The Analysis of Technological Pedagogical Current Knowledge (TPACK) Variables through Student Surveys

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Abstract

In facing technological developments in 21st century learning today, teachers are required to have knowledge that can integrate technology, pedagogical knowledge, and content. The purpose of this research was to analyze the Technological Pedagogical Content Knowledge (TPACK) variables through student surveys at SMA Negeri 7 Jambi. This research used a questionnaire consisting of 33 items to collect data from 272 respondents. Furthermore, data analysis used the Structural Equation Model-Partial Least Square (SEM-PLS). The findings indicate that there is a positive correlation between the TPACK variables. Of the 12 variables that have been analyzed, 10 variables have a direct correlation with other variables, and 2 variables did not have a direct correlation and have a significant effect.

Keywords
Teacher competence, *TPACK*, technology integration

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Introduction

Education is essential for enhancing the quality of life for individuals, and educators must strive to address the needs of students effectively. Meeting student needs hinges on the competency standards upheld by teachers. The overarching objective of national education is to foster the nation's growth and cultivate the Indonesian populace. Achieving the goals of national education necessitates the presence of proficient educators. According to Laurillard (2013), it is imperative for professional educators to continuously evolve in line with advancements in science, technology, and the evolving needs of students. In addressing student requirements, educators must adhere to established teacher competency standards. Teacher competence encompasses a spectrum of abilities, including knowledge, skills, critical thinking, adaptability, and the cultivation of positive attitudes and values integral to the teaching profession (Chalkiadaki, 2018). A good teacher must be able to master the content (lesson material/subject material) and master the science of teaching (pedagogy) (Fakhriyah et al., 2022). Sturko and Holyoke (2009) revealed that professional teachers do not only have academic and content skills but also integrate the two. Additionally, Mishra and Koehler (2006) emphasized the significance of technological competence as a crucial component for facilitating effective learning. In the evolving landscape of teacher education, more than keeping abreast of technological advancements is required; students and educators must adeptly navigate various learning technologies to access relevant knowledge.

At this time, the potential of a nation or country is no longer judged by the abundance of natural wealth but by the potential human resources formed through the world of education. According to Manrulu and Sari (2015), humans need education to improve their standard of living, and educators should fulfill these needs. A teacher who uses technology in learning can make it easier to convey abstract material that is easy for students to understand (Maeng, 2013). Educational needs will be met if the teacher has a standard based on the teacher's competence. 21st century teachers must have knowledge and skills in using various technological devices. According to Fishman et al. (2016), technology refers to the development and utilization of devices, materials, processes, and tools to help individuals in problem-solving. In addition to facilitating communication, technology offers numerous benefits in education. Educational technology, called edtech, encompasses systems designed to support learning and achieve desired educational objectives. Knowledge content expects teachers to be able to connect and see correlations between concepts, while pedagogical knowledge expects teachers to master methods that can help students learn about scientific problems. In the content knowledge aspect, teachers are expected to be able to learn and teach using an inquiry process. In contrast, pedagogy is expected to provide teachers with experience in creating or carrying out an inquiry process. The statements above show that there is an intersection between content and pedagogy.

Components of 21stcentury learning that are increasingly interacting with each other include 1) What are the activities of instructors/teachers/mentors/facilitators? 2) Online learning design, 3) Data as a learning resource (big data), 4) Online learning strategies, 5) Student performance. In facing technological developments in 21st century learning today, teachers must have knowledge that can integrate technology, pedagogical knowledge, and content. This integration of technology, pedagogy, and content is known as Technological Pedagogical Content Knowledge (TPACK). Technological Pedagogical Content Knowledge (TPACK), or Pedagogical Content Knowledge (PCK), encompasses the knowledge required for effective teaching practices. TPACK underscores the teacher's ability to integrate technology seamlessly into subject-related tasks to support student learning and to represent learning materials using pedagogical approaches (Cox & Graham, 2009; Herring et al., 2016).

