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Do Teachers' Years of Experience and Participation in Teacher Certification Training Influence TPACK Abilities?

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ABSTRACT

This article aims to investigate the relationship between teacher years of experience and teacher certification training on teachers' TPACK (Technological, Pedagogical, Content, Knowledge) abilities. Online questionnaires were distributed to 500 high school teachers across disciplines using the TPACK questionnaire. Data was analysed using descriptive statistical tests and Kruskal-Wallis. The findings show that teachers' TPACK abilities are good. There are differences in TK (Technological Knowledge), PK (Pedagogical Knowledge), TPK (Technological Pedagogical Knoowledge), TCK (Technological Content Knowledge), and TPACK abilities based on different teaching experiences and participation in teacher certification training. However, there was no significant difference in CK (Content Knowledge) ability between teachers' years of experience and participation in the certification training Programme.

Keywords: Professional certification Programme, teachers' training, TPACK ability, years of experience

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INTRODUCTION

One of the developments in 21st-century learning is the integration of information and communication technology (ICT) (Li et al., 2022; Xie et al., 2019). Integrating technology into learning has led to significant changes in classroom conditions (Bernacki et al., 2020; Scherer et al., 2017). The increasing popularity of technology among students from kindergarten to higher

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education has prompted teachers to use technology in the classroom learning process (Chisango et al., 2020; Faizi, 2018; Huang & Teo, 2021). The utilisation of technology and information in classroom learning presents a major challenge for teachers (Faizi, 2018; McCulloch et al., 2018). This is because teachers play an important role in the integration of technology (M. M. Cheng et al., 2022; Nekardová, 2022) to make learning more effective (Chin & Wang, 2021; K. Y. Lin et al., 2021; Majeed & ALRikabi, 2022; Putra et al., 2021). Along with the development of ICT in teaching and learning, several previous studies have shown increased learning motivation (Faridah et al., 2020; Jian, 2019; Wang & Reeves, 2007). Furthermore, other studies have frequently mentioned that the use of digital learning in education effectively enhances students' knowledge, critical thinking, and creativity (Sari et al., 2022; Lin et al., 2022; Chen and Wu, 2023).

For teachers, the development of digital technology in classroom learning also adds demands on their ability to integrate technology. Teachers play an essential role in supporting the use of digital technology as a learning resource and for instructional activities (Nekardová, 2022; Tirado-Morueta et al., 2023; Tołwińska, 2021; Xu & Zhu, 2023). They must understand the concepts of technology and integrate it within pedagogical frameworks and the subject matter context (Castéra et al., 2020; S. L. Cheng & Xie, 2018; Dong et al., 2020). However, there are still challenges regarding technology use among teachers. Research literature shows that many teachers struggle to integrate digital technology into various subject areas (Mundy et al., 2012; Z. Nxumalo & M. Nxumalo, 2023; Tze et al., 2020). Some prefer not to use technology with preschool students (Enochsson & Ribaeus, 2021). Other findings indicate that teachers often lack the knowledge and experience needed to integrate technology into learning (Muhazir & Retnawati, 2020; Tze et al., 2020). From teachers' perspectives, using technology makes it challenging to manage time effectively, leading them to focus more on content delivery than on how the content is taught (Muhazir & Retnawati, 2020). Although many teachers have started using technology in their daily lives, they still need proper training on how to integrate it into the classroom (Enochsson et al., 2022; Tze et al., 2020; Wood et al., 2005), specifically on understanding the components of technology, pedagogy, and content.

Competence in implementing technology, pedagogy, and content does not stand alone but rather interconnects and influences each other (Akyuz, 2018; Li et al., 2022). Integrating these components is known as TPACK (Technological Pedagogical Content Knowledge) (Castéra et al., 2020; Graham et al., 2009; Sahin, 2011). Introduced by Mishra and Koehler, TPACK assesses these three components and their relationships, providing a reliable way to evaluate teachers' digital competence (Bustamante, 2017; Graham et al., 2009). Therefore, the TPACK framework can explain teachers' abilities to implement

learning within a modern educational framework (Akyuz, 2018; Schmidt et al., 2009). 21st-century learning aims to sustainably enhance individuals' abilities within society for the future (Ridhwan et al., 2019; Sari et al., 2021).

TPACK encompasses the technology, pedagogy, and content knowledge that teachers need to integrate technology into the learning process. This framework describes the competencies to be developed to apply technology in 21st century learning and improve teachers' digital skills in the learning process (Li et al., 2022; Miguel-Revilla et al., 2020). The three main domains are Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK). CK refers to knowledge of the subject matter being taught (Graham et al., 2009; Tseng et al., 2022). PK relates to pedagogical approaches that support student learning, and TK involves knowledge of technology. These three components further form four other competencies: Pedagogical Content Knowledge (PCK), which is related to the pedagogical content of teaching; Technological Content Knowledge (TCK), which refers to technology that represents specific content; and Technological Pedagogical Knowledge (TPK), which is the technological knowledge that can be used in learning (Miguel-Revilla et al., 2020). Technological Pedagogical Content Knowledge (TPACK) encompasses the knowledge required by teachers to integrate technology into learning across content areas (Luik et al., 2019; Yanuarto et al., 2020).

