Developing technological pedagogical content knowledge skills during teaching practicum

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ABSTRACT

This study investigates the efforts of Indonesian pre-service teachers in developing their technological pedagogical content knowledge (TPACK) skills during teaching practicum, explores the obstacles they encounter in this process, and examines their responses to the challenges of TPACK skills development. Employing qualitative narrative inquiry as the research method, the study interviews five pre-service teachers from various study programs to gain insights into their experiences. The findings demonstrate that Indonesian pre-service teachers employ diverse strategies to enhance their TPACK skills, including observing experienced teachers, participating in workshops or online courses, reading relevant literature on TPACK, and consistently integrating TPACK into their teaching practice. However, they face obstacles such as a lack of confidence in their teaching abilities, limited time and resources for reflective practice, and inadequate self-awareness regarding their skills. To overcome these obstacles, they respond by collaborating with peers and mentors, engaging in reflective teaching practice, and setting goals for each practicum session. The study provides valuable insights for teacher training institutions (TTIs), educators, practitioners, and policymakers, facilitating the implementation of more effective strategies for integrating TPACK in future events.

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1. INTRODUCTION

Teachers in the twenty-first century must be proficient in both subject content and teaching methodologies. Recent advances in science, technology, and the arts demand that educators understand how to employ technology in the teaching and learning process. Teachers in the twenty-first century must be familiar with and capable of utilizing a wide range of digital resources to improve learning and learning outcomes. Teaching is a complex process that involves a variety of skills and knowledge. Teachers need to be knowledgeable about the material they are teaching and how to teach it effectively. They must also be familiar with the latest technologies to help them deliver instruction. These different types of knowledge intersect and support one another [1]. The assumption that teaching requires knowledge of content and pedagogy [2] is no longer valid in the 21st-century learning environment.

In order to enable students and teachers to engage with one another and with learning resources, learning in the twenty-first century must use various technological tools. Technology is a valuable tool, method, and resource for learning and applying what has been learnt in the real world [3]. As a result, students and teachers in the twenty-first century must be familiar with and understand technology [4]–[6]. Furthermore, persons wishing to become teachers must have high technological knowledge, skills, and talents to apply technology in learning successfully and efficiently [7]–[9].

In several nations, teacher-training institutions (TTI) have prioritized the preparation of prospective teachers for classroom technology use [10], [11]. As a result of recent demands, TTIs now need to help pre-service teachers develop successful technology integration skills by helping them make connections between their understanding of technology, pedagogy, and content [12], [13]. Technological pedagogical content knowledge (TPACK) is essential for twenty-first century teaching skills. TPACK is a new form of knowledge that instructors must acquire in order to effectively incorporate technology in the classroom [1]. In its evolution, TPACK has become a framework for analyzing teacher knowledge concerning the integration of technology in learning [14]–[16].

Several researchers have recognized the need to better integrate pre-service teacher education in the use of technology with pedagogical difficulties within the curriculum [17]–[19]. This mandate has led to implementation of many strategies to build teachers' TPACK [20], [21]. Nonetheless, developing pre-service teachers' TPACK in an integrated, curriculum-contextualized approach is a difficult process requiring several interventions [22].

Some studies investigate TPACK in teaching and learning processes [23]–[26]. Lestari and Asari [23] investigated how future English as a foreign language (EFL) teachers use technology for online learning and how they perceive their students when utilizing technology. Observations, interviews, and documentary analysis were employed to obtain data for the study. The results show that participants identified and employed learning technologies. Because of their simplicity of use, participants use videos and PowerPoint the most, which improves students' knowledge and class participation. Teaching and learning technology can help teachers identify and distribute instructional resources. Diamah *et al*. [24] examined how pre-service teachers evaluated TPACK after a 2-week training session. Explore-engage-reflection-transformation were the TPACK activities. The study used open and TPACK questionnaires. The one-group pre-post-post investigation examined TPACK self-efficacy. The significant difference between pretest and post-test scores was tested using paired t-test and Cohen's d to determine effect magnitude. The paired t-test indicated that all TPACK dimensions with substantial impact sizes had higher post-test than pretest scores. Koh and Sing [25] investigated the TPACK profile of pre-service teachers in Singapore. The research encompassed a sample of 1185 pre-service teachers who participated in a TPACK survey. Through exploratory factor analysis, the study identified five distinct constructs within the TPACK framework: technological knowledge, content knowledge, pedagogical knowledge, knowledge of teaching with technology, and knowledge derived from critical reflection. Interestingly, the participants did not consistently differentiate between TPACK constructs like technological content knowledge and technological pedagogical knowledge. While some gender-based variations in TPACK perceptions were noted, age and teaching level did not appear to exert significant influence.

