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Sequential explanatory technological pedagogical and content knowledge of madrasah teachers in Jambi

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ABSTRACT

This study aims to describe the structural model of Sequential Explanatory Technological Pedagogical and Content Knowledge (TPACK) of Madrasah Teachers in Jambi Province.This research involved 132 teachers for surveys and 5 teachers for interviews. Descriptive statistics, t-test, Anova, and SEM-PLS were used in quantitative data analysis, while qualitative data was carried out using descriptive thematics. The findings show that Madrasah teachers' TPACK is at a good category level. There are no differences in teachers' TPACK levels based on gender, certification status, madrasa level, age, teaching experience, and field of study. Technological pedagogical knowledge (TPK) has a stronger influence on technological pedagogical and content knowledge (TPACK) compared to technological content knowledge (TCK) and pedagogical content knowledge (PCK). Teachers need support from schools and communities to increase TPACK knowledge in addition to from self-awareness to developing competence as well as several other information that have been discussed in the discussion of this research. Teachers should increase their TPACK knowledge so that they can confidently implement technology in their learning

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INTRODUCTION

The Covid-19 pandemic has had an impact on Indonesian education policy formulation. The Ministry of Education and Culture issued a circular stating that education during the Covid-19 pandemic was carried out from home using distance learning or *Pembelajaran Jarak Jauh (PJJ)* both online and offline. Distance learning is a challenge for many teachers regarding the learning methods and technology used. Teachers must be able to prepare, implement, and evaluate learning that has been prepared by integrating technology, pedagogy, and learning content into the online learning process either synchronously (virtual face-to-face) or asynchronously (not virtual face-to-face). With the abilities of some teachers who are not used to it and have to adapt to these conditions, some learning processes do not pay attention to the characteristics of students, as stated by KPAI, some teachers give assignments that are considered difficult (Farisa, 2020). Apart from heavy assignments, interaction between teachers and students is only 20% and this is categorized as very minimal (Sung et al., 2016).

There are many difficulties faced by students in studying, students have to study and also carry out religious and social activities. This is due to the limitations of teaching staff in using technology, three out of four teachers do not have access to websites or online learning applications (CNN Indonesia, 2020) and lack of creativity and knowledge of technology (Feri, 2020).

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Many studies show that current distance learning can have negative impacts on children if no action is taken, including dropping out of school, decreasing learning outcomes and learning loss (Tempo, 2020). Education observers from the Center of Education Regulations and Development Analysis said that the various obstacles to PJJ currently prove that our education sector is not ready to face the 21st century (CNN Indonesia, 2020) which requires mastery of four skills, namely Critical Thinking and Problem Solving, Communication, Collaboration, and Creativity and Innovation (The American Association of Colleges for Teacher Education, 2010).

Behind the many weaknesses and obstacles in PJJ, there are opportunities to develop better education in the future (Direktorat Sekolah Dasar, 2020). Therefore, there needs to be concrete steps in preparing teachers who can collaborate on distance learning and face-to-face learning which can be combined and become a method. The combination of face-to-face learning and distance learning is called blended learning or hybrid learning (Abdelrahman & Irby, 2016).

Information and communication technology (ICT) influences all aspects of life, including education. The use of ICT in the classroom is important to provide students with opportunities to learn and apply necessary 21st century skills (Ratheeswari, 2018). Mobile devices such as laptops, computers and mobile phones have become learning tools with great potential both in the classroom and outside the classroom. This technology-based education makes society survive and can help all stakeholders to move forward. ICTs such as the internet and interactive multimedia are clearly a focus important for future education and needs to be effectively integrated into learning, especially in educational institutions and education personnel (Ratheeswari, 2018).

In line with this statement, professional teachers must be able to utilize information and communication technology in the learning they teach (Menteri Pendidikan Nasioanal, 2007). Based on these competency points, teachers should have the knowledge and ability to integrate technology, pedagogy and content learning into the learning process either online or offline. It is important for schools to provide support and facilitate teacher collaboration in ICT practices, classroom management, and student performance assessments using ICT (Azad, 2023; Delgado et al., 2015). The importance of integrating technology, pedagogy and knowedge content in learning provides an alternative framework for designing learning in schools to meet the demands of 21st century, so technological pedagogical and content knowledge (TPACK) can be used as a design framework (Rahmadi, 2019). In this regard, it is important to carry out research on the implementation of TPACK in learning, so that the basis for educational development policies can be obtained.

Technological Pedagogical Content Knowledge (TPACK) Framework in from Harris et al., (2009) is a relevant theory in this research. TPACK identifies basic knowledge in integrating technology in learning (Koehler, 2012). The essence of TPACK is the complex interaction of three main knowledge: knowledge content (CK), knowledge pedagogical (PK), and technology knowledge (TK). The TPACK framework (see Figure 1) does not look at these three knowledge bases separately, but TPACK emphasizes the types of knowledge that line at the intersection of the three main knowledge bases: Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical and Content Knowledge (Koehler et al., 2014).

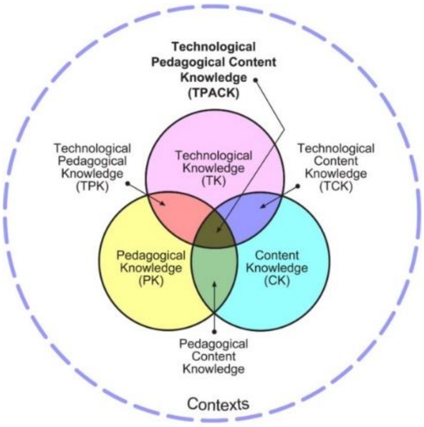

Figure 1. TPACK Framework

Effective technology integration in learning for specific subject matter necessitates a developed sensitivity to the dynamic transactional relationships between these knowledge components situated in distinct contexts. Individual teachers, grade levels, school-specific factors, demographics, culture, and other factors ensure that each situation is unique and that no single combination of content, technology, and pedagogy applies to each teacher, subject, or learning process.

