre-service science teachers' TPACK are found in terms of technological dimensions TPK, TK, TCK, and TPACK. Moreover, similar results reach in-service science teachers' TPACK scores of technological dimensions (TPK, TK, TCK & TPACK). It implies that both pre-service and in-service science teachers have a similar understanding of non-technological dimensions of their teaching, such as the concept of pedagogy. Otherwise, lower mean scores in both results also depict that both pre-service and in-service science science teachers are not knowledgeable in integrating ICT into science teaching.

RQ2: To what extent does the level vary depending on demographic variables (i.e gender, status and age)?

To solve the second problem, descriptive statistics and ANOVA results were presented. The analysis was performed to measure whether each demographic variable (i.e gender, status and age) differed significantly.

Table 3. TPACK in the Terms of Gender (Pre-service Science Teachers)

Dimension	Gender	*n*	*M*	*SD*	*F*	*p*
TK	F	148	19.8	2.553	.020	.889
	M	41	19.8	2.200		
CK	F	148	36.6	3.361	2.026	.156
	M	41	35.7	4.059		
PK	F	148	38.4	3.072	.383	.537
	M	41	38	3.114		
PCK	F	148	34.9	2.204	1.414	.236
	M	41	35.4	2.281		
TCK	F	148	16.5	2.389	.109	.742
	M	41	16.7	2.640		
TPK	F	148	9.5	1.146	.075	.785
	M	41	9.5	1.286		
TPACK	F	148	3.5	1.110	.893	.346
	M	41	3.7	1.234		

TPACK level in terms of gender between male and female pre-service science teachers is presented in Table 3. The result shows no significant difference between males and females for each dimension of TPACK. The data demonstrated that the highest score was the first dimension, TK (p(.889)>.05), while the lowest score was the second dimension, CK (p(.156)>.05). Other significance levels, PK (p=.537), PCK (p=.236), TCK (p=.742), TPK (p=785), and TPACK (p=.346), are above the alpha level (.05). It can be concluded that both male and female science teachers have similar understanding and implementation of TPACK in science classrooms.

Table 4. TPACK in the Terms of Gender (In-service Science Teachers)

Dimension	Gender	*n*	*M*	*SD*	*F*	*p*
TK	F	17	19.9	1.298	2.816	.109
	M	5	18.8	1.483		
CK	F	17	36.3	3.837	.380	.545
	M	5	37.4	1.817		
PK	F	17	41.2	2.186	.567	.460
	M	5	42	2		
PCK	F	17	34	3	1.272	.273
	M	5	32.2	3.633		
TCK	F	17	15.1	.781	.091	.766
	M	5	15	.707		
TPK	F	17	9.6	1.698	.229	.638
	M	5	9.2	1.095		
TPACK	F	17	2.5	.943	1.070	.313
	M	5	3	1.225		

As for the gender level of in-service science teachers, similar results have been found. The level of TCK, TPK, CK, PK, TPACK, PCK, and TK is above the alpha level, which shows that male and female in-service science teachers did not have significantly different technological and content knowledge concepts. Male teachers (M=41.2) prove they have better pedagogical knowledge competence. Both male and female teachers were competent in terms of pedagogical and content knowledge.

Table 5. TPACK in the Terms of Status (Pre-service Science Teachers or In-service Science Teachers)

Dimension	Status	*n*	*M*	*SD*	*F*	*p*
TK	PST	189	19.8	2.475	.052	.820
	IST	22	19.7	1.393		
CK	PST	189	36.4	3.531	.046	.831
	IST	22	36.5	3.474		
PK	PST	189	38.3	3.076	20.468	.000
	IST	22	41.4	2.128		
PCK	PST	189	35.1	2.223	7.959	.005
	IST	22	33.6	3.157		
TCK	PST	189	16.6	2.439	7.988	.005
	IST	22	15.1	.750		
TPK	PST	189	9.5	1.174	.001	.977
	IST	22	9.5	1.566		
TPACK	PST	189	3.5	1.137	13.869	.000
	IST	22	2.6	1.008		

Unlike gender, the TPACK level among pre-service and in-service science teachers' status varies in terms of its dimension. Based on the analysis of the independent t-test, there were four dimensions (i.e, PK, PCK, TCK, and TPACK) that were significantly different: PK (p=.000); PCK (p=.005); TCK (p=.000); TPACK (p=.000). Both pre-service and in-service science teachers did not show any difference in understanding and utilizing TK (p=.820), CK

(p=.831), and TPK (p=.977) in their teaching. This result demonstrates that pre-service and in-service science teachers have means differences in terms of knowledge of pedagogy, pedagogy and content, technology and content, and technology, pedagogy, and content. As for PK, in-service science teachers (M=41.4) are more experienced than pre-service science teachers (M=38.3) in teaching Science. Meanwhile, pre-service science teachers seems to be more experienced in terms of PCK (M=35.1), TCK (M=16.6), and TPACK (M=3.5) if compared to in-service science teachers.

