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# TPACK Competency of Indonesian Mathematics Education Students in Designing Lesson Plans: Utilization of ICT in Education

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**ABSTRACT**
The purpose of this study is to examine the level of competency among Indonesian mathematics education students in the area of technological pedagogical content knowledge (TPACK) as it pertains to the development of instructional strategies that make use of ICT. The purpose of this study is to evaluate the ability of twenty undergraduates in their seventh semester to effectively use technology in the classroom without compromising their grasp of course material. To test the participants' tech integration skills, we had them design tech-based lessons and then interview three students in depth to see how well they did. While the majority of students have a good grasp of the subject matter, pedagogy, and technology, the results show that they struggle to integrate all three into their lessons. The main problems that have been found were not knowing how to effectively use ICT into teaching methods and not having enough technical abilities. To help students in Mathematics Education build their TPACK abilities, this qualitative descriptive research highlights the importance of a well-rounded education, strong teacher support, and a new curriculum. In addition to adding to the ongoing conversation around TPACK competency in math education, this study also calls for specific treatments to help students develop their technical abilities and acquire the background knowledge they need to effectively incorporate technology into their classrooms.

**Keywords**: TPACK Competency, Designing Learning, ICT Education, Mathematics Education Students

## INTRODUCTION

To meet the challenges of the digital age and take advantage of its potential, ICT in education has become an essential component. The demands of a technology-oriented society are being met by universities all over the globe through an ongoing effort to incorporate technology into the educational process [1]. A critical framework that unites technology, pedagogy, and subject matter is Technological Pedagogical Content Knowledge (TPACK)[2, 3]. Teachers can use TPACK as a springboard to create engaging lessons that capitalize on generation [4].

Examining the TPACK competency of mathematics education students in the setting of higher education as it pertains to the creation and examination of reports using ICT is the primary objective of this research. As a result, the study's overarching goal is to quantify the degree to which college students can utilize technology effectively in the classroom. Fundamentally, enhancing students' TPACK skills in mathematics education can also positively impact the development of their digital competencies [5]. Recognizing the difficulties students have when trying to incorporate technology into

mathematics instruction, this study takes a student-centered approach to the problem of building students' TPACK competency. Insights on how to better equip students to meet the ever-increasing challenges of digital education are anticipated from the results of this study.

Students are anticipated to have the ability to design learning experiences that are more significant and applicable to the digital age with a solid grounding in TPACK [6]. A significant addition to the literature on technology integration in higher education, this research will shed light on students' preparedness and capacity to enhance TPACK abilities.

## 1) TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK)

Teachers need to be able to take the initiative to make learning engaging, entertaining, creative, and inventive. The ability to use computers and other forms of modern technology is equally essential for teachers. Modern equipment that may be utilized to facilitate labor is known as technology. When a teacher uses technology in the classroom, it's typically a computer, laptop, or other device. A teacher must be able to use technology effectively. According to Koehler, M.J., and Mishra, TPACK (teacher professional competence in technology) is crucial for successful technology integration in the classroom [7]. Technology, pedagogy, and teachers' subject matter expertise are all part of Technological Pedagogical Content Knowledge (TPACK), which is in keeping with this (Figure 1). TPACK refers to a teacher's understanding of pedagogical and technical techniques that might help pupils learn [8]. The term "TPACK" refers to a framework in the field of education that integrates technology, pedagogy, and content to create learning models [9].

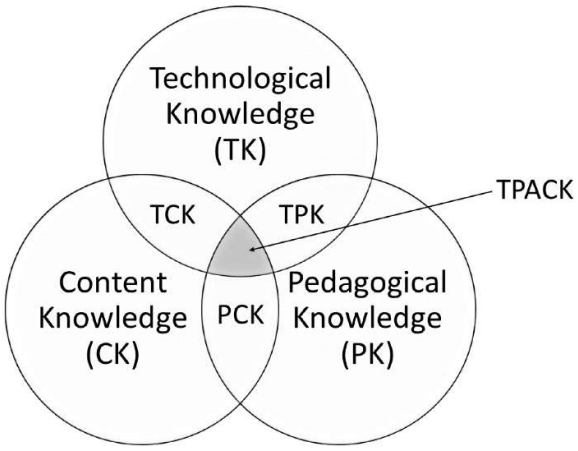


**Figure 1** Research Framework

It follows that a deeper comprehension of the interplay between technology, pedagogy, and content, as well as the appropriate use of each in different settings, is necessary for high-quality learning [10]. The following are the seven sections that make up TPACK: Knowledge of technology encompasses a wide range of domains, including but not limited to tools, procedures, and resources. What a teacher needs to know in order to accomplish learning objectives in the classroom is known as pedagogical knowledge (PK), and it includes both theoretical and practical information concerning lesson preparation, assessment, and evaluation. The term "content knowledge" (CK) refers to educators' familiarity with the material they are required to study and pass on to their pupils. Pedagogical content knowledge (PCK) refers to a body of information on how to teach a certain subject. The term "technological pedagogical knowledge" (TPK) refers to an understanding of the many ways in which technology may improve the educational process. A teacher's ability to effectively use technology within sound pedagogical practices is known as technological content knowledge (TPACK) [11]. TCK refers to an understanding of the two-way street that is technology and content.