Several studies have been conducted related to the implementation of ICT in education, including the influence of technology implementation (Means, 2010), internet and interactive multimedia (Ratheeswari, 2018), mobile devices (Sung et al., 2016) on learning achievement, teacher perceptions about TPACK in the structural model (Koh et al., 2013), and the contribution of content knowledge, pedagogy, and technology to TPACK (Yulisman et al., 2020). From the results of this research, it is proven that the implementation of technology in education is very necessary to prepare resources that will master the capabilities of the 21st century.

Research on TPACK has also been carried out in Indonesia, including analysis of prospective teachers' TPACK (Hayati et al., 2019; Purwaningsih et al., 2018), and teacher TPACK analysis (Hidayati et al., 2018; Muhaimin et al., 2019; Nevrita et al., 2020; Nofrion et al., 2018; Surahman et al., 2020; Suyamto et al., 2020). TPACK analysis in several subjects has also been carried out including in mathematics subjects (Listiawan & Baskoro, 2016), physics (Muhaimin et al., 2019; Purwaningsih et al., 2018), Biology (Nevrita et al., 2020; Surahman et al., 2020; Suyamto et al., 2020), English (Mahdum, 2015), Arabic (Muzaffar et al., 2020), Islamic education (Sari, 2022), geography (Nofrion et al., 2018), PPKn (Hayati et al., 2019), Social Sciences (Hidayati et al., 2018), and office administration (Hasrul et al., 2022).

According to these studies, the TPACK abilities of prospective teachers and teachers are in the good category. This means that teachers are able to develop and apply TPACK, using learning software, designing simple media and designing presentation media. However, data was obtained which identified that of all TPACK components, technology knowledge (TK) was lower than the other components, TK and TPACK are lower than other components.

In practice, there are challenges in implementing TPACK, including the effectiveness of time in learning using ICT (Means, 2010) and originality of ICT products (Nofrion et al., 2018). But, in general, ICT has an effect on improving learning (Sung et al., 2016). Competency development is still needed in designing, implementing and evaluating technology-based learning (Surahman et al., 2020).

The previous research has explored information on the level of TPACK for prospective teachers and teachers, but it is still dominant in Senior High School (SMA) teachers and still few in Junior High School (SMP), and information on the implementation of TPACK has not been obtained for madrasah teachers, both Aliyah and Tsanawiyah, so that research needs to involve Madrasah teachers. There is still very little TPACK research that includes demographic variables and structural models of the TPACK framework in Indonesia, more specifically in Jambi. This research will include demographic variables and create a structural model of TPACK.

The objectives of this study were as follows: (1) describe the level of TPACK of Madrasah teachers in Jambi Province; (2) determine differences in TPACK levels for Madrasah teachers in Jambi Province based on gender, certification status, madrasah level, age, teaching experience and field of study; 3) describe the TPACK structural model for Madrasah teachers in Jambi Province.

RESEARCH METHOD

This research is quantitative research with a survey method (Creswell, 2014). The populations in this study were all Madrasah teachers in Jambi with sampling using clusters, followed by purposive subject matter and random sampling. The first sample was drawn using a cluster technique, namely several city districts in Jambi province, followed by subject teachers in the fields of mathematics (MTK), Natural Sciences (IPA), Social Sciences (IPS), Language and Islamic or religious education, then proportional to the adequacy of the sample size (considering demographics), and finally randomly selecting research subjects who had fulfilled the previous sampling process, resulting in 132 teachers being sampled in this study.

The variables of this research are the seven components of TPACK (1) Content Knowledge (CK), operationally it is the teacher's knowledge about the learning material to be taught; (2) Pedagogical Knowledge (PK), operationally is the teacher's knowledge about processes,practice, and learning methods; (3) Technology Knowledge (TK), operationally is knowledge about how to think and work with technology, technological tools and technological resources; (4) Pedagogical Content Knowledge (PCK), operationally is pedagogical knowledge that can be applied to certain learning content; (5) Technological Content Knowledge (TCK), operationally is an understanding of how technology can be used to explain learning content; (6) Technological Pedagogical Knowledge (TPK), operationally is an understanding of how learning can be dynamic when certain technologies are used in specific ways; and (7) Technological Pedagogical Content Knowledge (TPACK), TPACK underlies meaningful and highly skilled learning using technology, TPACK is different from the three concepts at the beginning individually. TPACK is the basis for effective learning using technology, which requires an understanding of how to explain concepts and pedagogical techniques using technology in a constructive way.

The data in this research are data about knowledge and perceptions about teacher TPACK technology integration in Jambi. So two methods of data collection were used, namely surveys and interviews. It is important to use both methods of data collection to obtain detailed information in this research. Following are some of the data required (1) Demographic information/characteristics; (2) TPACK knowledge; (3) TPACK Model.