Shulman (1986) promoted a Pedagogical Content Knowledge (PCK) framework for developing sound learning and required components. Shulman (1986) was the first to introduce pedagogical content knowledge. He described Pedagogical Content Knowledge (PCK) as an understanding of how topics and strategies in a particular field of study are understood and misunderstood. Pedagogical Content Knowledge (PCK) is the result of a combination of understanding teaching material (content knowledge) and understanding how to educate (pedagogical knowledge), which blend into one thing that a teacher needs to have (Sutawidjaja & Irawati, 2017). From the Shulman Pedagogical Content Knowledge (PCK) framework, the Technological Pedagogical Content Knowledge (TPACK) framework was developed by Mishra and Koehler (2006). The results are the combination of three basic knowledge-producing new knowledge, namely: Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006). Technological Pedagogical Content Knowledge (TPACK) is a comprehensive integration of knowledge and skills in terms of integrated material and pedagogy into technological developments (Suyamto et al., 2020). Technological Pedagogical Content Knowledge (TPACK) has advantages over the previous concept, namely Pedagogical Content Knowledge (PCK). Among them are preparing instructional designs, learning models and strategies, assessment systems, and designing curriculums. Everything is integrated with technology. With changes in the 21st century learning paradigm, which demands communication, collaboration, creativity, and critical thinking skills (Kivunja, 2014). In other words, mastering Technological Pedagogical Content Knowledge (TPACK) has become a demand for teachers and prospective teachers preparing to dedicate themselves to becoming educators.

This research aims to examine (1) the effect of Content Knowledge (CK) on Technology Pedagogical Content Knowledge (TPACK), (2) the effect of Content Knowledge (CK) on Pedagogical Content Knowledge (PCK), (3) the effect of Content Knowledge (CK) on Technological Content Knowledge (TCK), (4) Effect of Pedagogical Knowledge (PK) on Technological Pedagogical Content Knowledge (TPACK), (5) Effect of Pedagogical Knowledge (PK) on Pedagogical Content Knowledge (PCK), (6) Effect of Pedagogical Knowledge (PK) on Technological Pedagogical Knowledge (TPK), (7) Effect of Technological Knowledge (TK) on Technological Pedagogical Content Knowledge (TPACK), (8) influence of Technological Knowledge (TK) on Technological Content Knowledge (TCK),(9) the effect of Technological Knowledge (TK) on Technological Pedagogical Knowledge (TPK), (10) the effect of Technological Pedagogical Knowledge (TPK) on Technological Pedagogical Content Knowledge (TPACK), (11) the effect of Pedagogical Content Knowledge (PCK) on Technological Pedagogical Content Knowledge (TPACK),

(12) the effect of Technological Content Knowledge (TCK) on Technological Pedagogical Content Knowledge (TPACK).

Literature Review

Technological pedagogical content knowledge

Technological Pedagogical Content Knowledge (TPACK) is a framework that identifies the knowledge teachers need to teach effectively with a technical framework. According to Mishra et al. (2016), Technological Pedagogical Content Knowledge (TPACK) is a framework for understanding and describing the knowledge needed by a teacher to make pedagogical practices effective and understand concepts by integrating technology into the learning environment. The basic idea of Technological Pedagogical Content Knowledge (TPACK) is it was first introduced by Mishra and Koehler in 2006. They discussed TPACK as a framework for teachers to integrate technology into learning. The TPACK concept emerged in learning technology based on the Pedagogy Content Knowledge (PCK) model pioneered by Shulman. Technological Pedagogical Content Knowledge (TPACK) is a learning framework that integrates technology knowledge, content knowledge, and pedagogical knowledge in definite learning contexts (Voogt, 2013). According to Rahayu (2017), TPACK is the knowledge needed to integrate technology into the learning process. The knowledge needed is technological, pedagogical, and content knowledge, and how these three can be used according to the context. According to Sariçoban et al. (2018), TPACK is a concept needed by teachers that can integrate technology, pedagogy, and content according to the context so that the learning process reaches its maximum. TPACK is a teacher framework for teaching effectively using technology (Durdu & Dag, 2017; Padmavathi, 2017). TPACK-based learning is quite relevant to the demands of the Industrial Revolution 4.0, which emphasizes mastery of technology.