Knowledge of the teacher TPACK level requires decisions and advanced activities, such as holding courses and teacher training (Li et al., 2022; Miguel-Revilla et al., 2020). Such training aims to create professional, certified teachers. Teachers who have completed certification training have better competencies than those who have not (Ghavifekr & Rosdy, 2015; Y. Lee & J. Lee, 2014; Miguel-Revilla et al., 2020; Wu et al., 2022). Teacher training activities to improve TPACK abilities are necessary to improve the quality of teachers. However, before holding the training, it is necessary to measure the skills of the TPACK teacher. It aims to determine the teaching ability of teachers, especially in the use of technology in teaching (Aumann et al., 2023; Li et al., 2022; Sahin, 2011; Sahin et al., 2013). Several previous studies have carried out a series of TPACK skills measurements from prospective teachers to teachers (Akyuz, 2018; Li et al., 2022; Sahin et al., 2013; Scott et al., 2023). The measurement results show that teachers' TPACK skills still need to be improved. Furthermore, the quality of training related to curriculum and training materials is still considered insufficient to accommodate the ability to master the latest technology in teachers. Research findings from Woodside (2014) mentioned that inadequate competency training materials cause training objectives to be difficult to achieve. Training materials and the quality of trainers are an important part. The impact requires improvement efforts from teachers and institutions to increase knowledge and skills in integrating TPACK

in learning. Measuring TPACK aims to identify the TPACK subcomponents that need development, highlighting the importance of TPACK assessment before initiating teacher skill development.

Several factors influence teachers' TPACK capabilities. Previous studies reveal that teaching level and academic qualifications impact TPACK skills (Li et al., 2022). Research findings indicate that teaching level affects teachers' confidence in integrating technology into classroom learning (Li et al., 2022). Regarding academic qualifications, TPACK competence relates to teaching experience, technology use experience, and the provision of high-quality educational services (Antony et al., 2019; Chingos & Peterson, 2011; Doğanay & Öztürk, 2011; Graham et al., 2020). Other previous research found TPACK abilities in terms of teacher gender differences (Astuti et al., 2019; Gómez-Trigueros & De Aldecoa, 2021). These studies aim to design TPACK training tailored to teachers' individual needs.

Based on the issue description, numerous efforts have been made to assess teachers' TPACK abilities and compare them based on teaching level and academic qualifications. Although some research shows that length of teaching experience affects teacher professionalism (Alamsyah et al., 2020). Such findings confirm that length of teaching experience acts as a factor in teacher professionalism. However, it has not highlighted in depth the competencies that are improved and does not link the use of technology. Thus, there is a lack of research comparing TPACK measurement in relation to years of teaching experience and participation in teacher certification training Programmes. This study highlights explicitly the comparison between teachers' teaching experience and participation in certification training. This research explores TPACK skills broken down into TK, PK, TPK, CK, TCK, and TPACK, so that the findings receive a more in-depth analysis. The research offers systematic comparisons that allow for clearer comparative analysis. Therefore, this study aims to explore teachers' TPACK skill levels and analyse differences in TPACK abilities based on teaching experience and participation in teacher certification training.

Research Question

This study is to analyse teachers' TPACK abilities based on their years of teaching experience and participation in teacher certification Programmes. There are three research questions:

a. What is the level of teachers' TPACK abilities?

b. How is the ability of teachers' TPACK and any significant difference in teachers' TPACK abilities based on their years of teaching experience?

c. How is the ability of teachers' TPACK and significant difference in teachers' TPACK abilities based on their participation in teacher certification Programmes?

METHODS

Participants

This study analysed the TPACK abilities of 500 teachers across various subjects (social sciences, natural sciences, and languages). The participating teachers were selected from 57 high schools in Aceh, Indonesia, with an average student enrollment of 800 per school. Teachers were chosen regardless of geographical location but were selected from schools with education performance ratings of "yellow" (average quality) and "red" (low quality) (from raporpendidikan.kemdikbud.go.id). Teachers were categorised by teaching grade: 200 in grade X, 150 in grade XI, and 150 in grade XII. Of the participants, 460 hold a bachelor's degree, while 40 hold a master's degree. In terms of gender, there were 370 female teachers and 80 male teachers (Table 1).