Instrument in this research is the TPACK questionnaire. Questionnaire items were adapted from the TPACK questionnaire (Schmidt et al., 2014) and Sahin (2011), with adjustments to the content, language, and changes to several words to suit generalities in Indonesia. Quantitative data were analyzed using descriptive statistics (percentage, mean, and standard deviation), t-test, analysis of variance (ANOVA), and structural equation modeling (SEM). Descriptive statistics are used to describe the characteristics/demographics of research variables. The categorization of research variable scores is also presented to provide a general description of the research variables (very good, good, fair, poor, and very poor). For this purpose, variables in the form of scores are transformed into interval data through the successive interval application in the Excel program. Inferential analysis was carried out using

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independent two-sample t-test, ANOVA and SEM. In connection with large data abnormalities, the robust t-test statistic for data abnormalities (Hair et al., 2015; Kline, 2016) and so does Anova (Tabachnick & Fidell, 2013) so that statistical tests can be carried out even if the data is not normally distributed.

Table 1. Categorization of Research Variable Scores

Category	Intervals	Information
Very good	X > (Mi+1.8 SDi)	
Good	(Mi+0.6 SDi) (Mi+1.8 SDi)	Mi: Average is ideal
Fair	(Mi-0.6S Di) ≤	SDi: Ideal standard deviation
Poor	(Mi-1.8 SDi) (Mi-0.6S Di)	X: Variable score
Very Poor	X < (Mi-1.8 SDi)	

Source : (Azwar, 2012)

The next analysis is SEM *Partial Least Square* (PLS), this analysis is a multivariate statistical analysis that estimates the influence between variables simultaneously with the aim of prediction studies, exploration or development of structural models (Hair et al., 2015). PLS model evaluation consists of three steps: measurement model evaluation, structural model evaluation, and goodness and fit evaluation

FINDINGS AND DISCUSSION

Findings

Demographics of Respondents

This research involved State Madrasah Tsanawiyah (MTs) and State Madrasah Aliyah (MA) teachers in Jambi Province as research subjects with the following characteristics: Gender male and female, age 24 years to 58 years, last education Bachelor and Masters, teaching experience 1 year up to 40 years old, recipients of certification and non-certification, with study areas of Mathematics, Natural Sciences, Social Sciences, Languages, and PAI/Religious Affairs and accreditation status A, B, and C.

TPACK Knowledge

Based on the data obtained, Madrasah teachers in Jambi Province have levels of technological pedagogical and content knowledge (TPACK) and TPACK Accumulation components (accumulation of all components) in the categories very good 6%-33%, good 52%-71%, fair 6%-31 %, poor 1%-7%, and very poor 1%-2% (see Figure 2). These results can be categorized at the level of technological pedagogical and content knowledge or knowledge of technology, pedagogy, and content/learning materials for Jambi Province Madrasah teachers in the good category. Of all components, the TK (62%), TCK (71%) and TPACK (74%) components have the lowest percent for the combined good and very good level categories.

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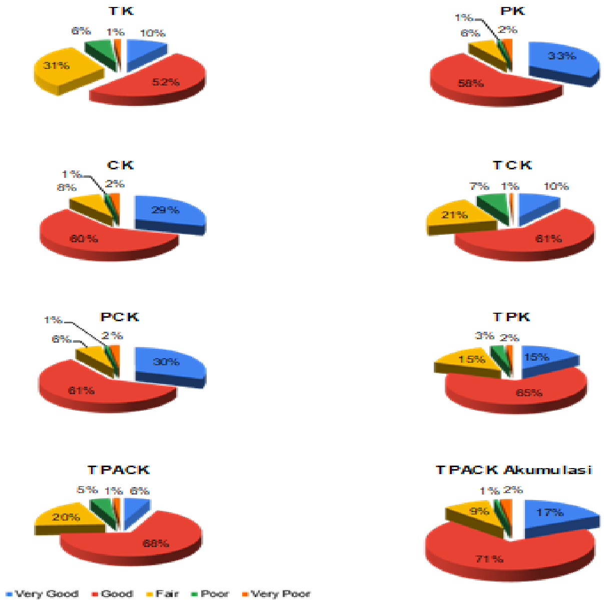

