

Mathematics Professional Teacher Education (TPE) Participants Viewed From Technological Pedagogical Content Knowledge (TPACK)

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Abstract

This research seeks to examine the perceptions of Teacher Professional Education (PPG) participants on the professionalism of mathematics educators via the lens of the Technology Pedagogical Content Knowledge (TPACK) paradigm. In the present educational landscape, educators and aspiring educators must focus not only on content and pedagogy but also on pertinent technologies to enhance learning efficacy. This qualitative study includes seven participants selected from a total of 30 PPG volunteers who teach at Vocational High Schools (SMK). Data were gathered by surveys, interviews, and observations. The findings indicated that participants' comprehension of TPACK was inconsistent; some could identify its components, but others could not grasp the significance of the integration between pedagogy and technology. Participants' opinion of mathematics instructors' professionalism is mostly confined to their pedagogical skills and technological proficiency, despite their acknowledgment of the urgent need for a more profound understanding of TPACK to enhance teaching quality. This research concludes that the advancement of TPACK among potential mathematics educators is crucial for enhancing their professionalism. Many vocational school students exhibited less enthusiasm for mathematics sessions, highlighting the need for a more contextual and relevant pedagogical approach. Consequently, it is advisable for the PPG program to emphasize technology integration training in educational practices and curriculum modifications to include digital literacy. By enhancing their comprehension of TPACK, it is anticipated that future educators will be more proficient in instructing and equipping pupils to confront obstacles in an increasingly digital workforce.

Keywords: *TPACK; Teacher Professional Education.*

INTRODUCTION

The development of technology is increasing, and this has an impact on all fields; with such conditions demanding human resources to follow the development of the era, as well as in the field of education must be able to sort out good things for the birth of the nation's successors, in the field of education of all parties including parents, society, of course, the teacher must be able to guide this situation into learning. Moreover, the teacher is the center of learning in schools; with the development of technology, there are so many weaknesses and strengths; one of the weaknesses is that technology cannot provide a touch of affection for a teacher or parent needed for learning activities (Laelasari et al., 2019). Therefore, a teacher is required to have the ability to teach material abilities; as expressed by Shulman, the combination of understanding and knowledge of reasonable and appropriate teaching methods is commonly referred to as pedagogical content knowledge (Jankvist et al., 2020; Laelasari 2019), and this time It turns out that teachers are also highly demanded to have technological capability. This is in line with the results of previous researchers, namely Technology Pedagogical Content Knowledge (TPACK) as a dynamic construction that illustrates the knowledge needed by teachers when designing, implementing curriculum, and teaching by guiding students in learning with digital technology (Aminah & Wahyuni, 2018a).

Research that has been done before has many benefits when teachers can master technology, teachers have a feeling of attitude that is needed when students, teachers must also

have the ability to follow student developments in this digital era technologically, Universitas Swadaya Gunung Jati as one of the private LPTK in Cirebon has faculties that give birth to prospective teachers, are required to be able to follow the changing times, and prepare themselves to be even better in giving birth to professional teacher candidates, to produce professional teacher candidates many ways that have been taken, one of them is revamping the curriculum facing the era digital 4.0 in the curriculum students are given courses related to digital literacy, but unfortunately in previous research conducted by Aminah and Wahyuni (Aminah & Wahyuni, 2019) reported that students in mathematics study programs still rarely use digital in teaching practices. Based on the explanation above, further research is needed.

Specifically, this study analyzes students' perceptions of the mathematics teacher's professionalism based on the TPACK framework. This research will obtain findings from exploring students' perceptions of their abilities regarding TPACK.

Learning with a teacher's technology is not enough to have good computer skills; a teacher must be able to design learning that will be presented with content and pedagogical skills. Several studies have shown that teachers who have good computer skills by attending special training in the use of computers also have good knowledge in designing computer-assisted learning, rather than teachers who have good technical skills but are not equipped with special training in the use of computers, (Aminah et al., 2022, 2023). They concluded that teacher training activities on interactions between technology, content, and pedagogy must be carried out explicitly to determine the ability of teachers to develop TPACK's ability to recognize, describe, and use learning theories.