Despite the increasing recognition of the importance of TPACK in twenty-first-century teaching, limited research has been conducted on how Indonesian pre-service teachers navigate the development of TPACK during their teaching practicum. While some studies have explored aspects of TPACK and its impact on teaching and learning processes, there is a lack of comprehensive understanding regarding the specific activities undertaken by Indonesian pre-service teachers to enhance their TPACK skills, the obstacles they face in this process, and their responses to these challenges. Therefore, this study aims to address this research gap by investigating the efforts of Indonesian pre-service teachers in developing their TPACK skills during teaching practicum, examining the obstacles they encounter, and exploring their responses to the challenges of TPACK skills development. By gaining insights into these areas, this research seeks to provide valuable knowledge and inform the design of more effective strategies for integrating TPACK into pre-service teacher education programs in Indonesia.

To address this research gap, the present study aims to investigate how Indonesian pre-service teachers engage with TPACK skills during teaching practice. The research questions of this study are formulated as: i) What activities did Indonesian pre-service teachers undertake during their teaching practicum to enhance their TPACK skills; ii) What obstacles did they encounter while developing TPACK skills during their teaching practicum; iii) How did they respond to the challenges of TPACK skills development? Based on these research questions, the research objectives, in details are: i) to elucidate the specific activities that Indonesian pre-service teachers engage in during their teaching practicum in order to bolster and refine their TPACK skills; ii) to uncover the various obstacles and challenges that the pre-service teachers encounter as they endeavor to cultivate their TPACK skills within the context of their teaching

practicum; and iii) to shed light on the adaptive responses and strategies employed by the Indonesian pre-service teachers in response to the multifaceted challenges encountered during the development of their TPACK skills.

2.   RESEARCH METHOD
2.1. Design
The objectives of this study were i) to reveal what Indonesian pre-service teachers undertook throughout their teaching practicum to build their TPACK skills; ii) to analyze the obstacles they confronted while developing TPACK skills during their teaching practicum; and iii) to uncover how they responded to TPACK skills development challenges. In order to get more reliable data from the real-life happenings described by research participants, this recent qualitative study was guided by narrative inquiry. As Clandinin and Caine [27] admit, the primary advantage of narrative inquiry is that it allows researchers to collect more reliable data from the testimonies of research participants. A narrative inquiry research method is a qualitative research method that uses stories to explore personal experiences and meanings. Narrative inquiry can be used to explore a wide range of topics, including personal experiences, professional experiences, and the experiences of groups or organizations. One of the advantages of using narrative inquiry as a research method is that it can help researchers to understand the complex and often contradictory nature of personal experiences.

2.2. Participants
This study involved five pre-service teachers from different study programs, namely English language education, Arabic language education, mathematics education, Islamic education, and early childhood Islamic education. Participants were selected purposively by considering several criteria, such as the ability to become research participants, having participated in the teaching practice program at school, and having experience improving TPACK skills. Participants in this study were interviewed regarding their experiences during teaching practice in schools within 1.5 months. The data explored were related to how they developed TPACK skills, what obstacles they faced when developing TPACK skills, and how they overcame these problems. To protect the participants' identity in this study and maintain research ethics, the researchers disguised their names with pseudonyms, as presented in Table 1.

Table 1 Participants' information

No.	Name	Study program	Gender	Period of teaching practicum
1	Dara	English Language Education	Female	1.5 months
2	Zara	Islamic Education	Female	1.5 months
3	Fara	Early Childhood Islamic Education	Female	1.5 months
4	Dana	Mathematics Education	Male	1.5 months
5	Doni	Arabic Language Education	Male	1.5 months

This confidentiality and anonymity assurance was crucial in fostering an environment of trust and open communication during the interviews. Participants, feeling assured that their identities would not be disclosed, were more likely to candidly share their genuine experiences, thus facilitating a more authentic and valuable data collection process. This comprehensive approach aimed to yield a deeper understanding of the participants' TPACK skill development, the obstacles they faced, and the innovative methods they utilized to address these challenges within the context of their diverse academic programs.