Table 1
Teachers' demographic characteristics

Variable	Frequency	Percentage
Teaching Grade		
Class X	200	40%
Class XI	150	20%
Class XII	150	20%
Education Qualification		
Bachelor's Degree	457	91,4%
Postgraduate Degree	43	8,6%
Gender		
Male	163	32,6%
Female	337	67,4%

To analyse the variable of teaching experience, teachers were given a questionnaire regarding their years of teaching experience, with data collected in primary statistical form. Teaching experience was categorised based on a literature review of previous studies examining teaching quality and years of teaching experience (Chingos & Peterson, 2011; Graham et al., 2020; Klassen & Chiu, 2010). The initial categorisation consisted of two groups: junior teachers with less than 5 years of experience (< 5 years) and senior teachers with more than 5 years (> 5 years). However, some studies indicate significant changes after 3 years of teaching experience (Chingos & Peterson, 2011; Klassen & Chiu, 2010). Based on the findings, the category of teaching experiences is more accurate in describing the teaching experiences of junior and senior teachers. By comparison, it showed that there was a decrease in teaching efficiency after 3 years. The teaching experience of 4-5 years is a transitional period as there is a change in the quality of teaching (Graham et al., 2020). In conclusion, we classify teachers into three categories: junior teachers, that is, young teachers who have teaching experience (<3 years), transition teachers who have 4 to 5 years of teaching experience, and senior teachers with >5 years of teaching experience.

The teacher certification Programme is a non-degree Programme designed for teachers who have completed a bachelor's degree and are deemed to meet the standards of competence and professionalism. Teachers were categorised as either having participated in the certification Programme or not. Characteristics of teaching experience and certification Programme participation are shown in Table 2.

Table 2
Characteristics of teachers' years of experience and teachers' certification training Programmes

Variable	Frequency	Percentage
Years of teaching experience		
< 3 years	92	18,4%
4-5 years	318	63,6%
> 5 years	90	18%
Experience in teacher certification programme		
Has participated	258	48,4
Has not participated	242	51,6

Instrument

Previous studies have extensively developed TPACK measurement instruments through teacher self-assessments (Sahin, 2011; Sahin et al., 2013; Li, Liu and Su, 2022). This study focuses on in-service teachers without consideration of specific teaching subjects. The instrument from Sahin's (Sahin, 2011) was selected, as it does not consider the subject area and is tailored for in-service teachers. The instrument consists of 48 items across seven indicators: Technology Knowledge (TK) with 15 items, Pedagogy Knowledge (PK) with 7 items, Content Knowledge (CK) with 6 items, Technological Pedagogical Knowledge (TPK) with 4 items, Pedagogical Content Knowledge (PCK) with 7 items, Technological Content Knowledge (TCK) with 4 items, and Technological Pedagogical and Content Knowledge (TPACK) with 5 items. The instrument uses a self-assessment scale from 1 (strongly disagree) to 5 (strongly agree). Before the instrument is tested, the instrument is consulted with experts to see the suitability of the instrument with the research objectives. Fifty teachers participated in the TPACK instrument testing. Instrument analysis included internal consistency and confirmation analysis to ensure validity and reliability. SPSS 26 was used for data analysis, and invalid items were removed. Cronbach's alpha indicated high consistency, with a total scale score of 0.875. Reliability by subscale was as follows: TK (0.617), PK (0.361), CK (0.689), TPK (0.600), PCK (0.510), TCK (0.582), TPACK (0.583). Validity testing with the Kaiser-Meyer-Olkin (KMO) test yielded a result of 0.521, and Bartlett's test had a significance of $0.000 < 0.05$. Subscale KMO values were: TK (0.512), PK (0.551), CK (0.585), TPK (0.589), PCK (0.530), TCK (0.556), and TPACK (0.625), indicating acceptable validity.

Data Collection Procedure

Data collection took place over three months, from May to July 2023. Teachers' TPACK abilities were assessed through self-reflection by completing a reliable and valid questionnaire. The online questionnaire was distributed via SurveyMonkey (accessed from May to July 2023). The survey link was shared through the Aceh Provincial Education Office via WhatsApp and Telegram groups. Participants were informed about their anonymity and data confidentiality at the beginning of the questionnaire. They were assured that their responses would be used solely for research purposes and published in scientific journals. Teachers who agreed to these terms proceeded to the main questionnaire, while others could leave the survey. A total of 500

teachers participated within the three-month period. The 48-item questionnaire responses were analysed using descriptive statistics.

Data Analysis

Data analysis was conducted using SPSS 26 for Windows. The application was used for data entry and analysis. Demographic data were analysed descriptively by calculating frequencies, means, and standard deviations for each subvariable of teachers' TPACK abilities. Normality of responses for each item was tested using the Kolmogorov-Smirnov test. The result with a significant value of $p < 0.05$ ($p = 0.000$) indicated non-normal distribution across variables TK, PK, CK, TPK, PCK, TCK, and TPACK. The Kruskal Wallis test was used to analyse the variable length of teaching. The Kruskal Wallis test is a non-parametric statistical test that is appropriate for data that is not normally distributed (Charles et al., 2022). Furthermore, the reason for choosing the Kruskal Wallis method is that in the data study there are 3 independent groups (teaching experience < 3 years, teaching experience 3-5 years, and teaching experience > 5 years) so that the Kruskal Wallis analysis method is appropriate for analyzing the character of the research data and the analysis objectives to be achieved. Furthermore, the non-parametric Mann-Whitney U test was used for the teacher certification variable.