Pedagogical Knowledge and Technological Content (TPACK) is a conceptual framework that displays the integration between the three pieces of knowledge that teachers must master, namely technology, pedagogy, and content (Absari et al., 2020). The result of a combination of three (3) basic knowledge This produces new knowledge, namely: Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), Pedagogical Technology, and Content Knowledge (TPACK) Framework (Mishra & Koehler, 2006). TPACK has advantages compared to the previous concept, namely Pedagogical Content Knowledge (PCK), including compiling instructional design, learning models and strategies, assessment systems, and curriculum design, which are integrated with technology.

Mishra and Koehler (2006) introduced the TPACK framework to address the lack of theoretical frameworks for evaluating technology integration into instructional practices. Since its inception, the TPACK framework has played a crucial role in research related to technology in education and the professional development of educators. TPACK represents an extension of the Pedagogical Content Knowledge (PCK) concept, which pertains to the understanding of how to teach specific content, further enhanced by technology incorporation.

Furthermore, Tseng et al. (2011) suggested that the technological incorporation tools can complement traditional teaching methods such as the present-practice-produce sequence. Bingimlas (2009) contended that integrating TPACK into teaching practices led to effective instruction in Saudi Arabia. The study involved randomly selected participants from across Saudi Arabia who expressed interest in improving their TPACK competencies as educators. Consequently, teachers transitioned from conventional teaching methods to more advanced approaches involving technology, although the results appeared somewhat biased.

In summary, numerous studies on TPACK indicate the need for further refinement and detailed elucidation. Specifically, there is a need for a comprehensive understanding of teachers' competencies in TPACK, encompassing the preparation, implementation, and evaluation of learning activities and the practical application of TPACK in teaching students. Theoretically, TPACK should serve as an integrated approach that educators utilize effectively.

Technological pedagogical content knowledge components

The basic concept of TPACK emphasizes the correlation between subject matter, technology, and pedagogy (Harris et al., 2009). The interaction between these three components has the power and attraction to foster active learning that focuses on students. It is a form of a shift in understanding initially centered on the teacher and then shifted to the students. Technological Pedagogical Content Knowledge (TPACK) emphasizes the correlations between technology, curriculum content, and pedagogical approaches that interact with each other. The correlation between the three components, including C, P, and K. C becomes (CK). P becomes (PK), and T becomes Technological Knowledge (TK). The correlation is as follows:

- Content Knowledge (CK) is knowledge about the subject matter to be studied. This material is contained in the curriculum, like high school students studying chemistry, physics, biology, and mathematics, so the subject matter contained in the curriculum should be interpreted. Shulman (1986) noted that subject matter includes knowledge of concepts, theories, ideas, frameworks, and methods equipped with scientific methods and their application in everyday life, such as the acid-base concept, acid-base theory, natural indicators, acid-base indicators, pH of solutions, and acid or base ionization constants.
- Pedagogy Knowledge (PK) describes in-depth knowledge about teaching and learning theory and practice, including objectives, processes, assessment learning methods, strategies, etc. Pedagogical knowledge requires understanding cognitive, affective, and social aspects, developing learning theories, and how these theories can be applied in the learning process. Teachers should realize the required pedagogy profoundly and focus on how students understand and construct knowledge, attitudes, and skills (Mishra et al., 2011), such as constructivism, scientific discovery learning, Problem-based Learning (PBL), guided inquiry, question and answer, discussion, presentation, observation, and practicum.
- Technological Knowledge (TK) is the basics of technology that can support learning, such as software, animation programs, internet access, molecular models, virtual laboratories, etc. For this reason, teachers need mastery in processing information and communicating with ICT in learning. Mishra et al. (2011) emphasized that basic knowledge, technological

knowledge, and skills support understanding of the subject matter. Furthermore, mastering this technology is a demand for 21st century students, such as Google Drive, OneNote, ChemDraw, ChemSketch, Prezi, Edmodo, YouTube, ULEAD, Windows Movie Maker, Avidemux, Jmol, HyperChem, Chemtool, BKChem, Lectora, Moodle, ATutor, Internet, LCD, Laptop, and PowerPoint (Astuti et al., 2023).