2.3. Data collection and analysis
To achieve the research purposes, open-ended narrative inquiry questions were administered to five pre-service teachers to investigate their experience with TPACK skill development during teaching practicum. The purpose of this collection of narrative inquiries was to provide more insight for Indonesian TTIs, educators, practitioners, and policymakers regarding the viability of more effective strategies in employing this cutting-edge teaching-learning approach in future events by examining the experiences of Indonesian pre-service teachers as they develop their TPACK skills. After that, the researchers analyzed the data using the pattern-coding method proposed by Miles *et al*. [28], developing preliminary codes based on the research questions that emerged from the themes and interview questions. To find patterns, emergent themes, and subthemes in the data, researchers first compared and contrasted all transcripts and then reread them line by line. Then, the researchers read the transcripts to get a feel for the information gleaned from the interviews. After analyzing the interviews, the researchers categorized the data depending on how similar the parts were. The researchers aimed to produce more robust data portrayals that relevant parties could

understand by providing argumentative elaborations of each data category with relevant past research findings and theoretical frameworks.

2.4. Data trustworthiness

The researchers employed the member-checking technique to ensure the data's trustworthiness. Member checking is a qualitative research technique used to ensure the accuracy of participant data. It involves having study participants review and verify the accuracy of the researchers' transcriptions of their interviews or focus group discussions [29], [30]. Member checking can also be used to assess participants' understanding of the research topic and their level of engagement in the research process. Data validity, reliability for qualitative interpretation, and accuracy were all ensured by this technique.

3.   RESULTS AND DISCUSSION

This section presents the findings and analysis of this study, focusing on the efforts, obstacles, and responses of Indonesian pre-service teachers in developing their TPACK during their teaching practicum. Through qualitative narrative inquiry, data were gathered from interviews conducted with five pre-service teachers from various study programs, providing rich insights into their experiences. The results revealed that Indonesian pre-service teachers undertook a range of activities to enhance their TPACK skills, including observing experienced teachers, participating in workshops or online courses, engaging with TPACK-related literature, and actively integrating TPACK principles into their teaching practice. However, they also encountered several obstacles such as a lack of confidence in their teaching abilities, limited time and resources for reflective practice, and a lack of self-awareness regarding their TPACK skills. To overcome these challenges, the pre-service teachers adopted various strategies, including collaboration with peers and mentors, engaging in reflective teaching practice, and setting goals for each practicum session. These findings provide valuable insights into the specific contextual factors influencing TPACK development among Indonesian pre-service teachers and offer implications for teacher training institutions, educators, and policymakers. The discussion section will delve deeper into the implications of these findings, highlighting the importance of targeted interventions and strategies to support the effective integration of TPACK into pre-service teacher education programs in Indonesia and fostering more impactful technology integration in the classroom.

3.1. Indonesian pre-service teachers' efforts to build TPACK skills during teaching practicum

According to the interview results with the five participants, Indonesian pre-service teachers undertook various activities to build their TPACK skills throughout their teaching practicum. These included undertaking observations of experienced teachers, participating in workshops or online courses, reading related literature with TPACK, and always trying to integrate TPACK into their teaching practice. Additionally, they engaged in reflective practice activities, such as journaling and discussing their teaching experiences with friends and mentors. These activities helped the pre-service teachers better understand the TPACK framework and how to apply it in their teaching practice. The followings are the interview excerpts of the participants.

> "I attended workshops on TPACK and read articles and blogs related to TPACK. I also tried to integrate new technologies into my teaching whenever possible. And, of course, I observed my mentor using technology in the classroom." (Dara)
>
> "First, I observed how my mentor teacher utilized technology in learning, which was very helpful. Then, I have also attended various online workshops related to TPACK and read much literature on the topic. I have also tried to apply TPACK in my teaching practice as much as possible." (Zara)
>
> "I have taken a few online courses or workshops related to TPACK and tried integrating technology into my lessons as much as possible. Besides, I always observe my mentor about how he uses technology in the teaching and learning process." (Fara)

The interview excerpts provide valuable insights into the efforts made by the pre-service teachers to enhance their TPACK during their teaching practicum. Dara mentioned attending workshops on TPACK, reading relevant articles and blogs, and actively integrating new technologies into her teaching practice. She also emphasized the significance of observing her mentor's use of technology in the classroom. Similarly, Zara highlighted the importance of observing her mentor's practices and attending online workshops and extensive reading to deepen her understanding of TPACK. She actively applied TPACK principles in her teaching practice. Fara's approach aligns with the others, as she also emphasized attending online courses and

workshops, integrating technology into lessons, and observing her mentor's use of technology. These excerpts collectively highlight the proactive measures taken by the pre-service teachers, including professional development, self-study, and observation of experienced teachers, to build their TPACK skills during their teaching practicum.