Figure 2. Percentage diagram of Madrasah Teacher TPACK component categories

TPACK Model

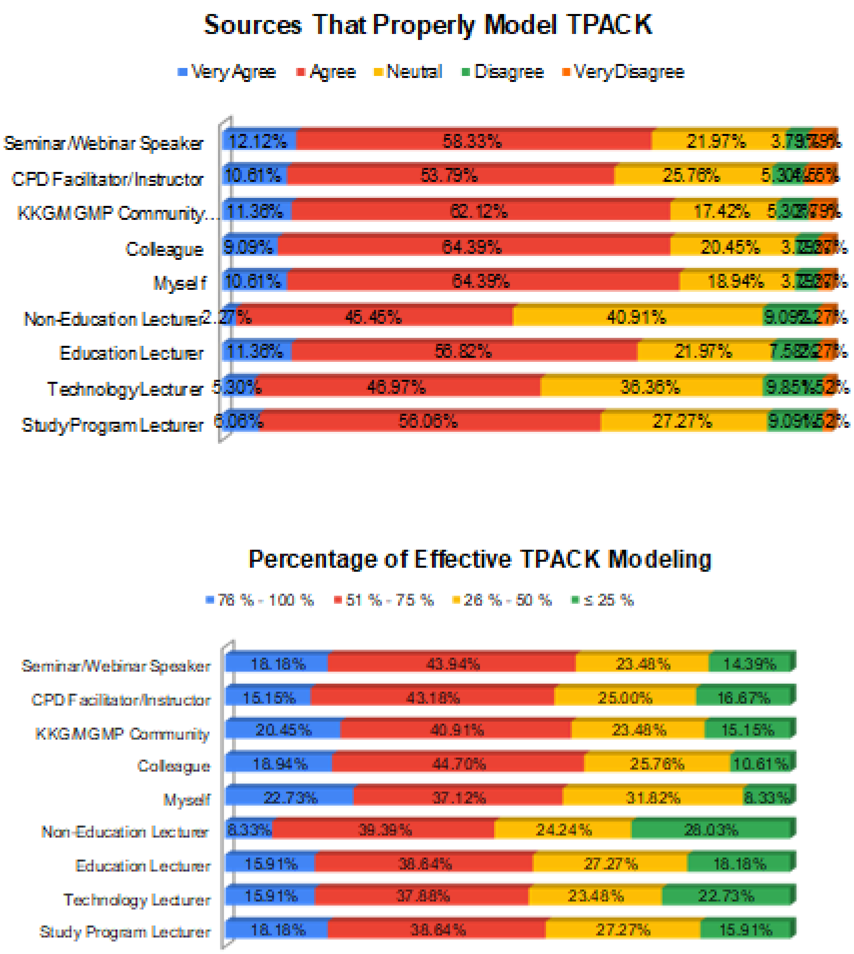

Figure 3. Percentage Diagram of Appropriate and Effective Sources for Modeling TPACK

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Based on data obtained from madrasa teachers, the following sources in order from the most provide appropriate and effective models for integrating content, technology and learning approaches in their teaching, namely themselves, the teacher working group or *kelompok kerja guru (*KKG)*,* subject teacher deliberation or *Musyawarah Guru Mata Pelajaran* (MGMP), colleagues, seminar/webinar speakers, education lecturers, Learning Activity Center or *Pusat Kegiatan Belajar* (PKB) facilitators/instructors, lecturers (Mathematics/Science/Language/Islami Educaton), technology lecturers, and non-education lecturers (see Figure 3).

TPACK Level Analysis Based on Respondent Demographics

The t-test statistic was used to answer the research question whether there were differences in TPACK levels based on gender (male and female), based on certification status (certified and not yet certified), and based on madrasah level (MTs and MA).

Table 2. "t" test results for differences in TPACK levels based on gender, certification status and madrasah level

Variable	Sig. (2-tailed)			**Note.**
	Gender	Certification Status	Madrasa level	
TK	0.240	0.196	0.099	Not significant
PK	0.930	0.378	0.364	Not significant
CK	0.515	0.121	0.174	Not significant
TCK	0.685	0.576	0.076	Not significant
PCK	0.224	0.517	0.140	Not significant
TPK	0.458	0.368	0.539	Not significant
TPCK	0.635	0.579	0.194	Not significant
TPACK	0.823	0.894	0.138	Not significant

Based on the Table 2, it can be proven that although the average TPACK scores are different between male and female teachers, those who have been certified and those who have not, and those who teach at MTs and at MA, statistically these differences are not significant. It can be concluded that there are no differences in the TPACK levels of madrasah teachers in Jambi Province based on gender, teacher certification status and madrasa accreditation level. The "ANOVA" test statistic was used to answer differences in TPACK levels based on age, teaching experience, and field of study.

Based on Table 3, it can be proven that even though the average TPACK score is different between teachers aged 20-30 years, 31-40 years, 41-50 years, and 51-60 years, teachers with 1-5 years of teaching experience, 6- 10 years, 11-15 years, 16-20 years, 21-25 years, and 26-40 years, and teachers who teach Mathematics, Natural Sciences, Social Sciences, Languages, and PAI/Religious study groups, but statistically there is no difference significant. As a result, no differences in the TPACK levels of madrasah teachers in Jambi Province can be found based on age, teaching experience, or field of study.

From the analysis, it can be concluded that although there is a difference in the average TPACK score between male and female teachers, a difference in the average TPACK score between certified and non-certified teachers, a difference in the average TPACK score between teachers who teach at the MTs and MA, the difference in the average TPACK score between teachers aged 20-30 years, 31-40 years, 41-50 years, and 51-60 years, the difference in the average TPACK score between teachers with 1-5 years of teaching, 6-10 years, 11-15 years, 16-20 years, 21-25 years, and 26-40 years, and the difference in average TPACK scores between teachers who teach Mathematics, Science, Social Sciences, Languages, and PAI but statistically the difference is not significant.

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Table 3. Results of the "Anova" test. Differences in TPACK levels based on age, teaching experience and field of study

Variable	Sig.			Note
	Age	Teaching experience	Study Field Clusters	
Technology Knowledge	0.127	0.392	0.141	Not significant
Pedagogy Knowledge	0.310	0.607	0.131	Not significant
Content Knowledge	0.929	0.830	0.412	Not significant
Technological Content Knowledge	0.223	0.430	0.378	Not significant
Pedagogical Content Knowledge	0.696	0.339	0.456	Not significant
Technological Pedagogical Knowledge	0.543	0.814	0.150	Not significant
Technological Pedagogical Content Knowledge	0.208	0.685	0.107	Not significant
Technological Pedagogical and Content Knowledge	0.367	0.831	0.176	Not significant

Analysis of the TPACK Knowledge Structural Model

Partial Least Square (PLS) is used to analyze the structural model in this research. Analysis. This is a multivariate statistical analysis that estimates the influence between variables simultaneously with the aim of predictive studies, exploration or development of structural models (Hair et al., 2015). Model evaluation in PLS consists of measurement model evaluation, structural model evaluation, and model goodness and fit evaluation.