The need to provide prospective teachers, namely those pursuing a degree in mathematics education, with a solid grounding in TPACK has been emphasized by studies on TPACK competency. In the context of mathematics education, these students are expected to possess not just technical proficiency but also knowledge of when and why to use it [12]. Nevertheless, acquiring TPACK competency is not without its difficulties. Important elements in fostering this competency include institutional backing, specialized training, and a course of study that emphasizes TPACK development.

To comprehend the crucial role that students' TPACK competency plays in the creation of learning experiences that use ICT in education, this theoretical framework must be followed.

## 2) METHODS

The researchers and informants in this study used qualitative descriptive research methods, which include collecting data through interviews and then presenting it visually and verbally in the form of sentences. In order to better understand how mathematics education students apply TPACK abilities when developing lesson plans, this study employs a qualitative methodology. Three primary areas—technological competence, pedagogical expertise, and subject

knowledge—make up this student's TPACK proficiency. Participants were undergraduates in the mathematics education program in their seventh semester who had taken and successfully completed the learning device creation course and had previously used microteaching in the classroom. Researchers selected three pupils out of twenty whose arithmetic skills were rated as good, average, or low. Observation, interviews, and documentation were the tools used to gather data.

**Table 1.** Assessment Indicator for the Lesson Plans

| Assessment Indicator | Description | Criteria |
|---|---|---|
| Technology Knowledge (TK) | The level of proficiency with which the lesson plans include a variety of technological resources. | Evaluate the level of competence in choosing and implementing technological tools to enrich the educational process. |
| Pedagogy Knowledge (PK) | How many attention-grabbing and interactive pedagogical tactics are included in the lesson plans. | Assess the lesson plans' capacity to promote active and collaborative learning, taking into consideration different types of learners. |
| Content Knowledge (CK) | The level of comprehension and practical application of mathematical concepts covered in class. | Evaluate the lesson plans based on how well they present mathematical ideas and how they relate to the real world. |
| TPACK Integration | The lesson plans' flawless incorporation of pedagogical, content, and technological knowledge. | Make that the learning experience is unified and successful by evaluating the mix of technology, pedagogy, and content. |

Asking students to design technology-based lesson plans is the initial step in this project. Researchers used an evaluation form they developed based on TPACK characteristics to sift through student-created lesson plans for relevant data (Table 1). The next step was to conduct interviews with the students to verify and gather further information on the lesson plans they had developed. Students are requested to try teaching utilizing the produced lesson plans after conducting interviews about the plans. After the students have had some classroom experience, they will be questioned to get their thoughts on what they learned. The objective is to gather comprehensive data on how student teachers work in the classroom. Students' perspectives, difficulties, and experiences with the usage of ICT in the classroom were also elucidated through this interview. Data reduction, data presentation, and conclusion formulation and verification were the steps used in this study's analysis according to Miles and Huberman [13].

## 3) RESULTS

The research aimed to explore the TPACK (Technological, Pedagogical, and Content Knowledge) competency of Indonesian Mathematics Education students in designing learning lesson plans with the utilization of ICT. This chapter presents the key findings derived from the analysis of lesson plans created by the subjects and the insights obtained from two in-depth interviews conducted with each subject.

### Lesson Plans Assessment Results

The first component of the research involved evaluating the lesson plans developed by the three subjects. The analysis was centered around TPACK integration, alignment with student needs, usability of technology, interactivity, and innovation. Each subject's lesson plan was assessed based on these criteria to gauge their overall TPACK competency.

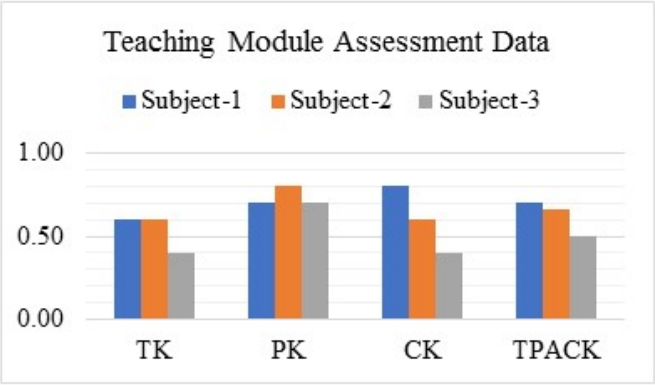


**Figure 2** Lesson Plans Assessment Data

**Subject 1:** She demonstrated a high level of TPACK competency, with seamless integration of technology, pedagogy, and content knowledge. The lesson plans effectively aligned with student needs, providing an engaging and interactive learning experience.