Technology Pedagogy and Content Knowledge (TPACK) focuses on the connections and interactions between content, pedagogy, and technology (Angeli & Valanides, 2015; Rossi & Trevisan, 2018). TPACK is a total teacher knowledge package needed to integrate technology, pedagogy, and content knowledge in a curriculum design and instruction. (Durdu & Dag, 2017; Lisa et al., 2021; Yamak et al., 2013) TPACK is new knowledge in understanding the complex interactions between content, pedagogy, and technology that produce successful integration of technology in the classroom. TPACK is a skill that must be mastered after PCK is conquered, where the teacher has to know how to change pedagogical strategies and content representation using technology. (Tanak, 2018) states that TPACK is a form of knowledge needed to use technology intelligently in teaching and learning activities in class.

Chai et al. (2019) claim that the TPACK framework directs researchers and educators to the components needed for teaching with technology to overcome teachers' difficulties in integrating technology into their teaching. In recent years, the TPACK framework has received great attention; according to this framework, a teacher not only has enough pedagogic knowledge and content but must also be able to integrate technological knowledge into teaching. The essence of TPACK teaching has three important components: content, pedagogy, and technology, all of which influence each other. (Chai et al., 2019; Lin et al., 2013).

Applying technology to teaching is not easy; Voogt's research results [10] define TPACK as the overall knowledge and insight that underlies teachers' actions with technology in teaching practice. The TPACK framework is an extension of Pedagogic Content Knowledge (PCK) created by Shulman (1986), which was later added by Misra and Koehler (Mishra & Koehler, 2006) to the concept of technology and emphasized that technology should not be studied separately, but must be accompanied by content knowledge and pedagogical. The following is a picture of the TPACK framework.

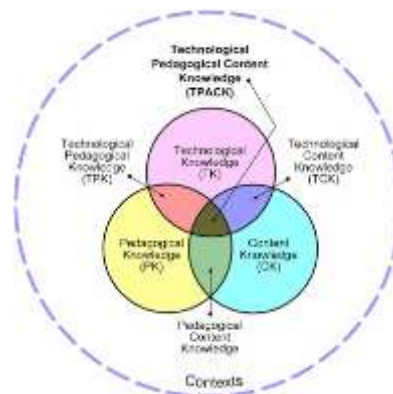


Figure 1: TPACK framework

Source (Aminah et al., 2020; Mishra & Koehler, 2006)

As shown in Figure 1, the TPACK framework, according to Mishra and Koehler (Koehler et al., 2013), contains three pillars: (1) content knowledge that is about the subject matter to be taught, (2) pedagogical knowledge that is about knowledge of teaching and learning processes, and (3) technological knowledge which is about teacher knowledge using technology in teaching, for example, using media with technology, providing computer-aided evaluation, even making online and interactive learning environments. These three pillars are integrated to form four knowledge bases: (1) pedagogical content knowledge (PCK) about how suitable methods are used for certain learning materials, (2) technology pedagogical knowledge (TPK) about technology that is suitable with teaching methods, (3) technological content knowledge (TCK), which is a way to align technology with learning content, and (4) technological, pedagogical and content knowledge (TPACK) about a combination of techniques, content, and pedagogy (Martini & Aminah, 2024; Romafilani et al., 2024).

A teacher certainly has to understand material knowledge as well as mathematics. Teachers must fully understand mathematical knowledge, known as mathematical knowledge for breaking (MKT), which is mathematical knowledge used in teaching work. Theoretically and empirically in working on MKT, Ball et al. (Kusriandi & Tiara Putrikusuma, 2014) which was followed very broadly, this was demonstrated, among other things, that MKT ownership could be measured, that MKT was held differently by teachers and non-teachers, that MKT was held differently by teachers who have a higher level of experience than teachers who have a low level of expertise, which makes a difference in student learning, and that scores on the MKT correlate with scores on observational measures of the quality of teaching mathematics (Aminah & Wahyuni, 2018b; Niess, 2005; Sung et al., 2017). The actions of the MKT group development work are primarily concentrated on the mathematics knowledge of elementary and middle school teachers (Postholm, 2012; Siraj et al., 2023; Yulando et al., 2019); many attempts have been made by researchers, one of which more recently has been developing MKT items in algebra (Kieran, 2019).