Evaluation of Measurement Models

The measurement model in this research is a reflective measurement model in which the variables are technology knowledge (TK), pedagogy knowledge (PK), content knowledge (CK), technological content knowledge (TCK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), and technological pedagogical and content knowledge (TPACK) are measured reflectively. In Marko et al., (2021), evaluation of the reflective measurement model consists of loading factor ≥ 0.70 composite reliability ≥ 0.70 Cronbach's alpha and average variance extracted (AVE) ≥ 0.50 as well as evaluation of discriminant validity, namely the Fornell and Lacker criteria and the heterotrait-monotrait ratio (HTMT) in below 0.90 and cross loading.

Table 4. Evaluation of the Technological Pedagogical and Content Knowledge (TPACK) Construct Measurement Model

Variable	Items	Convergent Validity		Reliability		
		Loading	Average Variance Extracted (AVE)	Cronbach's Alpha	rho_A	Composite Reliability
		> 0.70	> 0.5	0.70 - 0.90	> 0.70	> 0.70
TK	TK1-TK12	0.621-0.854	0.553	0.925	0.930	0.936
PK	PK1-PK9	0.777-0.875	0.694	0.945	0.946	0.953
CK	CK1-CK8	0.721-0.881	0.696	0.937	0.939	0.948
TCK	TCK1-TCK7	0.824-0.855	0.697	0.927	0.928	0.941
PCK	PCK1-PCK8	0.842-0.904	0.751	0.953	0.953	0.960
TPK	TPK1-TPK11	0.787-0.902	0.715	0.960	0.961	0.965
TPACK	TPACK1-TPACK7	0.804-0.897	0.735	0.940	0.942	0.951

Based on the Table 4, it is found that each item has a loading factor ≥ 0.70 except TK1 and TK11 which are 0.613 and 0.621 respectively. According to Kline (2016), a loading factor

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value ≥ 0.60 is acceptable, this shows that Technology Knowledge (TK), Pedagogy Knowledge (PK), Content Knowledge (CK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical and Content Knowledge (TPACK) are well reflected by statement items/indicators (Valid). Apart from that, the AVE value > 0.50 shows the mean variation of each measurement item contained by the variable. This measure describes convergent validity qualitatively as good. Cronbach's Alpha, rho_A, and Composite Reliability values greater than 0.70 indicate good internal consistency reliability. The evaluation results from the five measurements indicate that the Technological Pedagogical and Content Knowledge (TPACK) construct is both valid and reliable.

Evaluation of discriminant validity needs to be done by looking at the Fornell and Lacker criteria. Discriminant validity is a form of evaluation to ensure that a variable/construct is theoretically different from other variables/constructs. Fornell and Lacker's criteria are comparing the roots of AVE with the correlation between variables with the criterion that the roots of AVE variables are greater than the correlation between variables. For details on the specific criteria, please refer to Table 5.

Table 5. Fornell-Larcker Criterion TPACK

	CK	PCK	PK	TCK	TK	TPACK	TPK
CK	0.834						
PCK	0.707	0.867					
PK	0.797	0.680	0.833				
TCK	0.667	0.670	0.626	0.835			
TK	0.622	0.536	0.655	0.679	0.743		
TPACK	0.632	0.706	0.632	0.768	0.706	0.857	
TPK	0.637	0.686	0.654	0.771	0.730	0.848	0.846

Hair et al., (2017), recommend HTMT as a validity evaluationdiscriminant, because this measure of discriminant validity is considered more sensitive or more accurate in detecting discriminant validity. The recommended value is below 0.90. In other words, a variable shares the variation of a measurement item with the item that measures it more strongly than it shares the variance with other variable items.

Table 6. TPACK Heterotrait-Monotrait Ratio (HTMT)

	CK	PCK	PK	TCK	TK	TPACK
CK						
PCK	0.746					
PK	0.846	0.715				
TCK	0.714	0.712	0.666			
TK	0.672	0.569	0.703	0.727		
TPACK	0.675	0.744	0.668	0.818	0.754	
TPK	0.674	0.717	0.685	0.815	0.768	0.890

Based on the Table 6, all HTMT values are smaller than 0.90, so it can be said that the TPACK variable/construct meets discriminant validity. Overall, the TPACK construct meets all measurement model evaluations, namely meeting convergent validity, reliability and discriminant validity. So it can be concluded that the TPACK construct is well reflected by the

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statement items/indicators, empirically each TPACK construct is different from one another, and the TPACK construct is steady/consistent.

Structural Model Evaluation

Evaluation of the structural model is related to testing the hypothesis of influence between research variables. The structural model evaluation examination was carried out in three stages, namely first checking the absence of multicollinearity between variables and the inner VIF (variance inflated factor) measure (See Figure 4). Inner VIF values below 5 indicate there is no multicollinearity between variables (Hair et al., 2017).