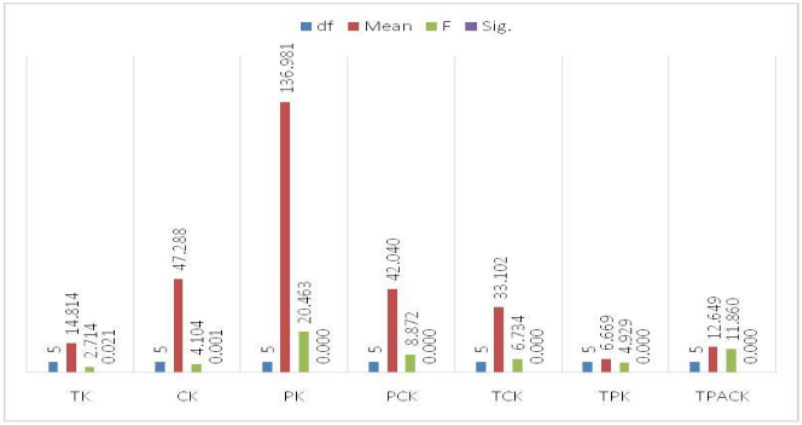

Figure 2. TPACK in Terms of Age

The one-way ANOVA test (Figure 2) shows a statistical mean difference of TK among the age levels. This also means that age affects the level of technology understanding among both groups of Science teachers (p(.021)<.05). The analysis shows that TCK level among Science teachers has a statistical mean difference (p(.000)<.05). It indicates that age has an impact on the level of TCK. The result (p(.000)<.05) depicts that there is a significant mean difference in TPK among both groups of Science teachers. It means that age statistically affects Science teachers' TPK levels. The result of the variance test (p(.000)<.05) for the TPACK dimension demonstrated that there is a statistical mean difference among the age groups. As for non-technological dimensions of TPACK, based on the ANOVA test result, a significant difference was found among the mean scores of CK (p(.001)<.05) and PK (p(.000)<.05).

As for the level of TPACK among pre-service and in-service science teachers, it was found that technological dimensions of TPACK such as TK, TCK, TPK, and TPACK are in the lower levels. In-service science teachers develop better in non-technological domains, while a lack of response was obtained from technological domains. The research by Carbová and Betáková (2013) depicted that non-technological dimensions such as PCK have important roles in shaping teachers' awareness, even though the teachers can integrate ICT into their teaching.

Voogt and McKenney (2017) stated that in-service teachers do not use ICT in their classrooms due to the difficulties and particular time of using ICT. Moreover, since pre-service science teachers have good integration in ICT, their ability to focus on CK and PK has not been developed (Nazari, Nafissi, Estaji & Marandi, 2019). Otherwise, in-service teachers act actively toward content and pedagogical knowledge (Hervey, 2015).

Unlike the above findings, previous studies on pre-service and in-service science teachers demonstrated that technological domains of TPACK among both pre-service and in-service science teachers are performed more than non-technological domains. In fact, many science teachers consider that ICT-based teaching supports such as online materials and digital presentations are more reliable for improving learners' science skills. Otherwise, science teachers have better attitudes toward both technological and non-technological dimensions. This result is important to note since either pre-service or in-service science teachers can integrate ICT into their teaching. One way to do this is by integrating ICT into science teaching materials and classroom assessments (Poonpon, 2021) such as books which results in the effectiveness of science teaching (Nushi & Momeni, 2020).

Meanwhile, Hofer and Grangenett (2012) believed that either non-technological or technological dimensions should not be developed simultaneously. The underlying reason might be that both pre-service and in-service science teachers are not properly provided with particular contexts and design focus of teaching, leading to ICT utilization (Abbitt, 2011). Furthermore, Koh and Chai (2016) emphasized that science teachers act better in pedagogy and content because technology-based teaching media do not directly allow learning to be developed through pedagogical values. This is in harmony with the study, which proved that both technological and non-technological dimensions are treated differently due to the influence of inconsistency between their knowledge and ability to implement. Moreover, technological tools such as online learning are considered to be difficult for teachers who are not used to operating such learning modes (Kamil & Sani, 2021).

To solve such a problem, it is a need for science teachers to be provided not only with the general use of ICT but also with how to integrate ICT in a particular course such as science teaching (Tondeur et al., 2012). In this case, science teachers are expected to be aware of the negative impact of ICT. Meanwhile, this is also intended to allow science teachers to develop their TPACK (Jang & Chen, 2010) and finally they can also develop their teaching profession. Professional teaching development must be developed as they are prepared to improve their teaching attitudes (Korkmaz & Unsal, 2020). It does not mean that in-service science teachers are not considered to get involved in ICT integration. Professional development of science

teachers should always be focused on increasing language teaching skills. To achieve this objective, teacher educators are expected to properly take part in developing professional teaching quality (Aktan, Toraman, & Orakcı, 2020). Another potential step to achieve is by pursuing intensive practicum and training for both pre-service and in-service science teachers.

