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Evaluation of TPACK Competencies Based on Gender, Education and Years in Teaching of Mathematics Lecturers in Indonesia

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Abstract. *This study evaluates the ability of mathematics lecturers in Indonesian universities to use TPACK (Technological Pedagogical Content Knowledge). It uses a Sequential Explanatory research method that integrates quantitative and qualitative approaches. The findings indicate that overall, the TPACK skills of mathematics lecturers in Indonesia are at a very good level (85,6%). The questionnaire data showed that the aspects of gender, length of teaching, and level of education had average scores of 85.2%, 85.5%, and 86.1%, respectively. Students' responses to lecturers' TPACK were also high, with an average questionnaire score of 85.1%. Further analysis showed no significant difference in the TPACK ability of mathematics lecturers based on gender, years of teaching, or level of education. However, partial analysis showed that female lecturers' CK and PK components were superior to male lecturers. This indicates a significant effect of gender partially on lecturers' TPACK. At the same time, the length of teaching and level of education does not have a significant impact either partially or jointly on the TPACK ability of mathematics lecturers in Indonesia. This study provides in-depth insights into the factors that influence the TPACK of mathematics lecturers, with important implications for professional development and improving the quality of learning in the Indonesian higher education context.*

Keyword*: Education; Evaluation; Gender; TPACK; Years in Teaching*

INTRODUCTION

TPACK (Technological Pedagogical Content Knowledge) is crucial in improving the quality of mathematics education in Indonesia. TPACK integration supports the creation of an effective balance between technological, pedagogical, and content skills (Agyei, D. D., & Voogt, J. M. (2015). Mathematics lecturers will struggle to integrate technology effectively without adequately understanding all three aspects (Reyes, 2017). This is important because technology is highly dominant in 21st-century mathematics education (Frydenberg & And one, 2011). Lecturers' low mastery of TPACK can be detrimental to students because it results in a lack of engagement and motivation to learn (Sintema & Phiri, 2018). This issue is even more crucial considering that Indonesia is Asia's 3rd largest internet user (Balhara, Mahapatra, Sharma & Bhargava, 2018). With 213 million users, equivalent to 77% of the total population, it signifies a high opportunity to integrate technology into learning (Lee, 2017). However, this opportunity will be wasted if lecturers as teachers do not have adequate TPACK skills, so learning does not follow the character of 21st-century students who tend to like technology in learning (Lester, 1996). Therefore, measuring how much TPACK ability of lecturers in Indonesia is important in providing an evaluation to improve the quality and relevance of learning with the times.

In mathematics education, TPACK studies have significantly contributed to improving teaching quality. For example, Adulyasas' research revealed that lecturers with good TPACK skills found it easier to explain Calculus to Thai students (Adulyasas, 2018). Similar findings were also

revealed in the analysis of Mao Li et al., who stated that TPACK plays a crucial role in developing integral material learning skills in Chinese universities (Noori & Li, 2023). Meanwhile, Aldossry & Lally successfully concluded that TPACK could be enhanced by innovative technology-based learning approaches in Saudi Arabia (Aldossry & Lally, 2019). This is reinforced by Garcia-Gomez's analysis, which explains that technology integration in mathematics learning can provide a more interesting and effective learning experience (Gómez-García et al., 2020). Not stopping here, Rodriguez, in his study, stated that mathematics lecturers in Spain with good TPACK qualities tend to have a higher level of adaptation to technological change (Rodríguez Moreno et al., 2019). While these studies have been of great benefit in developing an understanding of TPACK in mathematics, it is unfortunate that studies that specifically measure TPACK ability based on gender, level of education, and years of teaching are still rare, especially in the context of a Southeast Asian country like Indonesia. This is crucial given that Indonesia is the fourth most populous country in the world, with a high level of internet usage (Mangku et al., 2021).