Table 7. Inner VIF Values

	PCK	TCK	TPACK	TPK
CK	2.746	1.632		
PK	2.746			1.752
TK		1.632		1.752
PCK			2.084	
TCK			2.714	
TPK			2.829	

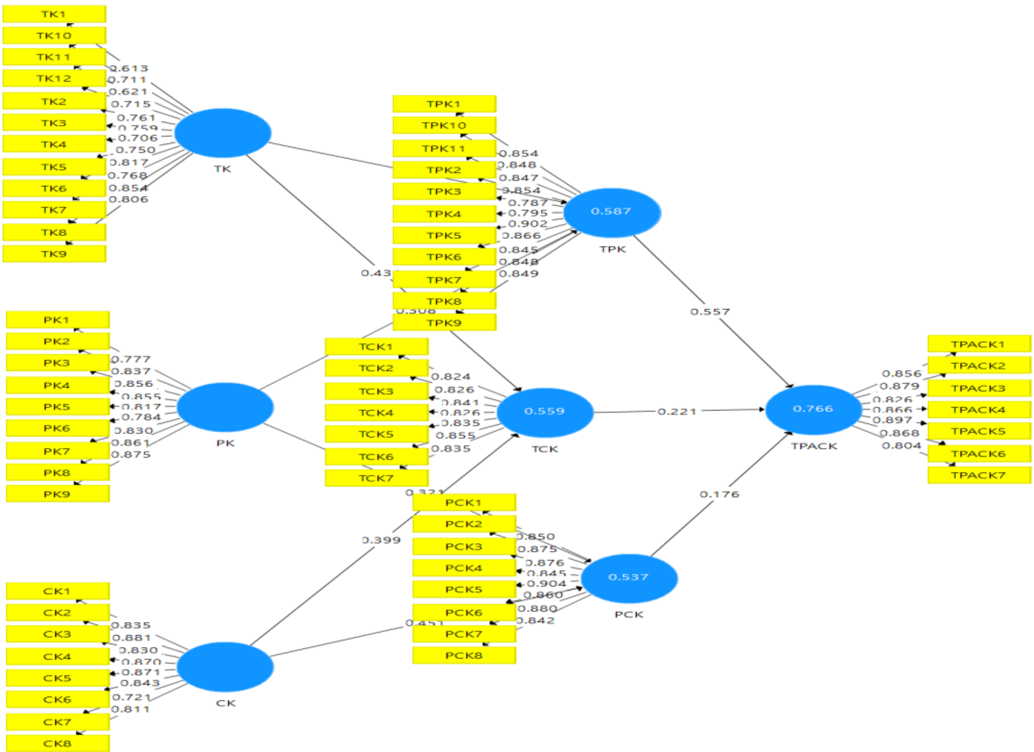

Figure 4. Structural Model of TPACK for Jambi Madrasah Teachers

Based on the Table 7, inner VIF or multicollinearity examination between variables, it is known that mark VIF below 5 indicates that multicollinearity does not occur. Next thing second is hypothesis testing between variables by looking at the t statistic or p-value. If the calculated t statistic is greater than 1.96 (t-table) or the p-value of the test results is smaller than 0.05 then

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there is a significant influence between the variables.Third is f square, namely the influence of variables at the structural level with criteria (f square 0.02 low, 0.15 moderate, and 0.35 high) (Hair et al., 2017).

TPK construct (0.557) has a strong effect (f square 0.468) on TPACK (See Table 8), followed by TCK (0.221), and PCK (0.176) which has a weak effect (f square 0.077 and 0.064) on TPACK. Based on the bootstrap results, TPK, TCK, and PCK significantly (p-value < 0.05) have an effect on TPACK. Pedagogical technology knowledge is a variable that has a strong influence on pedagogical and content technological knowledge compared to Jambi madrasah teachers' content technological knowledge and content pedagogical knowledge.

Table 8. Path Coefficients of the TPACK Structural Model

Track	Path Coefficient	P-values	95% confidence interval Path Coefficient		F Square	Information
			Lower limit	Upper limit		
CK -> PCK	0.451	0,000	0.222	0.667	0.160	Moderate
CK -> TCK	0.399	0,000	0.248	0.535	0.222	Moderate
PCK -> TPACK	0.176	0.031	0.019	0.332	0.064	Low
PK -> PCK	0.321	0.002	0.120	0.506	0.081	Low
PK -> TPK	0.308	0.001	0.099	0.473	0.131	Low
TCK -> TPACK	0.221	0.011	0.067	0.391	0.077	Low
TK -> TCK	0.431	0,000	0.255	0.619	0.258	Moderate
TK -> TPK	0.528	0,000	0.383	0.695	0.386	High
TPK -> TPACK	0.557	0,000	0.355	0.729	0.468	High

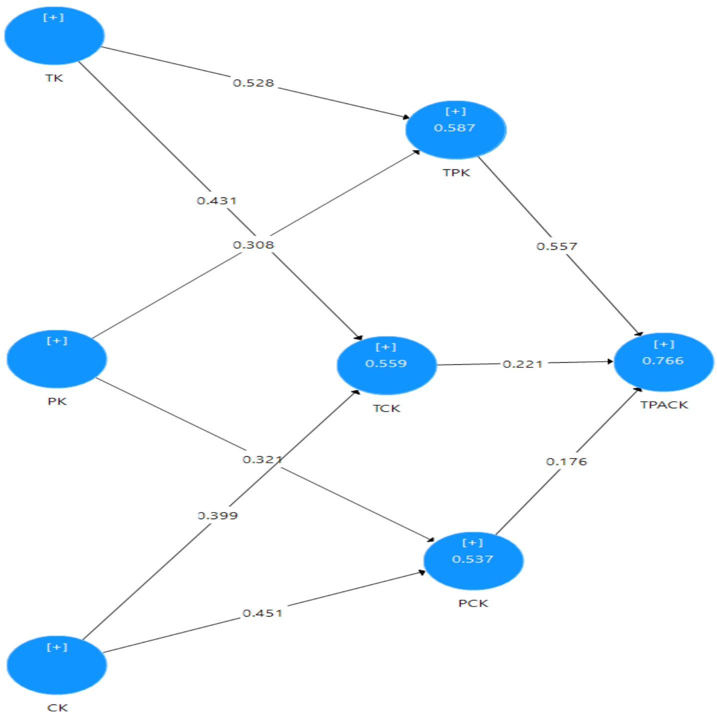

Figure 5. Jambi Madrasah Teacher TPACK Path Model

TK Construction (0.528) has a strong influence (f square 0.386) on TPK, followed by PK (0.308) which has a weak influence (f square 0.131) on TPK. Based on the results of the TK

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and PK bootstrap, it significantly (p-value < 0.05) has an effect on TPK. Technological knowledge is a variable that has a strong influence on pedagogical technological knowledge compared to Jambi madrasah teachers' pedagogical knowledge.