RESULTS AND DISCUSSION

Result

Teachers' TPACK Ability Level

The statistical data obtained from respondents was analysed using descriptive statistics to answer the question of teachers' TPACK ability (Table 3). The results show

Table 3
Teachers' TPACK ability level in terms of teachers' years of experience and teachers' certification training Programme experience

TPACK Ability M(SD)	Years of Teaching Experience M(SD)			Teacher Certification	
	< 3 years	– 5 years	> 5 years	Participated	Not Participated
TK 58,45 (10,313)	64,59 (4,953)	62,32 (3,550)	38,48 (5,519)	54,72(12,570)	62,42(4,591)
PK 24,13 (4,508)	16,58 (3,449)	25,61 (2,651)	26,64(1,880)	25,96(1,891)	22,19(5,560)
CK 25,28 (3,015)	24,67 (3,177)	25,40(3,106)	25,28(3,015)	25,43(2,107)	25,13(3,748)
TPK 16,00 (3,698)	17,79 (1,508)	17,29(2,307)	16,00(3,698)	14,44(3,925)	17,67(2,545)
PCK 29,15 (4,244)	25,23 (5,643)	30,49(3,348)	29,15(4,244)	29,45(2,285)	28,83(5,616)
TCK 15,94 (3,539)	17,95 (1,718)	16,97(2,196)	15,84(3,539)	14,53(3,911)	17,24(2,407)
TPACK 18,51 (4,685)	17,55 (3,323)	20,78(3,301)	18,51(4,685)	17,86(4,989)	19,21(4,236)

that, in general, the value of teachers' TPACK ability is high. If the teacher's ability in each sub-variable is sorted from highest to lowest, namely: TK (M = 58,45 SD=10,313), PCK (M = 29,15 SD=4,244), CK (M = 25,28 SD=3,015), PK (M = 24,13 SD=4,508), TPACK (M = 18,51 SD=4,685), TPK (M = 16,00 SD=3,698), and TCK (M = 15,94 SD=3,539).

Exploring Teachers' TPACK Ability by Years of Teaching Experience

The Kruskal-Walli's test was used to analyse differences in teachers' TPACK ability based on years of teaching experience. We divided the teachers into three groups: those with teaching experience of < 3 years, 3-5 years, and > 5 years. The three-year division is based on previous research that suggests differences in teaching ability within these timeframes (Graham et al., 2020). The results show significant differences in TK, PK, TPK, PCK, TCK, and TPACK. However, there is no difference in CK ability based on years of teaching experience. The descriptive statistical results of teachers' TPACK abilities based on their length of teaching experience can be seen in Table 4.

Table 4 shows that the probability values for TK, PK, TPK, PCK, TCK, and TPACK variables with a significance level < 0.05 indicate score differences based on years of teaching experience. Only CK does not show a significant score difference based on teaching experience. For further analysis of score significance differences, pairwise comparisons were used. Table 5 shows the pairwise comparisons for years of teaching experience.

Table 5 shows the pairwise comparisons of TPACK for different teaching experience lengths. In general, there are significant comparisons among the three groups of teaching experience. Teachers with 3–5 years of teaching experience generally scored the highest, particularly in CK, PCK, and TPACK abilities. Additionally, the highest difference in TK score was observed between teachers with <3 years and >5 years of teaching experience, with a difference of 26.11%. For PK, the most

Table 4
Teachers' TPACK ability in terms of teachers' years of experience

Independent Variable	Dependent variable	Mean Rank			X^2	df	P*
		< 3 years	3-5 years	> 5 years			
Years of Teaching Experience	TK	355,30	277,80	46,91	239,443	2	0,000
	PK	55,75	283,75	332,08	214,973	2	0,000
	CK	222,93	259,85	245,65	4,854	2	0,088
	TPK	312,66	288,45	52,87	210,669	2	0,000
	PCK	137,13	300,33	190,32	111,050	2	0,000
	TCK	341,46	279,91	53,59	221,644	2	0,000
	TPACK	203,74	318,96	56,42	245,410	2	0,000

Note. p<0,05

Table 5
Pairwise comparisons result for years of teaching experience

	Years of Teaching Experience		Mean Difference	*P**
TK	< 3 years	3-5 years	2,26	0,000
		> 5 years	26,11	0,000
	3-5 years	> 5 years	23,85	0,000
PK	< 3 years	3-5 years	9,03	0,000
		> 5 years	10,07	0,000
	3-5 years	> 5 years	1,03	0,004
TPK	< 3 years	3-5 years	0,50	0,123
		> 5 years	8,17	0,000
	3-5 years	> 5 years	7,67	0,000
PCK	< 3 years	3-5 years	5,26	0,000
		> 5 years	3,21	0,000
	3-5 years	> 5 years	2,05	0,000
TCK	< 3 years	3-5 years	0,97	0,000
		> 5 years	8,26	0,000
	3-5 years	> 5 years	7,29	0,000
TPACK	< 3 years	3-5 years	3,23	0,000
		> 5 years	6,08	0,000
	3-5 years	> 5 years	9,31	0,000

Note. $p<0,05$

significant difference was between teachers with <3 years and >5 years of teaching experience, at 10.07%. For TPK, an in-depth analysis revealed no significant difference between teachers with <3 years and 3–5 years of teaching experience ($p>0.05$; 0.123). The most significant difference in PCK was observed between teachers with <3 years and 3–5 years of experience, at 5.26%. The highest difference in TCK was observed between teachers with <3 years and >5 years of teaching experience, at 8.26%. Finally, teachers with 3–5 years of experience had the highest difference in TPACK ability compared to teachers with >5 years of experience, with a percentage difference of 9.31%.