Based on the urgency of the research described earlier, the study will investigate the influence of three main factors, namely gender, education level, and length of teaching experience, on the TPACK competency level of mathematics lecturers in Indonesia. This report begins by providing an overview of the TPACK capabilities of mathematics lecturers in several universities in Indonesia. This is followed by presenting the research results on the interaction between the three independent variables studied on the TPACK component. This process begins with a pre-requisite test of normality and homogeneity of the data, providing a strong basis for further analysis. This step is expected to answer the growing argument that factors such as those described in these variables must be considered for designing future mathematics lecturer development strategies (Benson & Ward, (2013).

METHOD

This research uses a mixed method by applying the Exploratory Sequential approach. The Sequential Explanatory steps consist of several stages, namely 1) collecting quantitative data through surveys using Likert scales, 2) analyzing quantitative data to obtain preliminary findings, 3) collecting qualitative data through in-depth interviews to explain and expand understanding of quantitative findings, and 4) integrating and interpreting quantitative and qualitative data as a whole (Santi, 2021). Before entering the Explanatory Sequential stage, this research emphasizes testing the validity and reliability of the data, especially since it uses Likert scales as measurement instruments in the research (Ponce & Pagán-Maldonado, 2015).

Participants

This study involved 68 Mathematics lecturers from nine universities in Indonesia from August – October 2022. Sampling was conducted randomly to determine the research locus, involving various well-known higher education institutions in Indonesia, such as Imam Bonjol State Islamic University Padang, Sunan Kalijaga State Islamic University Yogyakarta, Mahmud Yunus State Islamic University Batusangkar, Bukittinggi State Islamic University, SUSKA Riau State Islamic University, Jambi State Islamic University, Medan State Islamic University, Takengon State Islamic Institute, and Sorong State Islamic Institute. These various loci were selected to represent the characteristics and geographical conditions of various universities in Indonesia (Morgan & Harmon, 2001).

Data Collection

In this study, data collection was carried out through distributing questionnaires and interviews. Questionnaires were used to collect information about the ability of Lecturer Competence and Student Response in the TPACK-Based Learning Process. The questionnaire is closed with a Likert

scale to measure respondents' attitudes, opinions, and perceptions of social events or symptoms (Harmon, 2021). The preparation of the questionnaire is based on the needs of the research variables by adopting the study of Chai, Ching Sing, Koh, Joyce Hwee Ling, Tsai, Chin-Chung, and Tan (Chai, Koh & Tan, 2011). The questionnaire was distributed through Google Forms and shared through WhatsApp groups. Meanwhile, in-depth interviews were conducted with lecturers to collect data on lecturers' TPACK skills in the context of mathematics learning.

Data Analysis

In this study, data analysis was carried out descriptively and inferentially. Descriptive statistics were used to explain the average responses from questionnaires filled out by lecturers and students regarding the TPACK competence of lecturers. Meanwhile, inferential statistics were used to test the average difference of Lecturers' TPACK between gender (female and male), education level (Master and Doctoral), and teaching experience (less than 10 years and above 10 years). In addition, this study also tested the interaction between the three independent variables on the TPACK competence of Mathematics Lecturers in Indonesia. The prerequisite test involved a data normality test and a data homogeneity test using a univariate function. Decisions on the test results were made by comparing the analysis with the appropriate test criteria (Hake & Word, 2023). Furthermore, the Two Way Anova test with the help of SPSS was used to test the hypotheses that had been formulated, with a significance value (Sig.) greater than 0.05 (St & Wold, (1989).

Validity and Reliability

TPACK components are identified using a survey method with Likert scale measurements for each indicator. The instrument used to collect data must be tested beforehand. The instrument's feasibility is examined through two stages: validity testing and reliability testing to assess the quality of test items. Validity is a crucial quality of any test, determined by the accuracy and precision of an instrument in performing its function. If the instrument is valid, it can be used for measurement. Validity testing employs the simple Pearson product-moment correlation formula using SPSS software in this research. The significance level used is 5%, with a confidence level of 95%, and the number of statements is 33. Here are the results of the validity testing for variables TK, CK, PK, PCK, TCK, TPK, and TPACK.