- Pedagogy Content Knowledge (PCK) includes interactions and intersections between pedagogy (P) and subject matter (C). According to Wulandari (2019), Pedagogical Content Knowledge (PCK) is a learning concept that delivers the curriculum's lesson material. It includes the learning process related to the subject matter studied and the student assessment system. The learning model is expected to enable participants to learn effectively. It is understanding the correlation and intersection between (P) and (C), which briefly concerns how (P) can influence (C). Pedagogical Content Knowledge (PCK) is knowledge and a curriculum for a field of study. Knowledge transformation, general pedagogy, and learning strategies in educational contexts (Mishra & Koehler, 2006), like discovery learning and constructivism, are strategies used in learning the concept of acids and bases; guided inquiry approach is used in learning natural indicators, and student discussions on the idea of acids and bases in everyday life.
- Technological Content Knowledge (TCK) includes understanding technology and subject matter that can help and influence other components (Mishra & Koehler, 2006), like using Google Drive, which contains student worksheets on natural indicator material, using Prezi and YouTube in learning acid-base indicators, Edmodo is used to collect assignments regarding the pH of solid acid and robust base solutions.
- Technological Pedagogical Knowledge (TPK) is a series of understandings of how learning changes occur using technology to support active learning and can help simplify subject matter concepts. Technological Pedagogical Knowledge (TPK) requires understanding the advantages and disadvantages of the necessary technology applied in the context of the subject matter in the learning process (Schmidt et al. 2009), like using Prezi and YouTube to facilitate guided inquiry in discussing acid-base indicators and using Google Drive, which contains student worksheets to facilitate Discovery Learning in investigating natural indicators.
- Technology Pedagogy Content Knowledge (TPACK) summarizes a series of learning where the ability to master technology is integrated and cannot be separated from its constituent components (C), (P), and (K). TPACK requires multiple interactions and combinations between components, such as subject matter, pedagogy, and technology. According to Mishra and Koehler (2006), integration involves various domains/components of material and pedagogy that can support teachers, like using Prezi and YouTube with guided inquiry strategies that can help students understand acid-base indicator material; using Google Drive, which contains student worksheets with discovery learning strategies, can help students discover and analyze natural indicators.

Implementation of TPACK in learning

Implementing TPACK in learning is a learning activity carried out by teachers to achieve learning goals by integrating knowledge of technology, pedagogy, and content arranged into a single unit outlined in the learning plan (RPP). Implementing or applying TPACK in learning can provide solutions for teachers to solve problems by utilizing digital technology or ICT in teaching and learning activities in the classroom, which can create more meaningful learning for students. TPACK is also a form of developing teacher abilities, especially in managing classes and keeping up with increasingly rapid technological developments. The advantages of TPACK in learning are as follows.

- Increasing student understanding through technology engagement.
- Improving teacher skills in collaborating technology in learning.
- Facing new challenges in the learning process.
- Having complex learning content with the aid of technology.
- Helping teachers achieve competency development goals.

Meanwhile, the disadvantages of TPACK are as follows.

- Requiring additional infrastructure in the form of technological devices.
- If teachers can supervise their students carefully, technology is protected from misuse.
- Students who are still technologically illiterate may be left behind by their technologically literate friends.
- Unequal internet access can increase the gap in education quality.
- If the teacher is not yet proficient at using technology, then the teacher's time can be taken to focus on understanding the technology.