Exploring Teachers' TPACK Ability by Participation in Teacher Certification Training Programme

The Mann-Whitney U exam was used to determine the differences in TPACK teacher abilities in terms of their participation in the teacher certification training Programme. The independent variable tested has attended a teacher certification training Programme and has never participated in a teacher certification training Programme. Table 6 shows the Mann-Whitney U test results.

Table 6 shows that there are significant differences in teachers' TPACK abilities in terms of teachers' certification training Programme experience. This can be seen in the scores of TK, PK, TPK, PCK,

Table 6
Mann-Whitney U test results for teachers' tpack based on participation in teacher certification Programme

Independent variable	Dependent variable	Mean Rank		*Man, Whitney U*	Wilcoxon W	*Z*	*edP**
		Has participated	Never				
Teachers' certification training Programme experience	TK	218,00	285,15	22833,000	56244,000	-5,204	0,000
	PK	291,20	207,11	20717,500	50120,500	-6,538	0,000
	CK	242,52	259,01	29159,500	62570,500	-1,285	0,199
	TPK	183,75	321,67	13995,500	47406,500	-10,752	0,000
	PCK	236,84	265,06	27694,000	61105,000	-2,192	0,028
	TCK	197,69	306,80	17594,000	51005,000	-8,532	0,000
	TPACK	237,32	264,55	27817,500	61228,500	-2,115	0,034

Note. $p<0,05$

TCK, and TPACK. Meanwhile, there is no significant difference in the CK. It can be concluded that the ability of teachers in content knowledge does not differ between teachers who have participated in the teacher certification training Programme and those who have never participated in the teachers' certification training Programme. Based on the mean rank value, teachers who have participated in the eacher certification training Programme have an advantage in PK skills.

DISCUSSION

This study investigated the TPACK ability of 500 teachers (RQ1). We decided to conduct three classifications based on the teachers' years of experience (<3 years, 3 - 5 years, and >5 years) based on previous research findings that there are differences in teaching ability based on these intervals. From the data on teachers' TPACK ability, we explored whether years of teaching experience and certification training Programme experience affect teachers' TPACK ability. The results stated that there are differences in TK, PK, TPK, PCK, TCK, and TPACK when viewed from the teachers' years of experience (RQ2). Furthermore, the results of TK, PK, TPK, PCK, TCK, and TPACK show that there are differences between teachers who have attended in the teachers; certification training Programme and those who have never attended in the teacher certification training Programme.

Teachers' TPACK Ability Level

Teachers' abilities are classified in the highest category. More in-depth analysis resulted in an average score approaching a maximum score of 58.45, which is 75. Teachers rated their TK's abilities highly. This result was the same finding from research (Schmid et al., 2021) that mentions that teachers' TK was high. One of the main factors supporting this is teachers' widespread access to technology and basic computer software such as Microsoft Word and PowerPoint (Joo et al., 2018; Sami Novita et al., 2020). In addition, the trend

of owning the latest devices among teachers indicates their efforts to stay abreast of technological developments (Joo et al., 2018) and have started upgrading with learning technologies in the classroom, such as using laptops as learning media and learning resources (Blass & Köhler, 2019; Smith et al., 2022). Teachers have also become accustomed to operating learning support devices such as projectors and printers, which further strengthens their mastery of the technological aspects of TPACK.

However, further analysis shows that CK (Content Knowledge) ability is also one of the strongest aspects of teachers' TPACK, in accordance with the research findings (Akun & Mohammad, 2021). CK's ability is associated to teachers' academic background and scientific specialisation, so they have a strong understanding of learning content and are able to develop materials in depth. In addition involvement in professional communities in their respective fields allows teachers to continuously update their knowledge through regular meetings and discussions (Harro-Loit et al., 2021).

However, PK ability showed lower scores than other aspects, indicating challenges in pedagogical aspects (Sasmito et al., 2020). Teachers' PK ability is knowledge related to practice in teaching, including knowledge of student learning needs and accuracy of selection learning methods, as well as assessment of learning according to student needs (Embacher & Smidt, 2023; Gavrilyuk et al., 2019; Harding et al., 2019). The findings show that teachers are still not accustomed to the new curriculum, so they still need customisation. Especially in Indonesia, curricula have been upgraded since 2020 to be called "Kurikulum Merdeka," so educational policies require teachers to have the ability to implement learning according to student needs and study analysis (Institut Agama Islam Negeri Curup, 2023; Sari et al., 2022). Besides, teachers are not accustomed to conducting various evaluations of teaching and teaching methods (Sari et al., 2023).