Table 1. Validity Testing in R-values and Reliability Statistics

Statement	TK	CK	PK	PCK	TCK	TPK	TPACK
	1-7	8-12	13-19	20-25	26-27	28-30	31-33
1	0.517	0.314	0.753	0.739	0.684	0.473	0.581
2	0.510	0.645	0.397	0.546	0.310	0.383	0.462
3	0.812	0.679	0.712	0.670		0.646	0.705
4	0.523	0.679	0.595	0.693			
5	0.546	0.794	0.674	0.585			
6	0.688		0.626	0.547			
7	0.753		0.505				

Cronbach's Alpha = .895

Table 1 above illustrates the significance values of the correlation for each statement in each TPACK indicator, including TK, CK, PK, PCK, TCK, TPK, and TPACK, towards the total statement scores. Among the attributes of each variable, it is evident that all attributes have r value > r table = 0,3

The next step involves applying the reliability test, which aims to obtain reliable measurement results for multiple measurements on the same group of subjects and produce uniform results. The reliability test in this study was conducted using Cronbach's Alpha formula and SPSS software. Table 1 shows the reliability test results on the survey components distributed on each TPACK indicator. Furthermore, the TPACK reliability score is 0.895. Therefore, the

TPACK indicators in this study showed a high level of reliability, providing a strong basis for interpreting the research results regarding technology integration in the educational context.

FINDINGS

This study investigates the influence of gender, education level, and years of teaching on the TPACK competency level of mathematics lecturers in Indonesia. This research utilizes a mixed-method design by applying a Sequential Explanatory approach. Before conducting prerequisite tests involving data normality and homogeneity tests, it is necessary to conduct a descriptive analysis first to determine the general description of the data used in the study. This section will explain descriptive statistics about the respondents' profiles in this study.