Methodology

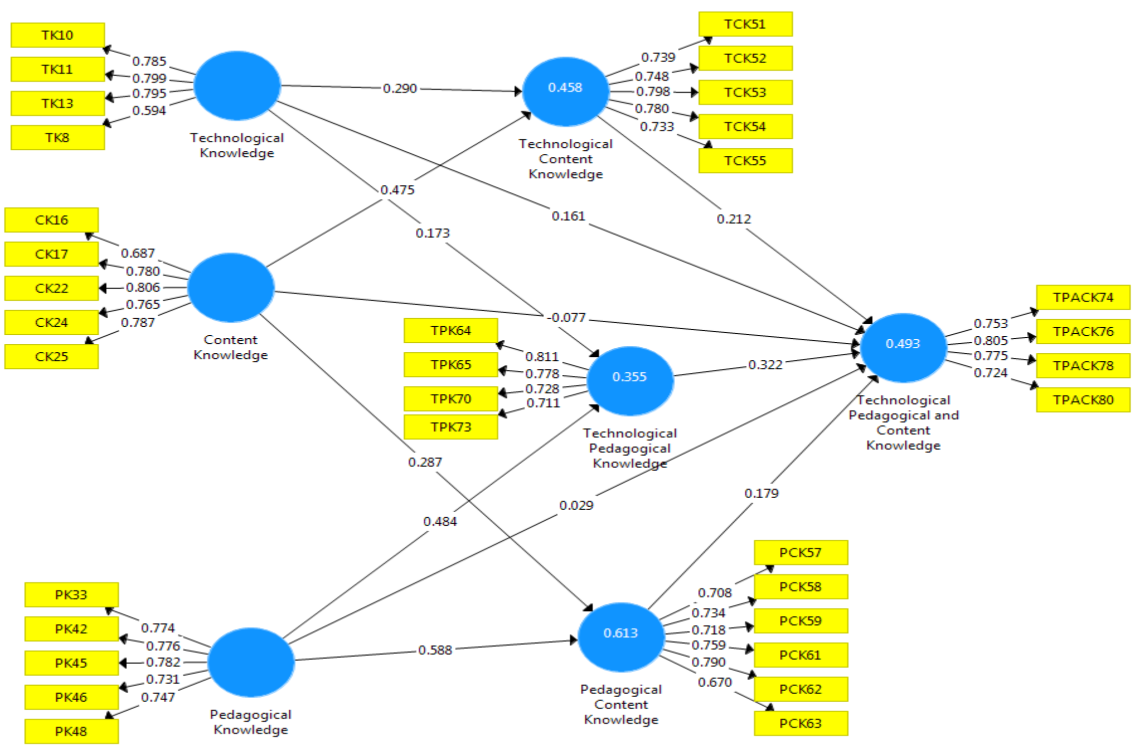
This research was conducted at SMA Negeri 7 Jambi in March 2022, where the research sample was high school students who were taken randomly using the random sampling technique. The data collection technique used in this research was a questionnaire. The questionnaire is a data collection technique that is carried out by giving a set of questions or written statements to answer to respondents (Roopa & Rani, 2012). The questionnaire was distributed via Google Forms from March 9 to March 23, 2022, to SMA Negeri 7 Jambi students. It used a Likert scale with a score range of 1 to 5. A total of 272 completed the questionnaires. The sample consisted of 70 students of class X, 91 students of class XI, and 111 students of class XII.

The 272 questionnaires were analyzed using the Structural Equation Model-Partial Least Square (SEM-PLS) method. Structural Equation Model (SEM) analysis technique is a multivariate analysis technique that combines factor analysis and correlation regression analysis, which aims to examine the correlations between variables that exist in a model, both between indicators and constructs or correlations between constructs. Hypothesis testing using SmartPLS 3.0 by looking at the value of the path coefficient analysis calculation on the inner model test. The hypothesis is said to be accepted if the t-statistic value is greater than t-table 1.96, which means that if the t-statistic value for each hypothesis is greater than the t-table, then it can be declared accepted or proven.

Results and Discussion

According to Susanti et al. (2022), the structural model aims to evaluate the correlation between the hypothesized latent constructs. The structural model in PLS is evaluated using the coefficient of determination, or R-square, for endogenous constructs, the path value, or the t-coefficient value for each path to test the significance of the inter-construction on the structural model. To measure the hypothetical correlation, path estimates, and t-statistics were calculated using the bootstrap procedure 500. The results of the SmartPLS analysis of the bootstrap procedure are in Figure 1.