Interestingly, although teachers' PK ability was low, teachers have quite good performance in integrating technology into learning. It's seen in the teacher's quite high TPK ability. TPK is the ability to integrate tools and technologies that match learning design to learning goals. (Akyuz, 2018). Teachers are already able to understand the advantages and disadvantages of the technology used so that they can choose the appropriate technology for teaching. TPK abilities are skills that relate to the general understanding of strategies applied in the use of technology in learning activities. These findings seem to contradict each other. This finding presents an interesting paradox, given that generally mastery of technology in learning often goes hand in hand with a strong pedagogical understanding (Peng et al., 2019). Furthermore, some other research also mentions that the ability to teach teachers in the 21st century requires teachers to be able to integrate technology into the teaching activity process (Sari et al., 2023).

The findings of this study have significant implications for teacher education, professional development Programmes and

education policy. The high TK rate indicates that teacher access to technology and digital learning is not a barrier. Professional development initiatives must focus on deeper technological integration. Training Programmes must improve teaching practices using new technology tools. The lower PK scores indicate that teachers face challenges in adapting to the demands of an ever-evolving curriculum. This requires intervention in teacher training, namely pedagogical strategies, management classes and structured mentoring. Especially in the "independent curriculum" there is a need for structured training and mentoring Programmes to help teachers transition well.

Teachers' TPACK Ability by Years of Teaching Experience

The results of the research showed that almost all the teacher's TPACK abilities, when reviewed from teachers' years of experience, showed significant differences. TK, PK, TPK, PCK, TCK and TPACK abilities show variations that reflect how teaching experience influences mastery of the various dimensions of TPACK. In this case, teachers with teaching experience > 5 years have superiority in PK compared to junior teachers (3-5 years and < 3 years of teaching experience). However, in the ability of TK, TPK, and TCK, the < 3-year teacher experience is better than that of the senior teacher (3-5 and > 5 years of experience teacher). If reviewed based on PCK and TPACK abilities, teachers with 3–5 years of teaching experience have an advantage over teachers with < 3 years and > 5 years of teaching experience.

When analysed further, this finding strengthens the argument that teaching experience contributes significantly to improving teachers' PK. Teachers with more experience tend to be more skillful in choosing learning methods, managing the classroom, evaluating learning, and adapting teaching approaches to students' needs (Hsu et al., 2021; Antony et al., 2019). Senior teachers have more experience dealing with different types of student learning styles and student learning problems (Podolsky et al., 2019). This indicates that teaching experience not only contributes to strengthening pedagogical skills but also increases teachers' flexibility and effectiveness in promoting student engagement. Compared to teachers with lower teaching experience (especially < 3 years), senior teachers are more able to control themselves and manage the classroom. The research findings are similar to previous research from (Graham et al., 2020). Senior teachers have a better attitude toward comprehending the qualities of their students. So, the teaching attitude of senior teachers is more flexible to encourage according to the learning purpose.

Other research findings show that teachers with < 3 years of teaching experience have superior abilities over TK, TPK, and TCK. This is in line with other studies that show that the more senior teachers have teaching experiences, the less teachers can use technology to support learning (Scherer et al., 2018). The findings also show that junior teachers have technological knowledge and the ability to

integrate technology into learning as well as learning content. Technological knowledge skills require teachers to understand the basic knowledge of technology. The average junior teacher has a younger age (20–30 years old). Young teachers have basic knowledge of technology and updates on the latest technological developments (Caena & Redecker, 2019). Young teachers can use social media platforms to update information related to learning as well as knowledge related to new technologies that teachers can use in teaching in the classroom (Falloon, 2020). Teachers with < 3 years of teaching experience have also followed the education of pre-service teachers whose educational material has directed them toward the use of technology. Therefore, junior teachers are accustomed to using technology in the training activities of candidates followed (Kong et al., 2020). This is different from senior teachers (> 5 years), despite having pedagogical excellence, generally have not fully integrated technology in learning. This suggests a gap in the application of technology among senior teachers, which could be an obstacle in supporting technology-based learning. Therefore, more specific training is needed for teachers with >5 years of experience to improve their competence in utilising technology to improve learning quality and self-efficacy in its use.