TK Construction (0.431) and CK (0.399) have a medium/moderate effect (f square 0.258 and 0.222) on TCK. Based on the bootstrap results, TK and CK have a significant (p-value < 0.05) effect on TCK. Technological knowledge and content knowledge are variables that have fair/moderate influence on Jambi madrasah teachers' content technological knowledge.

CK construct (0.451) has a fair/moderate effect (f square 0.160) on PCK, followed by PK (0.321) which has a weak effect (f square 0.081) on PCK. Based on the bootstrap results, CK and PK significantly (p-value < 0.05) have an effect on PCK. Content knowledge has a moderate effect on content pedagogy knowledge and pedagogy knowledge has a weak effect on content pedagogy knowledge. The Path Coefficients of the TPACK Structural Model has been visualized in Figure 5.

Table 9. Specific Indirect Effect of TPACK Variables on Jambi Madrasah Teachers

Track	Indirect Effects	P-values	95% confidence interval	
			Lower limit	Upper limit
CK -> PCK -> TPACK	0.079	0.047	0.008	0.161
PK -> PCK -> TPACK	0.057	0.113	0.004	0.134
CK -> TCK -> TPACK	0.088	0.012	0.027	0.163
TK -> TCK -> TPACK	0.095	0.065	0.022	0.212
PK -> TPK -> TPACK	0.172	0.003	0.059	0.277
TK -> TPK -> TPACK	0.294	0.000	0.164	0.437

Based on the Table 9, there is a significant indirect effect (p-value < 0.5) from TK to TPACK via TPK (0.294) while via TCK (0.095) it is not significant (p-value > 0.05), there is a significant indirect effect (p-value < 0.5) from PK to TPACK via TPK (0.172) while through PCK (0.057) it is not significant (p-value > 0.05), and there is a significant indirect effect (p-value < 0.5) from CK to TPACK either via TCK (0.088) or PCK (0.079).

There is an indirect influence of technological knowledge on pedagogical technological knowledge and content through pedagogical technological knowledge, there is also an indirect influence of pedagogical knowledge on pedagogical technological knowledge and content through pedagogical technological knowledge, and there is an indirect influence of content knowledge on pedagogical technological knowledge and content both through knowledge of content technology as well as through knowledge of content pedagogy.

Table 10. Indirect Effect of the TPACK Variable on Jambi Madrasah Teachers

Track	Indirect Effects	P-values	95% confidence interval	
			Lower limit	Upper limit
CK -> TPACK	0.167	0.001	0.077	0.270
PK -> TPACK	0.228	0,000	0.107	0.332
TK -> TPACK	0.389	0,000	0.275	0.526

Based on results in Table 10, the TK, PK, and CK bootstrap significantly (p-value<0.05) indirectly influences TPACK. TK Construction (0.389) indirectly has a moderate effect on TPACK, followed by PK (0.228), and CK (0.167) which has a weak effect on TPACK. Technological knowledge is a variable that indirectly has a moderate influence on technological knowledge of pedagogy and content, while pedagogical knowledge and content knowledge indirectly have a weak influence on the technological knowledge of pedagogy and content of Jambi madrasah teachers.

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Evaluation of Model Goodness and Fit

The statistical size R square describes the magnitude of variation in other exogenous/endogenous variables in the model. Meanwhile, Q squre describes a measure of prediction accuracy, namely how well each change in exogenous/endogenous variables is able to predict endogenous variables.

Table 11. R Square and Q Square TPACK Values for Jambi Madrasah Teachers

	R Square	*Q Square*	Information
PCK	0.537	0.397	Moderate Prediction Accuracy
TCK	0.559	0.373	Moderate Prediction Accuracy
TPK	0.587	0.401	Moderate Prediction Accuracy
TPACK	0.766	0.546	High Prediction Accuracy

Based on the Table 11, the endogenous variables PCK (Rsqr=0.537 and Qsqr=0.397), TCK (Rsqr=0.559 and Qsqr=0.373), and TPK (Rsqr=0.587 and Qsqr=0.401) have moderate prediction accuracy, while the endogenous variable TPACK (Rsqr=0.766 and Qsqr=0.546) have high prediction accuracy. In other words, TPACK has a good and acceptable level of model fit. Beside R square and Q square, Standardized Root Mean Square Resiodual (SRMR) too made a measure of evaluating goodness and fit of a model. In Hair et al., (2017) RSMR values below 0.08 indicate a fit model. However, in (Schermelleh-Engel & Moosbrugger, 2003), SRMR values between 0.08-0.10 indicate an acceptable fit model. Based on the PLS output, the SRMR value of 0.086 is very close to 0.08 so that the TPACK model for Jambi madrasah teachers is acceptable fit.

Finally, test the suitability of the model with PLS prediction which works as a form of validation strength PLS prediction test. If all measurement items in the PLS model have lower RMSE and MAE values than the model regression linear then the PLS model has high predictive power, if it is large then it has medium predictive power. Based on the PLS prediction output, all measurement items of the PLS model have lower RMSE and MAE values than the linear regression model, so the PLS TPACK model for Jambi madrasah teachers has high predictive power. In other words, all Jambi madrasa teacher TPACK model pathways have a high level of precision.