Attempts to report parallels using the same approach in developing instruments that measure mathematical knowledge in teaching high school geometry (MKT-G). While we recognize that other approaches to MKT at the secondary level have started by conceptualizing them independently (Niess, 2005; Sung et al., 2017).

The Ball and Hill's Learning Mathematics for Teaching (LMT) project has developed items that measure various MKT domains and, over time, has examined different content items, including numbers and operations, patterns, functions, algebra, and geometry. These instruments also include items intended to measure mathematics knowledge for teaching secondary school mathematics and elementary school mathematics. Extensive item development has resulted in

several validated items that can be integrated into forms that assess the MKT for a particular piece of content.

The interest in MKT stems from efforts to contribute to mathematical teaching theories that explain what teachers do in teaching in terms of a combination, on the one hand, the individual characteristics of practitioners and, on the other hand, practitioners' recognition of the norms of the teaching situations in which they participate and from the professional obligations they must respond (Chazan et al., 2021; Chazan & Herbst, 2023; Crespo et al., 2022; Herbst et al., 2022; Herbst & Chazan, 2020). This effort contributes to the long-term agenda of understanding teaching work in specific teaching systems, such as secondary school geometry.

This study has similarities with previous research that can be used as a reference in this paper, the first research from Cropton (Crespo et al., 2022) with the title "Pre-service Teachers' Developing Technological Pedagogical Content Knowledge (TPACK) and Beliefs on the Use of Technology in the K-12 Mathematics Classroom: A Review of the Literature ". In his research report, mathematics teachers may have to overcome many negative beliefs about integrating technology into mathematics. For example, in (Herbst et al., 2022), one participant believed that the Calculator gave students answers that led students to forget how to "do mathematics." With TPACK's increased understanding, the same participants explained how technology should be used significantly in mathematics classes. The technology could enable students to progress into learning higher-order concepts.

Further research related to designing evaluatory tools to see TPACK prospective teachers, this study was conducted by (Durdu & Dag, 2017; Lisa et al., 2021) entitled "Exploring TPACK Model Practices: Designing, Facilitating, and Evaluating the Effectiveness of Technology Experiences Among Pre-service Teachers "The results of the study show that TPACK skills, as measured by surveys for participants in the course, were found to be insignificant subscales worth noting, however, reminding us that the TPACK framework" does not offer specific direction on what content to teach ... a functional pedagogical approach. ... and the type of technology used (Ahmed et al., 2022; Mishra & Koehler, 2006) Therefore, TELs represent a contextual approach, especially one that relies on a constructivist theoretical framework, to apply understanding of TPACK development through specific course designs; it is ultimately valuable for the program to evaluate and adjust the development needs of TPACK in the field of course content for prospective teachers.

RESEARCH METHODS

This research uses a qualitative descriptive method to analyze Teacher Professional Education (TPE) participants' perceptions and positions regarding the professionalism of mathematics teachers as seen from the TPACK framework.

Research Subjects

This research involved seven teacher participants who taught at vocational schools out of 30 Teacher Professional Education (TPE) participants. Due to vocational schools' uniqueness, mathematics lessons are important, but many students ignore these lessons because they go straight to work without using mathematics after graduating. Each subject is given an M code from M1 to M7; this coding is taken from the distribution sequence of the subject's questionnaire responses submitted.

Profiles of prospective mathematics teachers about TPACK can be accommodated through questionnaire instruments, interview guidelines, and the observation process of teaching activities. The results of interviews and questionnaires have revealed this. The same instrument was also processed to determine TPACK and their mathematical knowledge. A questionnaire

instrument was used to capture information about prospective mathematics teachers using several descriptive questions.

Research data processing is done qualitatively through transcription, tabulation, coding, description, and data analysis. Interview guidelines were used to determine the clarity of the results of the questionnaire. In contrast, the observation activities were used to analyze the questionnaire results and describe the interviews of mathematics teacher candidates and their perceptions of the professionalism of mathematics teachers with TPACK work. The findings obtained are based on the information of prospective mathematics teachers and the actual conditions in the field, then adapted to the needs of prospective teachers in organizing teaching and learning activities. This need is related to preparing teacher candidates for the process of exploring ICT in the practice of teaching activities by adapting the seven TPACK domains. The methodology can be seen in the following chart.