Further, Dana mentioned utilizing technology in the classroom as a means to enhance his TPACK skills. Additionally, he emphasized the use of reflective journals to document his teaching practices, particularly highlighting the difficulties and obstacles encountered when implementing technology. Dana also highlighted the importance of discussing these challenges with his mentor, indicating a collaborative approach to problem-solving. Similarly, Doni emphasized the significance of collaboration with colleagues during teaching observations, specifically focusing on the use of technology in learning. Doni also emphasized the practice of recording experiences related to TPACK skills in a journal. Additionally, Doni highlighted the value of seeking guidance from both mentors and colleagues who possess stronger TPACK skills. These excerpts collectively highlight the pre-service teachers' use of technology in the classroom, reflective practices through journaling, and collaborative approaches to further develop their TPACK skills. The followings are the interview excerpts.

> *"I developed my TPACK skills by utilizing technology in the classroom. I also documented my teaching practices in reflective journals. In these journals, I detailed the difficulties and obstacles I encountered when implementing technology in my classroom. I then discussed the matter with my mentor."* (Dana)
> *"I collaborate with my colleagues to observe when I practice teaching and focus on using technology in learning. She recorded everything related to my TPACK skills in a journal. After that, if I feel something is missing, I discuss it with my mentor and colleagues who are better at TPACK skills."* (Doni)

The findings of this study dealing with the efforts made by the Indonesian pre-service teachers in developing their TPACK skills align with several previous studies. Among the efforts made by the Indonesian pre-service teachers are observing experienced teachers [31], joining workshops or online courses [32]–[34], reading literature about TPACK, integrating TPACK in the teaching process [35]–[37], and conducting reflective practice [37]–[39]. Observing experienced teachers can help pre-service teachers improve TPACK skills because they have a lot of knowledge and experience that they can share. They can help show pre-service teachers how to use technology in the classroom in a way that is effective and helps students learn. They can also help pre-service teachers to develop their teaching style and give them ideas for different ways to use technology in the classroom.

Furthermore, joining workshops or online courses can improve TPACK skills by providing pre-service teachers with opportunities to learn about and use technology in their teaching practice. Workshops and courses can also help them develop their understanding of how different technologies can support student learning. Also, reading about TPACK can help pre-service teachers improve their TPACK skills. The literature provides examples of integrating technology into their teaching practice, which can help them become more comfortable using technology in the classroom. It can also help them reflect on their teaching practice and identify ways to develop their TPACK skills further.

In order to integrate TPACK into the teaching process, pre-service teachers need to be aware of the different components of TPACK and be able to identify the connections between the different components. They also need to be familiar with different teaching strategies that can help them integrate the different components of TPACK into their teaching. In addition, pre-service teachers need to be able to reflect on their teaching practice and identify ways in which they can improve their TPACK skills. In addition, reflective practices can help pre-service teachers improve their TPACK skills by allowing them to think about their teaching practice and how it connects to their knowledge of technology, pedagogy, and content. Reflective practices can also help pre-service teachers to connect with other educators who can help them to develop their TPACK skills.

3.2. The obstacles encountered by Indonesian pre-service teachers in developing TPACK skills

Based on the interview results, there are various obstacles that Indonesian pre-service teachers face while developing their TPACK skills during their teaching practicum. Dara expressed uncertainties in integrating technology into her lessons, which required more planning and follow-through. She also identified the challenge of selecting the appropriate technology for each lesson, emphasizing the need to become familiar with different types of technology. Additionally, Dara faced difficulties in assessing student learning with technology, emphasizing the importance of planning and implementation. On the other hand, Zara identified two specific challenges: effectively integrating technology into teaching practice in a meaningful and engaging manner and collaborating with other educators to develop and implement

innovative teaching practices. These excerpts collectively underline the common challenges encountered, such as integrating technology meaningfully, selecting appropriate technology, assessing student learning, and fostering collaboration with fellow educators, underscoring the need for targeted strategies and support in addressing these obstacles to TPACK development. The followings are the interview excerpts with the participants.