Figure 1. *The model of the bootstrap technique SmartPLS analysis for the TPACK instrument*



Analysis of a variant or test of determination is to determine the influence of the independent variable on the dependent variable. The coefficient value of determination is in Table 1 below.

Table 1. *Value of r-square*

Variables	R-square
Pedagogical Content Knowledge (PCK)	0.613
Technological Content Knowledge (TCK)	0.458
Technological Pedagogical Knowledge (TPK)	0.355
Technological Pedagogical Content Knowledge (TPACK)	0.493

Table 1 shows the value of the R-square for the Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), TPK, and Technological Pedagogical Content Knowledge (TPACK) variables. Based on the R-square value, the R-square value for the Pedagogical Content Knowledge (PCK) construct is 0.613. It shows that 61.3% of the variance of the Pedagogical Content Knowledge (PCK) construct can be explained by the PK and CK constructs, while the other 38.7% is explained by other model variables. The Technological Content Knowledge (TCK) construct has an R-square value of 0.458. It indicates that 45.8% of the variance of the Technological Content Knowledge (TCK) construct can be explained by the TK and CK constructs, while 54.2% is explained by other variables outside the model. The Technological Pedagogical Knowledge (TPK) has an R-square value of 0.355, which indicates 35.5%; the variance of the Technological Pedagogical Knowledge (TPK) construct can be explained by the TK and PK constructs, and 64.5% is explained by other variables outside the model. The TPACK construct has an R-square value of 0.493. It means 49.3% of the variance for the TPACK construct can be explained by the TK, PK, CK, TCK, PCK, and TPK constructs, while the other 50.7% variance is explained by other variables outside the model. For the significance level, the path coefficient value is obtained by using the bootstrap procedure. It results in a t-statistical value, which is compared with the t-table value. The results of the path coefficients and their values are in Table 2.

Table 2. *Hypothesis results*

Variable	(O)	(STDEV)	T-stat	P-values	T-table (α = 0.05)	Decision
CK → PCK	0.287	0.061	4.739	0	1966	Accepted
CK → TCK	0.475	0.061	7.744	0	1966	Accepted
CK → TPACK	0.077	0.062	1.252	0.211	1966	Rejected
PCK → TPACK	0.179	0.091	1972	0.049	1966	Accepted
PK → PCK	0.588	0.054	10.913	0	1966	Accepted
PK → TPK	0.484	0.073	6.639	0	1966	Accepted
PK → TPACK	0.029	0.114	0.251	0.802	1966	Rejected
TCK → TPACK	0.212	0.095	2.231	0.026	1966	Accepted
TK → TCK	0.29	0.064	4.530	0	1966	Accepted
TK→ TPK	0.173	0.076	2.257	0.024	1966	Accepted
TK→ TPACK	0.161	0.061	2.626	0.009	1966	Accepted
TPK → TPACK	0.322	0.084	3.857	0	1966	Accepted

Of the 12 hypotheses proposed based on the SmartPLS analysis, it shows that there are variables with a positive influence on each other, and some have no effect. The first hypothesis tests the content knowledge variable that has a positive effect on pedagogical content knowledge. The test results show a t-statistic is equal to 4.739. These results indicate the t-statistic is significant because it is > 1.96 with a p-value < 0.05. It proves that content knowledge has a positive influence on pedagogical content knowledge.

The second hypothesis tests the content knowledge variable that has a positive effect on technological content knowledge. The test results show a t-statistic value of 7.744. It means the t-statistic is significant because it is >1.96 with a p-value < 0.05. It proves that content knowledge has a positive influence on technological content knowledge. The third hypothesis tests the content knowledge variable that has a positive effect on Technological Pedagogical Content Knowledge (TPACK). The test results show a t-statistic value of 1.252. It means the t-statistic is not significant because it is <1.96 with a p-value >0.05, so the third hypothesis is rejected. It proves that content knowledge is not proven to have a positive influence on Technological Pedagogical Content Knowledge (TPACK).