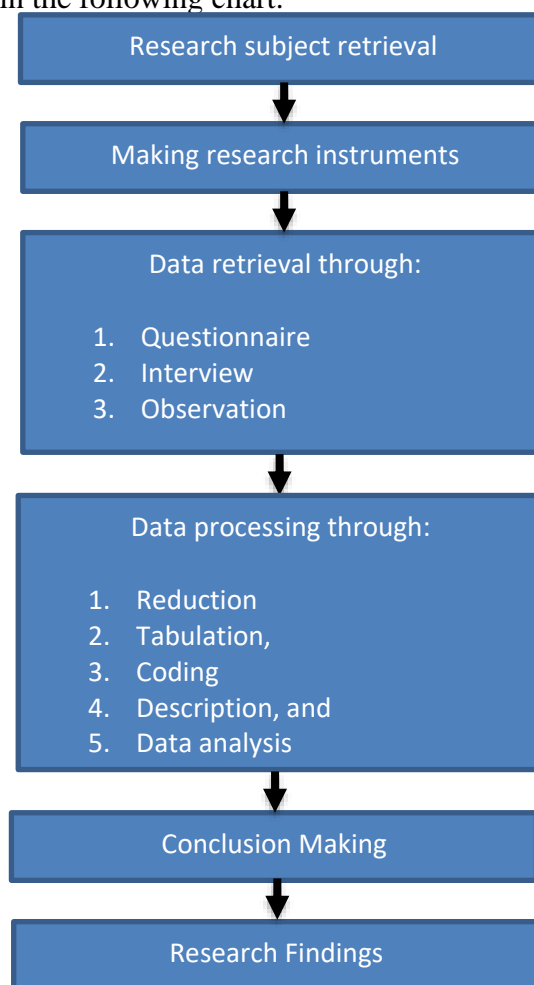


Figure1. The methodology chart

RESULT AND DISCUSSION

This research was conducted with online lectures for Teacher Professional Education (TPE) participants. Researchers collected data online, one of which was using Google Form facilities to distribute questionnaires, WhatsApp applications for discussions, and mobile phones to collect interview data for matching. Perception of questionnaire answers and videos are shared on YouTube to collect observation data.

The research begins by distributing questionnaires about how students' perceptions of professional teachers are viewed from the TPACK framework of the questionnaire. Then, interviews are conducted to cross-check the answers that have been answered by respondents; the first question is, what do you know about TPACK? Here are the answers from the seven research participants taken from Google form respondents.

Table 1. Answers to the First Question Question

Codding	Respondents' answers
M1	knowledge of how to facilitate the training of participants in certain content through pedagogical and technological approaches. So that the relationship between the variables mentioned above is known, it can find out what factors most significantly influence the teacher in the teaching and learning process for the future planning process to improve the quality of teachers who are professional and ICT-based.
M2	TPACK is an interaction between 3 essential knowledge components (CK, PK, TK) a teacher has when teaching content using appropriate pedagogical methods and technology. TPACK is an effective teaching method using technology.
M3	framework in designing new learning models by combining three main aspects, namely technology, pedagogy, and content / material knowledge
M4	TPACK is a framework / theoretical framework for designing learning models that integrate three main aspects: technology, pedagogy, and content.
M5	TPACK is the science that underlies the technological, pedagogical, and content knowledge capabilities to perfect. Before TPACK, initially only TPK, TCK, then perfected with TPACK, which in its elements covered everything
M6	TPACK is a skill that must be possessed by the teacher where it integrates technology into learning
M7	A learning that focuses on content through a pedagogical and technological approach

The answers given by respondents almost all of them answered well; in general, the respondents knew the purpose of TPACK, but there were a few obstacles for respondents with the M7 code after being interviewed regarding the answers to a few interviews to be explained:

Researcher: why does TPACK think of you as a learner who emphasizes content?

Answers M7: Sorry, I don't know deeply; I don't understand TPACK yet.