Significant differences obtained include technological dimensions such as TK, TPK, and TPACK. This is in harmony with the studies (Koh et al., 2010; Koh & Divaharan, 2011; Kurt et al., 2013) that mention that technological dimensions such as TK, TCK, TPK, and TPACK have been considered compulsory elements for pre-service science teachers. Each dimension is significantly different in that the science teachers are able to integrate ICT into their teaching. However, it is different from the finding of Abera (2014), who states that each dimension of TPACK among teachers does not result in a significant difference. A different level allows Science teachers to select an appropriate strategy for teaching or learning language or integration between language and other elements.

As for status level, the study demonstrates that PK, PCK, TCK, and TPACK dimensions significantly differ. In-service science teachers have a good understanding and implementation of pedagogical knowledge, while pre-service science teachers are considered to act better in terms of pedagogy, content, and technology dimensions. This is in harmony with the findings (Roig-Villa, Mengual-Andrés & Quinto-Medrano, 2015; Jang & Chang, 2016; Cheng, 2017; Hsu, Tsai, Chang & Liang, 2017; Nazari et al., 2019), who found that pre-service science teachers have a higher understanding on technological dimensions, while in-service science teachers have higher scores on non-technological dimension. Professional teaching skills are linear with knowledge of technology, pedagogy, and content which should be developed from the beginning (Villalta & Martinic, 2020). However, opposite findings (Valtonen et al., 2017) depict that teachers with less teaching experience, such as pre-service science teacher, are not competent in utilizing ICT. The reason is that pre-service science teacher is not offered sufficient time to learn how to use ICT in teaching. In this case, an intensive teacher practicum is needed to measure pre-service science teachers' competency to integrate ICT into their teaching more effectively.

Meanwhile, each level of age contains significant differences. This is an interesting finding since none of gender nor status was statistically significantly different in terms of all dimensions. It shows that TPACK levels of pre-service science teachers and in-service science teachers of different ages vary. In other words, each age corresponds to different levels of attitude, understanding, and implementation of TPACK. While the development of science teachers' TPACK include the seven dimensions (Hu & Fyfe, 2010; Chai, Koh & Tsai, 2010),

it is noticed that TPACK is important for increasing the quality and applicability of ICT integration (Hu & Fyfe, 2010; Kurt et al., 2013). For pre-service science teacher, the age level consists of sophomores, juniors, and seniors, while for in-service Science teachers, their ages match their teaching experiences. This result aligns with the study that senior pre-service science teachers, whose ages are between 20-21 years old, is knowledgeable in utilizing seven dimensions of TPACK. Interestingly, senior science teachers can develop both technological and non-technological dimensions compared to sophomores or juniors.

Gender level, however, illustrates that neither male nor female Science teacher does not have different attitudes towards both technological and non-technological dimensions. This is proved by the result, which showed that no significant difference was identified in all dimensions of TPACK. This agrees with the studies (Ersoy, Mehmet, Kabakçi-Yurdakul & Ceylan, 2016) which depicted no significant difference between gender means in terms of TPACK. In agreement with that, previous studies (Cussó-Calabuig, Farran & Bosch-Capblanch, 2018) mentioned that pre-service science teachers' TPACK makes no significant difference regarding technology usage and interest, such as mobile-assisted language learning.

However, different findings (Koh et al., 2010; Terzis & Economides, 2011; Lin, Tsai, Chai & Lee, 2013; Jang & Tsai, 2013; Mustafa, 2014; Liu, Zhang & Wang, 2015) convinced that there is the significant difference among male and female science teachers regarding knowledge of technology, pedagogy, and content. The study by Cetin-Berber & Erdem (2015) demonstrated that males act more actively towards technological knowledge, while females are more knowledgeable in comprehending concepts and implementing pedagogical knowledge. Furthermore, Yau, Chen, and Ho (2012) found that male science teachers are active users of ICT, such as mobile learning tools, while female science teachers show negative feedback towards ICT. This is in harmony with Zhonggen, Ying, Zhichun & Wentao (2019) finding which indicated that male teachers dominate activities regarding technology more than female teachers can do. It can be concluded that in some context, science teachers' TPACK is significantly different, while no difference is identified in other contexts.

CONCLUSION

To sum up, it is emphasized that the level of TPACK depends on the context in which the Biology and Science teachers interact. Some groups of teachers are aware of the importance of ICT integration. However, the same result only fits other groups of teachers who promote teaching with sufficient knowledge and skills in ICT integration. In teaching science, integrating technology and teaching content is paramount in developing professional teaching performance. For some Science teachers, however, knowledge and skills in understanding the

concept of teaching pedagogy and content are more valuable than utilizing ICT in the classrooms.

The limitation of this current study is identified. First, this study involved more PST than in-service Science teachers. Future research needs to extend the number of in-service Science teachers, and different comparisons will be investigated. Second, the study is limited to analyzing descriptive statistics and ANOVA. Further research should focus on statistics data analysis and qualitative data. Qualitative analysis is needed to support quantitative data to investigate a research topic more deeply.

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