**Subject 2:** She exhibited commendable TPACK competency, focused on addressing specific challenges faced by students. The lesson plans demonstrated innovation in utilizing technology to enhance understanding, although there were minor areas for improvement.

**Subject 3:** She faced challenges in TPACK integration, particularly in the usability of technology. Despite hurdles, she showed perseverance and a commitment to overcoming technical obstacles.

Overall, the lesson plan assessment results highlight varying levels of TPACK competency among the subjects, providing insights into their proficiency in integrating technology into mathematics education.

**Interview Insights**

The second component involved conducting two in-depth interviews with each subject. The first interview centered around the creation of lesson plans, while the second explored subjects' experiences, challenges, and perceptions regarding the use of ICT in learning.

**Subject 1:** "Seiring dengan perkembangan teknologi, saya menyadari pentingnya mengintegrasikan ICT dalam pembelajaran matematika. Dalam pengembangan modul saya, respons positif dari siswa menjadi indikator kesuksesan pengintegrasian TPACK. Saya berusaha memahami kebutuhan siswa dan merancang modul yang tidak hanya memanfaatkan teknologi, tetapi juga relevan dengan kurikulum dan memberikan pengalaman belajar yang menarik." (Translation: “As technology develops, I realize the importance of integrating ICT in mathematics learning. In developing my lesson plans, positive responses from students are an indicator of the success of integrating TPACK. I try to understand students' needs and design lesson plans that not only utilize technology but are also relevant to the curriculum and provide an interesting learning experience”.)

The interviews with Subject 1 revealed a strategic and thoughtful approach to lesson plan creation. Positive feedback from students indicated successful TPACK integration. Challenges were acknowledged, and proactive measures were taken to overcome them.

**Subject 2**: "Wawancara ini memberi saya pemahaman yang lebih mendalam tentang tantangan yang dihadapi siswa dalam menghadapi teknologi. Beberapa siswa mungkin belum memiliki kecakapan teknis yang memadai, dan itu memengaruhi bagaimana mereka merespons modul saya. Saya melihat bahwa pentingnya dukungan teknis tambahan untuk siswa yang mungkin belum terbiasa dengan teknologi." (Translation: "This interview gave me a deeper understanding of the challenges students face in dealing with technology. Some students may not have sufficient technical proficiency, and that impacts how they respond to my lesson plans. I see the importance of additional technical support for students who may not be familiar with technology”.)

Subject 2 demonstrated adaptability and consideration of students' diverse needs in both interviews. Challenges related to varying levels of technological familiarity among students were recognized, yet the subject maintained a positive outlook on the potential of ICT.

**Subject 3**: "Saya menyadari bahwa integrasi teknologi dalam pengajaran adalah kebutuhan mendesak. Meskipun saya menghadapi beberapa kesulitan teknis dalam mengembangkan modul, saya merasa perlu untuk terus belajar dan berkembang. Wawancara ini memberi saya wawasan tentang pentingnya kesabaran dan kemauan untuk mengatasi hambatan teknis dalam mengintegrasikan TPACK dalam pembelajaran matematika." (Translation: "I realized that the integration of technology in teaching is an urgent need. Although I faced some technical difficulties in developing the lesson plans, I felt the need to continue learning and developing. This interview gave me insight into the importance of patience and willingness to overcome technical obstacles in integrating TPACK in learning mathematics.")

The interviews with Subject 3 highlighted pronounced challenges, particularly in technical aspects. Her recognition of the importance of technology and a willingness to learn and adapt suggested the potential for growth in TPACK competency.

**Cross-Analysis of Lesson Plans and Interviews**

The cross-analysis of lesson plans and interview insights provided a comprehensive understanding of each subject's TPACK competency. She demonstrated higher TPACK competency showcasing not only technical proficiency but also strategic planning, adaptability, and an understanding of students' needs.

## 4) DISCUSSION

The study highlights several key challenges faced by The discussion chapter aims to synthesize the research findings with relevant theoretical frameworks and previous studies, providing a comprehensive understanding of the TPACK (Technological, Pedagogical, and Content Knowledge) competency of Indonesian Mathematics Education students in designing lesson plans with the utilization of ICT.

**Integration of TPACK Components**

The results of the research revealed varying levels of TPACK competency among the three subjects. Subject 1 demonstrated a high level of integration, seamlessly incorporating technology, pedagogy, and content knowledge into the lesson plans. This aligns with Mishra and Koehler's TPACK framework [14], emphasizing the interplay of these components. Subject 2 exhibited commendable competency, addressing specific challenges through innovative technology integration, while Subject 3 faced pronounced challenges, particularly in the usability of technology. These findings resonate with the notion that successful TPACK integration requires a delicate balance between technological skills, pedagogical strategies, and content understanding [15].