> "I faced a few obstacles when developing TPACK skills during my practicum. One obstacle was that I was unsure how to integrate technology into my lessons. I needed to spend more time planning how to use technology in my lessons, and then I needed to follow through with that plan. Another obstacle was that I was unsure what technology to use in my lessons. I needed to become more familiar with different types of technology, and then I needed to select the right type of technology for each lesson. A final obstacle was that I was unsure how to assess student learning with technology. I needed to spend more time planning how to assess student learning with technology, and then I needed to follow through with that plan." (Dara)
>
> "The challenges that I found to develop my TPACK skills during teaching practicum were: i) How to effectively integrate technology into my teaching practice in a way that is meaningful and engaging for my students; and ii) How to effectively collaborate with other educators to develop and implement innovative teaching practices." (Zara)

From the interview excerpts, it can be inferred that Dara and Zara lacked confidence in their teaching abilities regarding pedagogical and professional competencies, including using technologies and feeling unprepared to teach in a classroom setting [40], [41]. Selfe [41] discussed how teachers often lack the confidence to use technologies in the classroom and feel unprepared to teach effectively. She argues that these feelings can be a major obstacle to successful teaching practice and that teachers need to be educated on using technology in the classroom to succeed.

Further, Fara and Dana asserted they had difficulties identifying areas for improvement [42]. Fara expressed difficulties in reflecting on her teaching due to a lack of understanding of what effective teaching entails. This lack of clarity made it challenging for her to identify areas in need of improvement. Fara also mentioned a lack of self-confidence and fear of being critical of her work, which hindered her from engaging in reflective practices. Similarly, Dana highlighted the lack of access to constructive feedback from students and colleagues, which made it difficult for him to pinpoint areas for growth. These excerpts collectively emphasize the difficulties the pre-service teachers faced in self-reflection and receiving adequate support and guidance for professional development. Addressing these challenges and providing structured support for reflection and feedback can greatly contribute to their growth and the development of their teaching skills. The followings are the interview excerpts.

> "I had difficulties reflecting on my teaching practice and identifying the parts that need improvement. It was because I did not clearly understand what effective teaching looks like. Without this understanding, it can be difficult to identify areas in which improvement is needed. I was also reluctant to reflect on my practice due to a lack of self-confidence or a fear of being critical of my work. That is why I have not received adequate support or guidance in reflection and development." (Fara)
>
> "I was confused with the parts of my teaching skills that need to be improved. This was because I did not have access to good feedback from my students or colleagues to help me identify growth areas." (Dana)

Gast et al. [42] systematically reviewed the literature to identify the challenges teachers face in identifying their professional development needs and the strategies used to overcome this obstacle. The study found that the main challenges faced by teachers were a lack of self-awareness of their skills and a lack of knowledge about available training resources. The authors suggest that teacher educators should support and guide teachers in identifying their professional development needs and providing access to resources that can help them understand and develop their skills. Dealing with the obstacles in teaching practicum, pre-service teachers should i) focus on collaboration with each other and with outside experts to share best practices and build their professional networks; ii) embrace technology by incorporating technology into the practicum to enhance instruction and to allow for more digital forms of professional development; iii) make time for reflection on their instructional practices and to assess their teaching; iv) set goals for each practicum session to ensure that they are expanding their knowledge and improving their practice; v) incorporate research-based professional development into the practicum to ensure that they are learning the most effective strategies; and

vi) offer continued support to teachers after the practicum has ended to ensure they have the tools they need to grow and improve continually.

3.3. Indonesian pre-service teachers' responses towards the obstacles and how to solve them

Based on the results of this study, there are several things that Indonesian pre-service teachers do related to the barriers or obstacles they face when improving their TPACK skills. The interview excerpts highlight the importance of collaboration with peers and mentors in the development of TPACK skills. Fara emphasized the significance of receiving different perspectives on how to use technology in the classroom, recognizing the value of collaborative learning. Similarly, Zara acknowledged her need to learn more about technology and sought help from peers and mentors who possessed greater expertise. Through collaboration, Zara was able to learn from their experiences and develop her TPACK skills. Dana also recognized the importance of collaborating with more experienced peers and mentors to learn from their experiences and receive feedback on her work. Additionally, Dana emphasized the desire to build relationships with these individuals for future learning opportunities. These excerpts collectively underscore the role of collaboration in TPACK development, emphasizing the benefits of learning from others' experiences, accessing valuable feedback, and establishing relationships for ongoing professional growth. The following are the interview excerpts with the participants.