Although there are significant differences between TK, PK, TPK, PCK, TCK, and TPACK, the teacher's CK abilities have not been found to be significantly different from the teacher's years of experience. This suggests that content mastery is more influenced by academic background and formal training than length of teaching experience. The teacher's CK abilities relate to the subjects taught and are related to the specifications of the teacher's education. The difference in teacher knowledge specifications is caused by formal education when achieving a bachelor's degree in education. Teachers in various teaching experiences tend to have mastered basic concepts in their fields of science before graduating from formal education. Therefore, teachers have their advantages in specific subjects taught, and this also relates to the education and training of teachers in each subject (Falloon, 2020). Furthermore, related to the dynamic context of the material, teachers continue to update and deepen it through various activities such as group discussions for teachers in each subject, workshops, and academic forums. The findings are also due to the teachers' monthly gathering activities on each subject, so teachers are constantly updating resources that support the development of learning content. Furthermore, the presence of conference activities in the subject areas taught by teachers also affects CK's ability. Previous research from (Amhag et al., 2019) mentions that the development of teacher skills in each subject can be enhanced by holding scientific meetings. This greatly supports the emergence of the latest developments in the discipline of teacher science so that both new and old teachers have relatively equal access to CK developments. Furthermore, along with

increasing teaching experience, teachers focus more on developing pedagogical and technological aspects. Teachers with a long teaching experience tend to emphasise more on learning strategies, classroom management, and management of the learning environment (Ball et al., 2008). Furthermore, in some subjects in schools, nature is static, so most teachers are still required to teach basic concepts that are more static. Therefore, teachers with longer teaching experience are not higher than junior teachers because the source of teacher knowledge is still the same from the early education period. This is emphasised by (Baumert et al., 2010) said that teachers depend more on academic education than on the length of teaching experience. Therefore, teacher training Programmes require more intervention.

The findings not only strengthen the understanding of how teaching experience influences various aspects of TPACK but also reveal an interesting paradox: senior teachers are superior in PK but less adaptive in technology, while junior teachers are more proficient in technology but have limitations in pedagogical aspects. Therefore, the results of this study provide important implications for education policy, especially in designing more targeted training Programmes to ensure a balance between pedagogy and technology in learning.

Teachers' TPACK Ability by Participation in Teacher Certification Training Programme

The results of this study explicitly confirm the differences in teachers' TPACK abilities based on their experience in participating in the teacher certification training Programme. This can be seen in the capacity of TK, PK, TPK, PCK, TCK, and TPACK. Meanwhile, the ability of TK and TPK had a very high difference effect with a significance of 0,000, ($p < 0.05$). which shows that the technological knowledge of the teachers who have not participated in teacher certification training is superior to that of those who have already undergone teacher certification training Programmes. It appears that the findings of this study are in contrast to previous research findings that explained the impact of improving the quality of teaching through the use of technology for teachers who follow teacher training. However, this finding does not necessarily negate the benefits of certification training but rather highlights other factors that contribute to the differences, namely, age and exposure to technology in daily life. Non-certified teaches is a teacher with < 3 years of experience who is accustomed to using technology in everyday life, including in teaching activities. As described by (Joo et al., 2018), young teachers are close to the use of technology to facilitate the delivery of content on subjects (Spiteri & Chang Rundgren, 2020). Among these findings is the ability to integrate technology into learning, which can be seen in the teacher's ability to choose and use technology to support student learning. Teachers who have not attended the teacher certification training Programme are also better able to use computer applications to deliver learning material on each subject. Using technology can help teachers deepen material content

by joining online teaching sites and holding discussions with colleagues on the platform (Faridah et al., 2020; Majeed & ALRikabi, 2022). Therefore, these findings challenge the assumption that certification training automatically improves teachers' technological competence, while also indicating a potential gap between the substance of training and the real needs of teachers in the digital era.

Another significant difference is seen in the PK ability. However, unlike previous findings, teachers who have attended teacher certification training Programmes were far superior. The research result is the same as the research (Fernandes et al., 2019; Wu et al., 2022) which confirms that certification training plays a crucial role in improving teachers' pedagogical skills, such as selecting appropriate learning strategies, classroom management, and effective evaluation methods. The teacher's ability to manage the classroom is an important skill that the teacher possesses (Salifu & Abonyi, 2023). In this case, certification training provides practical insights that not only equip teachers with teaching theory, but also train them in dealing with real situations in the classroom, whether in conventional, laboratory, or project-based and experimental environments (Pozo-Rico et al., 2020). As a result, certified teachers are more confident in carrying out their role as learning facilitators, as well as better prepared to manage classroom dynamics effectively.

The findings also showed that there was a difference between the PCK and TPACK abilities reviewed based on the teachers' certification training Programme experience, even though the effect was small. Teachers who have not attended certification training Programmes have better PCK and TPACK skills scores than ever before. This is due to teacher certification training Programmes, which focus on the development of teacher teaching skills. Teachers follow the instructions without looking at the subject matter taught. Thus, in the training Programme, regular teaching skills are taught, such as recognising the characteristics of students and choosing the right learning strategy to achieve learning goals. PCK ability is seen from the teacher's ability to choose teaching strategies according to the content of the subject (Aumann et al., 2023; Spiteri & Chang Rundgren, 2020). PCK abilities are taught when pre-service teachers pursue a bachelor's degree. So fresh-graduate teachers are more confident and can link the content of the learning material to the conditions of the contextual environment. Furthermore, the teachers' TPACK ability of those who have not attended the teacher certification training Programme was higher than that of those who have attended the teacher certification training Programme. Tpack's ability to integrate learning methods and technology into material content areas (Nuruzzakiah et al., 2022; Tseng et al., 2022). Teachers who have not attended were mostly teachers with less than 5 years of teaching experience, so they are better able to apply a variety of computer software.