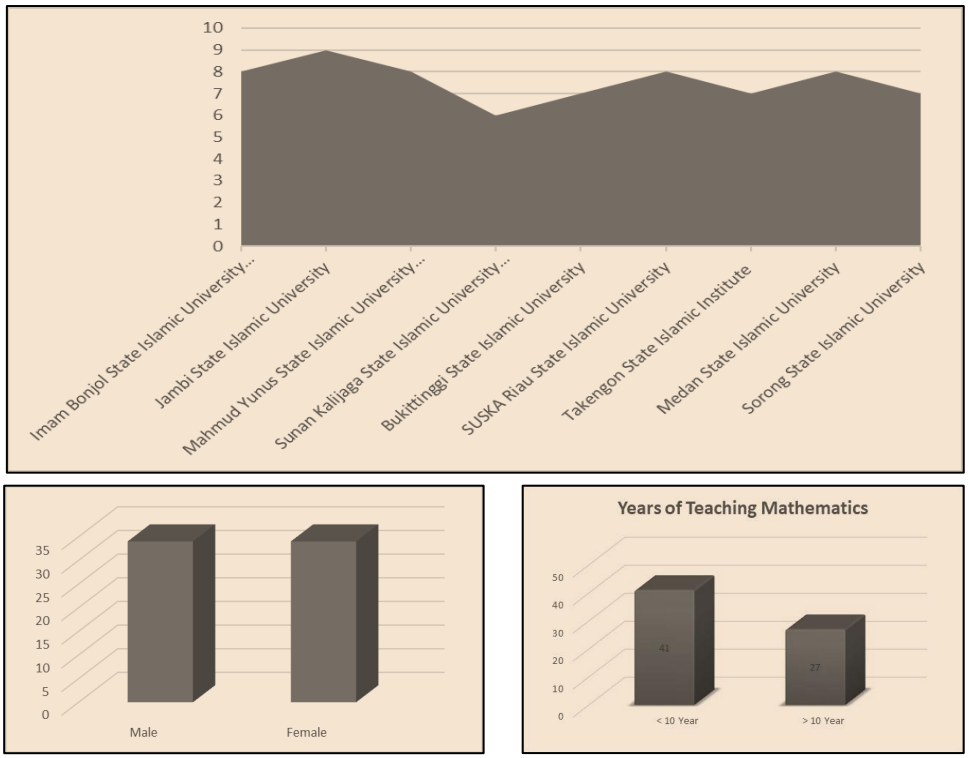

Figure 1. Profile of Respondents Based on Geographical Distribution

As Figure 1 shows, several mathematics lecturers from well-known universities in Indonesia were part of this study. Imam Bonjol State Islamic University Padang contributed 8 respondents, followed by Mahmud Yunus State Islamic University Batusangkar and Medan State Islamic University with 8 respondents each. Jambi State Islamic University contributed with 9 respondents. In contrast, Sunan Kalijaga State Islamic University Yogyakarta, Bukittinggi State Islamic University, SUSKA Riau State Islamic University, Takengon State Islamic Institute, and Sorong State Islamic Institute contributed 6, 7, 8, 7, and 7 respondents respectively. Figure 1 also illustrates the participation in this study, which involved 34 male and 34 female respondents. An equal number of respondents was selected to maintain balance and representativeness between the two gender groups. This is important in this study as it ensures that the findings can reflect the variations and characteristics between the two groups so that the results can be considered more generalizable.

Figure 1 shows that 41 lecturers have less than 10 years of teaching experience, while 27 others have more than 10 years of teaching experience. This analysis shows the distribution of teaching experience among the lecturers observed, with most teaching experience within a shorter period. This comparison can be an important indicator for understanding the teaching profile of the environment. It can form the basis for developing strategies for developing teaching skills and experience in the future. In addition, 46 people or 79.3% of the total lecturers, had a master's degree, while 12 people or 20.7%, had achieved a doctoral degree. Analysis of this data can provide insight into the distribution of lecturers' education levels in the institution, which can be the basis for consideration in developing and improving the quality of human resources in higher education.

Next, the table below displays data on the TPACK abilities of Indonesian PTKIN Mathematics Lecturers based on the survey results when viewed from the aspects of gender, length of teaching, and education as follows:

Table 2. Mathematics Lecturers' Competence on TPACK Components Based on Gender, Length of Teaching and Education

Component	Gender		Mean	Year of Teaching		Mean	Education Level		Mean
	Male	Female		< 10	> 10		S2	S3	
TK	86,9	90,9	88,9	89,5	89,7	89,6	89,2	90,9	90
CK	85	89,2	87.1	87.6	88.2	87.9	86.9	90.4	88.6
PK	83,8	86.7	85.3	85.2	86.9	86	84.7	88.9	86.8
PCK	85.6	86.3	85.9	85.9	86,3	86.1	85.4	88	86.7
TCK	81,9	82.9	82,4	82,9	82	82,5	81.6	85,3	83,5
TPK	83.2	83.6	83.4	84.4	81.9	83.1	83.1	84.3	83.7
TPACK	83,2	83,55	83,4	84,7	81,3	83	83,4	83,5	83,5
Mean	84,2	86.2	85.2	85.8	85.2	85,5	84,9	87,3	86,1

Based on Table 2, the average TPACK score of PTKIN mathematics lecturers with the highest TPACK component is based on the level of education, which is in the outstanding criteria, with an average score of 90.92 in the kindergarten component. The lowest average TPACK score was found in the TPACK component of lecturers who taught for more than 10 years, with an average of 81.33, but still in the outstanding category. Overall, the average TPACK ability of mathematics lecturers with a very good average is around 85.