Discussion

Pedagogical technology knowledge (TPK) is a variable that has a strong influence on pedagogical and content technology knowledge (TPACK) compared to Jambi madrasah teachers' content technology knowledge (TCK) and content pedagogical knowledge (PCK). This can happen because technological knowledge of pedagogy and content is the basis of effective learning using technology, which requires an understanding of how to explain pedagogical concepts and techniques using technology in a constructive way (Koehler et al., 2014; Schmidt et al., 2014). Then, it was found that technological knowledge (TK) was a variable that had a strong influence on pedagogical technological knowledge (TPK) compared to Jambi madrasah teachers' pedagogical knowledge (PK). This can happen because pedagogical technology knowledge is an understanding of how learning can be dynamic when certain technologies are used in certain ways. This includes knowing the pedagogical capabilities and constraints of various technological tools related to disciplinary and developmentally appropriate learning designs and strategies (Koehler et al., 2014).

Technology knowledge (TK) and content knowledge (CK) are variables that have a moderate influence on the content technology knowledge (TCK) of Jambi madrasah teachers.

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This can happen because content technology knowledge is an understanding of how technology can be used to explain learning content. Teachers must master the subject matter that they teach, as well as have a thorough awareness of how the subject matter.

Another finding was that content knowledge (CK) had a moderate effect on content pedagogy knowledge (PCK) and pedagogical knowledge (PK) had a weak effect on content pedagogy knowledge (PCK). This can happen because pedagogical content knowledge is pedagogical knowledge that can be applied to certain learning content. Central to Shulman's conceptualization of PCK is the idea of transforming subject matter for teaching. Specifically, according to Shulman (1986), this transformation occurs when teachers represent lesson material, find various ways to convey it, and adapt teaching materials to students' alternative conceptions and previous knowledge. PCK covers the core activities of teaching, learning, curriculum, assessment and reporting (Yulisman et al., 2020).

Related to indirect influence is that technological knowledge (TK) is a variable that indirectly has a moderate influence on pedagogical and content technological knowledge (TPACK) while pedagogical knowledge (PK) and content knowledge (CK) indirectly have a weak influence on pedagogical technological knowledge and content (TPACK) of Jambi madrasah teachers. This can happen because technological knowledge of pedagogy and content is the basis for effective learning using technology (Hayati et al., 2019; Koehler et al., 2014; Sahin, 2011). Regarding the level of goodness and suitability of the TPACK model for Jambi madrasah teachers, it was found that the endogenous variables TPK, TCK, and PCK had moderate prediction accuracy, while the endogenous variable TPACK had high prediction accuracy. In other words, TPACK has a good and acceptable level of model fit. This is also supported by empirical evidence based on SRMR which has a value of 0.086 including acceptable fit and PLS predict. All measurement items of the PLS model have lower RMSE and MAE values than the linear regression model, so that the TPACK model for Jambi madrasah teachers has high predictive power. In other words, all Jambi madrasa teacher TPACK model pathways have a high level of precision.

CONCLUSION

Based on the results of the study, it can be concluded that Madrasah teachers in Jambi Province have levels of technology knowledge (TK), pedagogy knowledge (PK), content knowledge (CK), technological content knowledge (TCK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), and technological pedagogical and content knowledge (TPACK) in the good category level.

There are no differences in the TPACK levels of madrasa teachers in Jambi Province, both male and female, those with certification and those without certification, those who teach at MTs and MA levels, those aged 20-30 years, 31-40 years, 41-50 years, and 51-60 years old, those with teaching experience of 1-5 years, 6-10 years, 11-15 years, 16-20 years, 21-25 years, and 26-40 years, and those who teach MTK, Natural Sciences, Social Sciences study groups, Language, and PAI/Religious Education.

Pedagogical technology knowledge (TPK) is a variable that has a strong influence on pedagogical and content technological knowledge (TPACK) compared to Jambi madrasah teachers' content technological knowledge (TCK) and content pedagogical knowledge (PCK). Technological knowledge (TK) is a variable that has a strong influence on pedagogical technological knowledge (TPK) compared to Jambi madrasah teachers' pedagogical knowledge (PK). Technology knowledge (TK) and content knowledge (CK) are variables that have a medium/moderate influence on the content technology knowledge (TCK) of Jambi madrasah teachers. Content knowledge (CK) has a moderate effect on content pedagogy knowledge (PCK) and pedagogy knowledge (PK) has a weak effect on content pedagogy knowledge (PCK).

There is an indirect influence of technological knowledge (TK) on pedagogical and content technological knowledge (TPACK) through pedagogical technological knowledge (TPK), there is also an indirect influence of pedagogical knowledge (PK) on pedagogical and content technological knowledge (TPACK) through pedagogical technological knowledge (TPK), and there is an indirect influence of content knowledge (CK) on pedagogical and content technology knowledge (TPACK) both through content technology knowledge (TCK) and through content pedagogical knowledge (PCK). Technological knowledge (TK) is a variable that indirectly has a moderate influence on the pedagogical and content technology knowledge (TPACK) of Jambi madrasah teachers, while pedagogical knowledge (PK) and content knowledge (CK) indirectly have a weak influence.

Based on these conclusions, there are several suggestions, that teachers should increase their TPACK knowledge so that they can confidently implement technology in their learning. In increasing TPACK knowledge, teachers can first increase pedagogical technology knowledge (TPK), content technology knowledge (TCK), and content pedagogical knowledge (PCK), because based on the model developed, these three variables influence TPACK. Then, it is hoped that schools and learning communities will effectively, plan, periodically and continuously develop programs that encourage increased teacher competency.

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Conflict of interests

There are no known conflicts of interest associated with this publication.

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