The researcher wants to know the extent to which students understand TPACK. Given that TPACK was first published by Mishra and Kohrer in 2006, the second question is how many components of TPACK, according to Mishra and Kohrer, are mentioned. The following researchers present the results of the descriptions of the seven respondents.

Table 2. Answers to the Second Question Question

Codding	Respondents' answers
M1	6
M2	7, Technological Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), Technological Pedagogical Content Knowledge (TPACK)
M3	7, CK, PK, TK, PCK, TPK, TCK, TPACK
M4	7, Content Knowledge, Technological Knowledge, Pedagogical Knowledge, Pedagogical Content Knowledge, Technological Content Knowledge,

	Technological Pedagogical Knowledge, and Technological Pedagogical Content Knowledge.
M5	3. TK, PK, CK
M6	TPACK is a framework for understanding and describing the knowledge needed by a teacher to streamline pedagogical practices and conceptual understanding by integrating technology into the learning environment.
M7	7, Content Knowledge, Technological Knowledge, Pedagogical Knowledge, Pedagogical Content Knowledge, Technological Content Knowledge, Technological Pedagogical Knowledge, and Technological Pedagogical Content Knowledge.

The second question is seen as a student who has not answered it, namely with the M1 code. Then, the researcher checks through interviews conducted with a group of 7 respondents; the brief glimpse of the conversation is as follows.

Q: "I'm sorry you missed the time; there is something you want to ask about the answer to the questionnaire via the Google form related to TPACK. The second question is how many components of TPACK there are, according to Mishra and Koehler. You are 6. May you know what the reason is?"

M1: "All I know is six months, CK, TK, PCK, TPK, TCK, TPACK."

Q: "There should be 7; it's okay; you missed not mentioning the PK domain?"

M1: "Oh, I see, mam; the PK domain (pedagogic knowledge) is left behind.

Q: "Then you ask the M5 code again?"

M5: "The reason for this is that in the theory study, according to Mishra and the TPACK cohort, that is, integrated from technological, pedagogical, and content knowledge. This integrated form of knowledge is PCK, TCK, and TPK, but"

Q: "Does that mean you only have to deal with large slices?"

M5: Yes, yes, Mam, I do not know more; thank you for the explanation.

Q: "You continue to ask the reason for your M6 code to answer." TPACK is a framework for understanding and describing the type of knowledge required by a teacher to streamline the practice of pedagogy and understanding concepts by integrating technology into the learning environment. What are the reasons?

M6: "I'm sorry, Mom. I read the question wrong. I think I was asked an explanation about TPACK."

Q: "Okay, that means reading the question wrong."

Q: "Thanks to everyone for responding to my questions."

CONCLUSION

Students' perceptions about professional teachers turned out that they only knew from a theoretical point of view, while from the lens of the TPACK framework, they did not fully understand; this finding was the subject of further research, where learning needs to be carried out with the TPACK framework which previously had to be made before developing instrument development with good.

The study's findings indicated that participants' comprehension of TPACK differed. Some participants successfully identified the six components of TPACK, while others failed to comprehend the significance of combining pedagogy and technology in education. Participants' opinion of mathematics instructors' professionalism is often confined to certain areas, like

pedagogical skills and technological proficiency. They recognized that a comprehensive grasp of TPACK was crucial for enhancing the quality of their instruction.

A issue encountered by participants is that many vocational school students disregard math lectures, seeing them as unnecessary to their post-graduation employment. This underscores the need for a more contextualized and relevant methodology in mathematics instruction, enabling pupils to see the immediate advantages of their acquired knowledge.

This research proposes that the PPG program prioritize the enhancement of TPACK among aspiring instructors. This entails offering comprehensive training on the integration of technology in education. Furthermore, curricular modifications are necessary to include digital literacy and technology utilization pertinent to the requirements of students in the contemporary digital age.

This research underscores the need of cultivating TPACK for future mathematics educators to enhance their expertise. By enhancing the comprehension of the interplay of technology, pedagogy, and material, it is anticipated that future educators will be more proficient in instructing and equipping students to confront obstacles in an ever-evolving digital workforce. This study offers significant insights into how aspiring mathematics educators may enhance their competencies by deepening their grasp of TPACK and the importance of mathematics education in vocational institutions.

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