Next, we will analyze the factors described in Table 1 concerning the TPACK ability of mathematics lecturers. Before conducting hypothesis testing to prove whether or not there are differences in the TPACK of lecturers based on gender, length of teaching and level of education, it is known that the data is typically distributed and homogeneous. Still, hypothesis testing results show no differences in the TPACK abilities of lecturers when viewed from these three aspects. More details can be seen in Table 3 below:

Table 3. TPACK Hypothesis Test Based on Gender Years of Teaching and Level of Education

Aspects	Sig.(2-Tailed)	Decision
Gender	0.103	Accept H_0
Length of Teaching	0.895	Accept H_0
Education Level	0.454	Accept H_0

Source: Field Data Result (2022).

The results of hypothesis testing related to Technological Pedagogical Content Knowledge (TPACK) based on gender, length of teaching, and education level show no significant difference. Specifically, regarding gender with a significance value of 0.103, the decision to accept H0 indicates no significant difference in the mastery of TPACK between respondents based on gender. Similarly, the length of teaching and level of education, which have significance values of 0.895 and 0.454, respectively, resulted in the decision to accept H_0. This means there is no significant

difference in the mastery of TPACK based on the respondents' length of teaching and level of education.

Table 4. Hypothesis Test of TPACK Components Based on Gender

TPACK Aspects	Sig.	Decision
TK	0.051	Accept H_0
CK	0.036	Reject H_0
PK	0.031	Reject H_0
PCK	0.174	Accept H_0
TCK	0.355	Accept H_0
TPK	0.566	Accept H_0
TPACK	0.150	Accept H_0

Source: Field Data Result (2022).

The TPACK component hypothesis testing results based on gender showed variations in the significance level for each component. For the TK Component, the results showed a significance value of 0.051, which resulted in the acceptance of the null hypothesis (H_0). In contrast, the CK and PK Components showed significance values of 0.036 and 0.031, respectively, which resulted in rejecting the null hypothesis. Meanwhile, the PCK, TCK, TPK, and TPACK components showed significance values of 0.174, 0.355, 0.566, and 0.150, respectively, all leading to the acceptance of the null hypothesis. Thus, it can be concluded that there are significant differences in TPACK understanding based on gender, especially in the CK and PK Components.

To test the interaction between the three independent variables (Gender, Length of Teaching and Level of Education) on the TPACK component, the pre-requisite test of normality and homogeneity of data was preceded by the results of the Kolmogorof-Smirnov test with a significance value of 0.2 with df 68 and the results of the homogeneity test with df 0.638 with df1 = 6 and df 2 = 61, so it can be concluded that the data is normally distributed and homogeneous. Hence, it meets the requirements of the two-way ANOVA test. The results of the two-way ANOVA hypothesis test can be seen in Table 5 below:

Tabel 5. Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.173[a]	6	.196	1.356	.247
Intercept	580.152	1	580.152	4022.145	.000
Gender	.583	1	.583	4.039	.049
Level_Education	.363	1	.363	2.514	.118
Years of teaching	.304	1	.304	2.109	.152
Gender * Level_Education	.057	1	.057	.395	.532
Gender * Years of teaching_	.099	1	.099	.684	.412
Level_Education Years of teaching_	.176	1	.176	1.218	.274
Gender * Level_Education * Years of teaching	1.173	6	.196	1.356	.247
Error	8.799	61	.144		
Total	1248.191	68			
Corrected Total	9.972	67			

a. R Squared = .076 (Adjusted R Squared = -.054)

Source: Field Data Result (2022)

Table 5 displays the results of the between-subjects effect test for the dependent variable TPACK (Technological Pedagogical Content Knowledge). The analysis results included in the Corrected Model show a Sum of Squares value of 1.173 with degrees of freedom (df) of 6. The Mean Square value is 0.196, the F-statistic is 1.356, and the p-value (Sig.) is 0.247. However, the

Adjusted R Squared value of -0.054 suggests this model may not optimally explain the variation in the data.