"I collaborated with my peers and mentors to develop my TPACK skills. I think it is important to get different perspectives on how to use technology in the classroom." (Fara)
"I collaborated with my peers and mentors to develop my TPACK skills. I knew I needed to learn more about technology and how to use it in the classroom, so I sought help from those who knew more than I did. By collaborating with my peers and mentors, I learned from their experiences and expertise, which helped me develop my TPACK skills." (Zara)
"I collaborated with my more experienced peers and mentors to develop my TPACK skills because I wanted to learn from their experiences and get feedback on my work. I also wanted to build relationships with these people to learn from them in the future." (Dana)

Further, Doni emphasized the importance of continuous reflection on teaching practices and learning from others to improve. Reflective teaching was recognized as a valuable tool for teachers to enhance their practice. Similarly, Dara highlighted the various benefits of reflective teaching. It provides opportunities to learn from teaching experiences, as well as from peers and mentors. Reflective teaching helps teachers become more aware of their beliefs and assumptions about teaching and learning, fostering a deeper understanding of the connections between theory and practice. Additionally, it enables teachers to become effective problem-solvers and develop more impactful teaching strategies. These excerpts collectively underscore the pivotal role of reflective teaching in TPACK skill development, emphasizing its contribution to self-improvement, knowledge expansion, and pedagogical effectiveness. The followings are the interview excerpts.

"I engaged in reflective teaching to develop my TPACK skills. I knew that I needed to constantly reflect on my teaching practices and learn from others to improve. Reflective teaching is a valuable tool for teachers to improve their practice." (Doni)
"I conducted reflective teaching. Reflective teaching practices can help us to develop our TPACK skills by providing opportunities to learn from our teaching experiences and the experiences of our peers and mentors. Reflective teaching can also help us to become more aware of our beliefs and assumptions about teaching and learning and to develop a deeper understanding of the connections between theory and practice. In addition, reflective teaching can help us to become more effective problem-solvers and to develop more effective teaching strategies." (Dara)

For pre-service teachers, collaborating with peers and mentoring teachers [31], [43], [44] is a great way to gain practical knowledge and experience in the field of teaching. It allows teachers to share their expertise and advice with their peers, which can be invaluable in helping pre-service teachers learn and grow in their teaching careers. Furthermore, working with experienced mentors can help pre-service teachers gain insight into classroom management and educational methods, which can be invaluable once they enter the classroom. By collaborating with peers and mentoring teachers, pre-service teachers can benefit from a wealth of knowledge, experience, and advice to help them become successful educators.

Furthermore, reflective teaching practice [45]–[48] is a valuable tool for pre-service teachers to build upon their teaching skills and improve their instructional approaches. Reflective teaching practice encourages pre-service teachers to assess their teaching techniques and student outcomes and make necessary

changes to promote better learning outcomes. Reflective teaching practice also helps pre-service teachers understand the complexities of teaching and learning, making them more aware of their teaching methods and how to support their students better. Additionally, reflective teaching practice allows pre-service teachers to identify areas of growth and improvement and create a plan to move forward in their teaching careers. Overall, reflective teaching practice is essential for pre-service teachers to enhance their teaching skills and better support their students.

4.   CONCLUSION

Indonesian pre-service teachers enhanced their TPACK skills through activities like observing experienced educators, participating in workshops and online courses, reading relevant literature, integrating TPACK into their teaching, and engaging in reflective practices during their teaching practicum. These endeavors faced challenges including a lack of confidence, unpreparedness for classroom teaching, and difficulty in self-assessment. To overcome these hurdles, they collaborated with peers and mentors, sought guidance from experienced teachers, and practiced reflection. Despite its valuable findings, this study is limited by its focus on a small group of Indonesian participants and its reliance on interviews for data collection. Future research could delve deeper into the impact of TPACK on Indonesian pre-service teachers, conduct qualitative studies on their experiences, compare TPACK skills internationally, and investigate factors influencing their development, such as teaching methods and available resources.

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