The fourth hypothesis tests the pedagogical content knowledge variable that has a positive effect on Technological Pedagogical Content Knowledge (TPACK). The test results show a t-statistic value of 1.972. It means the t-statistic is significant because it is >1.96 with a p-value < 0.05 so the fourth hypothesis is accepted. It proves that pedagogical content knowledge has a positive influence on Technological Pedagogical Content Knowledge (TPACK).

The fifth hypothesis tests the pedagogical knowledge variable that has a positive effect on pedagogical content knowledge. The test results show a t-statistic value of 10.913. It means the t-statistic is significant because it is > 1.96 with a p-value < 0.05 so the fifth hypothesis is accepted. It proves that pedagogical knowledge has a positive effect on pedagogical content knowledge. The sixth hypothesis tests that the pedagogical knowledge variable positively affects Technological Pedagogical Knowledge (TPK). The test results show a t-statistic value of 6639. It means the t-statistic is significant because it is > 1.96 with a p-value < 0.05 so the sixth hypothesis is accepted. It proves that pedagogical knowledge has a positive effect on Technological Pedagogical Knowledge (TPK).

The seventh hypothesis tests that the pedagogical knowledge variable positively affects Technological Pedagogical Content Knowledge (TPACK). The test results show a t-statistic value of 0.251. It means the t-statistic is not significant because it is < 1.96 with a p-value > 0.05, so the seventh hypothesis is rejected. It proves that pedagogical knowledge is not proven to have a positive influence on Technological Pedagogical Content Knowledge (TPACK). The eighth hypothesis tests the technological content knowledge variable that has a positive effect on Technological Pedagogical Content Knowledge (TPACK). The test results show a t-statistic value of 2.231. It means the t-statistic is significant because it is > 1.96 with a p-value < 0.05, so the eighth hypothesis is accepted. It proves that technological content knowledge has a positive influence on Technological Pedagogical Content Knowledge (TPACK).

The ninth hypothesis tests the technological knowledge variable that has a positive effect on technological content knowledge. The test results show a t-statistic value of 4.530. It means the t-statistic is significant because it is >1.96 with a p-value < 0.05, so the ninth hypothesis is accepted. It proves that technological knowledge has a positive influence on technological content knowledge. The tenth hypothesis tests the technological knowledge variable that has a positive effect on Technological Pedagogical Knowledge (TPK). The test results show a t-statistic value of 2.257. It means the t-statistic is significant because it is >1.96 with a p-value < 0.05, so the tenth hypothesis is accepted. It proves that technological knowledge has a positive influence on technological pedagogical knowledge.

The eleventh hypothesis tests the technological knowledge variable that has a positive effect on Technological Pedagogical Content Knowledge (TPACK). The test results show a t-statistic value of 2.626. It means the t-statistic is significant because it is > 1.96 with a p-value < 0.05, so the eleventh hypothesis is accepted. It proves that technological knowledge has a positive influence on Technological Pedagogical Content Knowledge (TPACK). The twelfth hypothesis tests the technological pedagogical knowledge variable that has a positive effect on Technological Pedagogical Content Knowledge (TPACK). The test results show a t-statistic value of 3.857. It means the t-statistic is significant because it is >1.96 with a p-value < 0.05, so the twelfth hypothesis is accepted. It proves that technological pedagogical knowledge has a positive influence on Technological Pedagogical Content Knowledge (TPACK).

Conclusion

Based on the data analysis and discussion above, there is a significant positive correlation between the variables on the TPACK instrument. There are 12 correlation variables analyzed, and 12 variables have a direct correlation with other variables. In the 12 direct variables, 10 variables have a positive correlation and have a significant effect, namely the correlation between variables 1) PCK → TPACK; 2) CK → PCK; 3) CK → TCK; 4) TCK → TPACK; 5) PK → PCK; 6) PK → TPK; 7) TK → TPACK; 8) TK → TCK; 9) TK → TPK; 10) TPK → TPACK. In addition, 2 variables that do not have a significant effect, namely the CK → TPACK and PK → TPACK variables.

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