The results of the between-subjects effect test show that the Intercept variable significantly influences TPACK, with an F-statistic value of 4022.145 and a p-value of <0.001. In addition, the Gender variable also showed a significant effect with an F-statistic value of 4.039 and a p-value of 0.049, signaling a significant difference in TPACK between gender groups. Meanwhile, the variables of Level of Education, Years of Teaching, and the interaction between Gender and Level of Education or Years of Teaching did not significantly influence TPACK, with a p-value greater than 0.05. Despite the significant influence of some variables, the low R Squared (0.076) indicates that the variability of TPACK explained by this model is relatively small. Therefore, further consideration is needed regarding other factors that may influence TPACK in the context of this study.

DISCUSSION

This research shows that TPACK (Technological Pedagogical Content Knowledge) of mathematics lecturers can be evaluated based on the average ability in several components, namely TK (Technological Knowledge), CK (Content Knowledge), PK (Pedagogical Knowledge), PCK (Pedagogical Content Knowledge), TCK (Technological Content Knowledge), and TPK (Technological Pedagogical Knowledge). From the analysis, the average TPACK of mathematics lecturers was about 83.5, indicating a good ability to combine technological, pedagogical, and mathematical content knowledge. Furthermore, it was noted that the highest TPACK was achieved in the group of lecturers with more than 10 years of teaching experience, doctoral education level, and female gender. This analysis can serve as a basis for developing strategies and training programs to improve the TPACK skills of mathematics lecturers, focusing on specific aspects that need improvement.

In addition, this study also shows no significant difference in TPACK mastery among respondents when viewed from the aspects of gender, length of teaching, and level of education. This is shown by the significance values of 0.103, 0.895, and 0.454, respectively, resulting in the decision to accept H_0. However, further analysis of the hypothesis testing of TPACK components based on gender showed variations in the significance level for each component. The CK and PK components showed significance values of 0.036 and 0.031, respectively, which resulted in the rejection of the null hypothesis so that it can be interpreted that there are significant differences in the understanding of TPACK based on gender, especially in the CK and PK components. The results of the between-subjects effect test also indicated that the Intercept variable had a significant influence on TPACK, with an F-statistic value of 4022.145 and a p-value <0.001. In addition, the gender variable also showed a significant effect, with an F-statistic value of 4.039 and a p-value of 0.049.

This study confirmed that the mastery of Technology, Pedagogy, and Content Knowledge (TPACK) among mathematics lecturers does not always depend on aspects of their gender, length of teaching, and level of education. This supports Gomez's study, which concluded that these factors do not significantly influence TPACK mastery (Gómez-Trigueros & Yáñez de Aldecoa, 2021). In contrast, Joh Koh's study suggests that influential factors in developing lecturers' TPACK may include practical experience integrating technology in teaching, participation in relevant training, and linking technological knowledge to mathematical content and pedagogy (Koh & Chai, 2011). Jeremy Catera's analysis may need to consider that TPACK skills of lecturers who have practical experience and are actively involved in technology-related professional development tend to have better mastery, independent of factors such as gender, years of teaching, and level of education (Castéra et al., 2020).

However, further analysis showed significant differences in TPACK understanding based on gender in the CK and PK aspects. This aligns with Choi and Hong's study, which explains that social and cultural factors influence individual experiences and education (Choi & Hong, 2022).

For example, gender stereotypes still inherent in society can affect how men and women approach and integrate technology in educational contexts. Differences in content knowledge (CK) and pedagogical knowledge (PK) may also be reflected in traditional gender roles in education. In addition, Jang & Tsai mentioned that psychological aspects and personal preferences that may vary between genders may also contribute to significant differences in TPACK understanding (Jang & Tsai, 2012). Therefore, a deeper understanding of gender dynamics in the context of TPACK learning could be key to designing more inclusive and effective approaches to integrating technology into learning.