Based on the findings of the research, there is a need for teachers to receive

training materials on the use of technology in learning. It is important to accelerate the digital competence of teachers. Meanwhile, the rapid development of technology must be able to respond to the existing training challenges, so there is a need to update the teachers' training curriculum.

Theoretical Contribution

This study significantly contributes theoretically to the development of the TPACK framework, especially in the context of the relationship between teaching experience and participation in teacher certification training. Based on the field findings, TPACK is not a teacher ability that can develop dynamically along with the various experiences that teachers have had, especially in the context of teaching experience and teacher involvement in professional training. This is in line with the TPACK development approach by (Hsu et al., 2021) which states that as a dynamic skill framework, TPACK emphasises the importance of contextual and reflective training on experiences so that it can further shape TPACK competencies.

This study also expands the dimensions of TPACK by integrating the theory of professional learning development which states that teachers' ability to utilise technology is not only determined by access to tools, but also due to continuous practical experience in learning (Li et al., 2022). As the research found, teachers with 3-5 years of teaching experience have superior TPACK performance compared to teachers with <3 years and >5 years of experience. This finding is interesting in that it provides a new perspective in understanding TPACK, namely that there is an optimal transition phase in the early years of teaching, namely the formation of a balance of technological, pedagogical and content knowledge.

Furthermore, this study contributes to transformative learning (Pozo-Rico et al., 2020) in teacher education by showing that participation in certification training affects mastery of pedagogical skills (PK), although not as much as the technological dimension (TK). This shows that conventional certification training tends to be oriented towards pedagogical skills and does not fully support the needs of teachers in integrating technology in learning. Through this research, it can encourage innovation in the substance of 21st century teacher training in order to adopt the use of technology in learning contextually.

Therefore, based on the findings of this study, it has a theoretical contribution to the mapping of teachers' TPACK ability differentiation based on teaching experience and professional training, which is the basis for the formation of TPACK theory based on experience cycles and targeted training interventions. This research also provides a theoretical basis that can be used for teacher training curriculum designers to be able to design adaptive training according to the needs and characteristics of diverse teachers.

CONCLUSION

This study aims to analyse teachers' TPACK (Technological, Pedagogical, and Content

Knowledge) skills and to identify differences in teachers' TPACK abilities based on varying levels of teaching experience and participation in teacher certification training. The results show that teachers' TPACK skills are generally good, particularly in TK (Technological Knowledge) and CK (Content Knowledge). The study also indicates differences in TPACK skills depending on teaching experience and certification training participation. For teaching experience, differences are observed in TK, PK (Pedagogical Knowledge), TPK (Technological Pedagogical Knowledge), PCK (Pedagogical Content Knowledge), TCK (Technological Content Knowledge), and TPACK, especially between those with less than 3 years of experience and those with over 5 years. The findings also reveal differences in the components TK, PK, TPK, PCK, TCK, and TPACK when considering certification training experience, particularly in TK, TPK, and TCK. However, CK skills do not significantly differ based on either teaching experience or certification training participation.

This study has both theoretical and practical implications. In general, this study highlighted the differences between teachers' TPACK abilities in terms of teaching experience and participation in teacher certification training. This study has presented specific empirical evidence through a local approach so that this study can bridge the gap between general TPACK findings and application in various educational settings. In addition, the results of this study are very revealing of the differentiation that occurs between teachers so that it becomes clear from the professional development pathways in TPACK enhancement. In addition, in general, the findings of this study provide insights for curriculum policy makers and teacher training institutions to highlight the effectiveness of training Programmes, so this study informs future teacher training curriculum design needs.

Recommendations

This study offers recommendations for teachers and trainers in teacher certification Programmes. Based on the findings, technological integration in teaching is notably stronger among teachers with less than 3 years of experience, followed by those with 3-5 years. Therefore, greater focus on technology use in teaching should be given to teachers with more than 5 years of experience. Teaching experience relates to teaching motivation for teachers, so skill upgrading is necessary, particularly for more senior teachers. Another finding is that teachers who have participated in certification training actually have lower TPACK skills compared to those who have not. Thus, the second recommendation is to update the curriculum for teacher certification training by integrating technology into teaching. Trainers responsible for teacher professionalism training must include content related to knowledge of computer applications and technology integration in teaching. Finally, to support 21st-century learning, teacher proficiency in using technology needs greater emphasis from

the curriculum developers for teacher professional development, ensuring that teachers become familiar with technology in teaching.

Some of the main limitations of this study include sample representativeness and potential bias in the reported research data. Although we used a fairly large sample, this study only covered teachers in the Aceh region, so generalisation of research findings needs to be done more carefully. Furthermore, another limitation is that the data was collected through a questionnaire that relies on teacher perceptions, so the potential for reporting errors and social bias is very high. Therefore, suggestions for further research, namely using interviews, tests, or direct observation to increase the validity of the findings.

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