**Alignment with Student Needs**

The research emphasized the importance of aligning lesson plans with the unique needs and challenges of mathematics students. Subject 1's lesson plan was well-aligned, providing an engaging and interactive learning experience, while Subject 2 considered specific challenges faced by students. This aligns with studies suggesting that effective technology integration caters to students' diverse learning styles and needs [16]. Subject 3 faced challenges in this regard, highlighting the need for targeted support in aligning lesson plans with student needs.

The usability of technology emerged as a critical factor influencing TPACK competency. Subject 1 showcased user-friendly lesson plans, minimizing technical challenges. This resonates with prior research emphasizing the significance of considering the usability of technology tools in educational settings [17]. Subjects 2 and 3 faced varying degrees of challenges, emphasizing the need for interventions focusing on enhancing technical skills and addressing usability issues.

The challenges faced by Subject 3, particularly in technical aspects, underscored the complexities of TPACK integration. However, her perseverance and commitment to overcoming obstacles highlight the importance of resilience in navigating the challenges associated with technology integration in education. This aligns with Ertmer's assertion that overcoming barriers to technology integration requires a combination of technical skills and a positive mindset [18].

The research findings carry implications for mathematics education and emphasize the need for targeted training and support to enhance TPACK competency among students. The varying levels of proficiency observed underscore the importance of tailored interventions to address specific challenges faced by students in integrating technology into their teaching practices. This aligns with the broader literature on the importance of professional development programs to enhance teachers' TPACK competency [15].

Based on the research findings, recommendations for further research include exploring the long-term impact of TPACK training on mathematics education students, investigating the role of mentorship in enhancing TPACK competency, and assessing the effectiveness of specific interventions in addressing challenges related to technology integration. These recommendations align with the evolving nature of technology in education and the ongoing need for research to inform effective pedagogical practices [16].

## 5) CONCLUSION

The exploration of TPACK competency among Indonesian Mathematics Education students in designing lesson plans with the utilization of ICT has provided multifaceted insights into the intersection of technology, pedagogy, and content knowledge in educational practices.

The overarching aim of the study was to assess the students' ability to seamlessly integrate technology into their lesson plans while considering the needs of mathematics learners. The investigation, involving the analysis of lesson plans and in-depth interviews, unraveled key dimensions of TPACK competency.

In scrutinizing the lesson plans, the research brought to light the varying levels of TPACK proficiency among the three subjects. Subject 1 with high mathematics abilities exhibited a high level of integration, showcasing a harmonious blending of technology, pedagogy, and content knowledge. Subject 2 with medium mathematics abilities demonstrated commendable competency, focusing on addressing specific challenges faced by students. Subject 3 with low mathematics abilities, on the other hand, faced pronounced challenges, particularly in the usability of technology. This diversity underscores the need for tailored interventions and ongoing support systems to enhance TPACK competency among mathematics education students.

The alignment of lesson plans with the unique needs and challenges of mathematics students emerged as a crucial determinant of TPACK competency. Successful integration was closely tied to a strategic understanding of how technology could cater to diverse learning styles and needs. Subjects with higher TPACK competency were those whose lesson plans resonated well with student preferences, fostering engagement and interactive learning experiences.

The assessment of the usability of technology within the lesson plans further emphasized the importance of creating user-friendly educational tools. Subjects with lesson plans designed for ease of use demonstrated a better ability to minimize technical challenges, ultimately enhancing the overall learning experience. This finding aligns with the broader literature on technology integration in education, emphasizing the significance of usability in facilitating effective teaching practices.

Challenges, particularly technical hurdles, were acknowledged in the research. Subject 3 with low mathematics abilities perseverance and commitment to overcoming these challenges highlighted the resilience required to navigate the evolving landscape of technology in education. This resilience is crucial as educators strive to overcome barriers and integrate technology seamlessly into their teaching practices.

This study contributes valuable insights to the discourse on TPACK competency among mathematics education students. The varying levels of proficiency observed, coupled with the identified factors influencing TPACK integration, offer a foundation for further research and the development of targeted interventions. Enhancing TPACK competency is not only vital for individual educators but also for the broader advancement of mathematics education in the context of rapidly evolving technological landscapes. The findings call for ongoing professional development initiatives and support systems to empower educators in leveraging technology effectively for enhanced teaching and learning outcomes.

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## 7) CONFLICT OF INTEREST

All authors have stated that they have no competing interests.

## 8) AUTHOR CONTRIBUTIONS

Everyone who worked on the study had an adequate hand in it, and they all agreed with the final product..

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