In addition, this study revealed that the results of the between-subjects effect test showed a significant effect of the Intercept variable on TPACK, as evidenced by an F-statistic value of 4022.145 and a p-value of less than 0.001. This result indicates that Intercept has an important role in influencing the level of TPACK mastery. In addition, the gender variable also shows a significant impact, indicated by the F-statistic value of 4.039 and a p-value of 0.049. These results suggest that gender may be an influential factor in the level of understanding and application of TPACK, implying that gender differences may play an essential role in such contexts.

The results of this study are in line with the findings of Mariza Gomez, who revealed that Intercept and gender variables have a significant role in influencing TPACK, with F-statistic values of 4022.145 and 4.039, respectively, and p-values <0.001 and 0.049 (María Gómez-Trigueros & Yáñez de Aldecoa, 2021). This finding is also consistent with Khoifah's conclusion in its application to university students in India (Doghonadze, 2016). Nonetheless, the results of this study contrast with Ekrem & Recep's analysis, which emphasized that length of teaching has a central role in improving lecturers' TPACK competencies in Finland (Ekrem & Recep, 2014). Furthermore, this study identified novelty in the aspects of CK and PK, where previous studies did not highlight the role of gender in improving TPACK in both areas. The findings suggest that gender does make a noteworthy contribution in the context of CK and PK.

This study indicates the need for a policy review focusing on developing equitable training and coaching for all lecturers. Measures could include establishing TPACK training programs accessible to all mathematics lecturers regardless of gender, teaching experience, or level of education. In addition, efforts to improve curricula and teaching approaches that are inclusive and holistic could also be implemented to ensure that all lecturers have equal opportunities to improve their TPACK mastery, regardless of any particular factors (Akmal, 2017). This policy alignment can support creating an equitable and inclusive academic environment to improve the quality of mathematics education.

In addition, the results of this study suggest the importance of taking steps to effectively integrate technological knowledge, pedagogy, and mathematical content. First, lecturers need to continue to develop a deep understanding of mathematical content, ensuring that this knowledge includes not only mathematical concepts but also skills in explaining, demonstrating and facilitating student understanding (Іванюк, Венгловська, & Антипін, 2020). Furthermore, lecturers should understand how technology can enhance mathematics teaching and learning, including using relevant tools, software and digital platforms (Ivanova, 2018). In this context, it is also necessary to consider how technology can be adapted to students' learning styles (London, 2001). By synergistically combining technological knowledge, pedagogy and mathematical content, lecturers can create powerful mathematics learning experiences that support students' development of understanding in the digital age.

CONCLUSION

Based on the findings of this study, it can be concluded that the Pedagogical Content Knowledge Ability (TPACK) of mathematics lecturers in Indonesia as a whole is in an excellent category, with an average questionnaire score of 85.15% based on gender, 85.5% based on length of teaching, and 86.12% based on education level. Students' responses to the TPACK of mathematics lecturers were also very good, with an average questionnaire score of 85.06%. However, there was no

significant difference in the TPACK ability of Indonesian mathematics lecturers in terms of gender, length of teaching, or level of education. However, partially, the CK and PK components of female lecturers showed better performance compared to male lecturers. In addition, gender variables have a significant effect partially on the TPACK of lecturers. Meanwhile, the length of teaching and level of education, partially and jointly, do not significantly influence the TPACK ability of Indonesian mathematics lecturers. The implications of this study can provide valuable insights for developing and improving the quality of mathematics learning at the tertiary level, taking into account the role of gender in TPACK aspects. This study recommends the importance of future steps to involve in-depth analysis in exploring contextual factors or additional variables that may be triggering differences in TPACK improvement. Qualitative methods, such as interviews or observations, are also needed to gain a deeper understanding of the specific context that may have influenced the variation in results. Not only do these findings provide critical insights into the observed differences, but they can also serve as a valuable basis for developing more effective and inclusive learning strategies. In addition, the findings provide a clear direction for further research in understanding the dynamics of TPACK understanding in educational contexts.

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