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Unveiling the TPACK profile: Exploring mathematics prospective teachers in the micro teaching course

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ABSTRACT

The objective of this research is to ascertain the Technological Pedagogical Content Knowledge (TPACK) profile of prospective mathematics teachers in the microteaching course. The research methodology employed a survey research design. The target population for this investigation comprises prospective mathematics teacher students enrolled at a University in Banten, Indonesia. The sample for this study comprises students in their sixth semester of the Mathematics Education program who are currently enrolled in the microteaching course. The inclusion criteria for the sample require that these students have successfully completed coursework in foundational technology use, pedagogical principles, and both basic and advanced mathematics subjects. The research findings indicate that the majority of students exhibit a high level of Technological Content Knowledge (TCK) and Technological Pedagogical and Content Knowledge (TPACK), with percentages of 50% and 81.25% respectively. On the other hand, the majority of students demonstrate a moderate level of Pedagogical Knowledge (PK) and Technological Pedagogical Knowledge (TPK), with percentages of 56.25% and 31.25% respectively. Moreover, a significant portion of students show a low level of Technological Knowledge (TK) at 31.25%, Content Knowledge (CK) at 37.5%, and Pedagogical Content Knowledge (PCK) at 37.5%. It conluded, most prospective teachers use the Technological Conten Knowledge (TCK) and Technological Pedagogical and Content Knowledge (TPACK) domains to conduct learning.

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INTRODUCTION

The mastery of technology has emerged as a pivotal imperative for educators. Indeed, the assimilation of technological tools into pedagogical practices has garnered considerable attention among scholars. Technology, in its essence, serves to augment the educational landscape by facilitating learner engagement (Chien, 2019). However, despite its evident benefits, the predominant focus remains on technical functionalities rather than on the communicative and functional aspects crucial for student development (Lubis, 2018). Nonetheless, technology stands as a formidable conduit for learning and information dissemination, thereby streamlining the educational process (Surani, 2019). Its efficacy in fostering significant motivation among students has also been underscored (Nurhalimah et al., 2020).

In order to adequately prepare students to meet the evolving demands of 21st-century skills within the framework of Society 5.0, educators must possess a multifaceted skill set encompassing adeptness in technology utilization, mastery of core concepts, and proficiency in delivering content effectively. Beyond mere proficiency in subject matter, educators must also be realized of the pedagogical strategies employed in their instructional design. The manner in which content is imparted necessitates a meticulous organization of course material to facilitate robust student comprehension. Consequently, an adaptive instructional approach that delineates the procedural intricacies inherent to the designated content is imperative. Moreover, educators must adeptly integrate diverse considerations such as linguistic and cultural variances, individualized learning modalities, as well as inherent talents and cognitive capacities as the bedrock for implementing tailored teaching methodologies (Lestari, 2018). Furthermore, the seamless integration of pedagogy and technology warrants meticulous consideration. It is imperative to recognize that technology integration should transcend mere superficial supplementation and avoid becoming superfluous or detracting from the educational experience (Mdhlalose & Mlambo, 2023)

In the global educational landscape, there has emerged a paradigm for enhancing competency across three interconnected domains: technological proficiency, conceptual mastery, and effective content delivery, encapsulated within the framework known as TPACK (Technological, Pedagogical, Content Knowledge). The essence of TPACK lies in the holistic amalgamation of comprehensive knowledge and skills pertaining to content, pedagogy, and technology among educators (Rafi & Sabrina, 2019). Contrary to a narrow focus on technology utilization, TPACK emphasizes the strategic integration of technology to optimize the learning process (Alqurashi et al., 2017). Moreover, TPACK underscores the importance of educators' ability to discern technological affordances and leverage them advantageously within the teaching and learning (Koehler & Mishra, 2009). Fundamentally, TPACK represents educators' adeptness in utilizing technology across diverse pedagogical approaches. Originating from the seminal work of Mishra and Koehler (2006), the TPACK framework is illustrated in Figure 1.

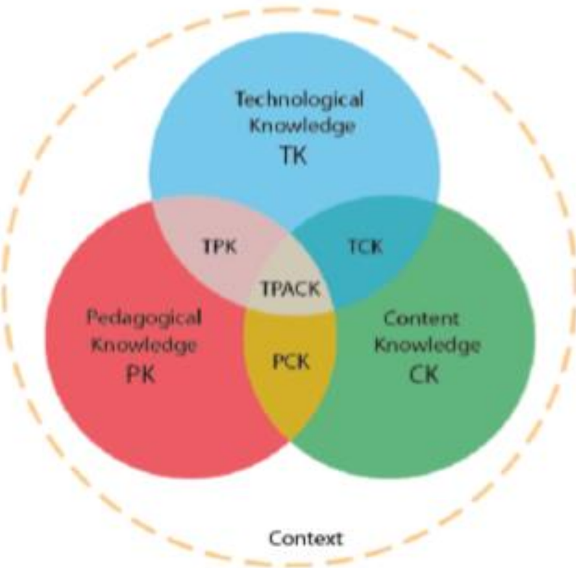

Figure 1. Mishra & Koehler's TPACK Framework

The PACK framework comprises three primary constituents alongside four integrated elements. The principal constituents encompass Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK) (Nevrita et al., 2020). Complementing these are four interwoven components, namely Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK) (Baumert et al., 2013). These seven components hold paramount significance for

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educators, as they collectively encapsulate the breadth of teaching expertise, spanning conceptual mastery, pedagogical adeptness, and the proficient utilization of technology as a facilitative conduit for student comprehension. TPACK, in particular, emerges as a pivotal hallmark denoting professional teaching proficiency, aligning with the delineated competencies of professional educators articulated in Law Number 14 of 2005 concerning teachers and lecturers, specifically pertaining to pedagogical and professional competencies, thereby underscoring its pivotal role as an essential metric in assessing teaching efficacy.

The proficient cultivation of Technological Pedagogical Content Knowledge (TPACK) is imperative for educators to craft pedagogically sound and engaging learning experiences (Alhamid & Mohammad-Salehi, 2024). Microteaching courses have emerged as a strategic avenue for refining students' pedagogical competencies, offering prospective mathematics teachers the opportunity to acquire instructional acumen under the mentorship and appraisal of seasoned faculty members. However, the prerequisite of adeptness in integrating the TPACK framework among aspiring educators warrants careful consideration, constituting a concerted endeavor towards enhancing teaching efficacy. Consequently, this research endeavors to delineate the TPACK proficiency of prospective mathematics educators engaged in microteaching courses, thereby furnishing invaluable insights conducive to the refinement of mathematics education curricula and teacher training paradigms. In light of the aforementioned context, the research inquiry is succinctly formulated as follows: What is the extent of Technological Pedagogical Content Knowledge (TPACK) comprehension among prospective mathematics instructors participating in microteaching courses?

METHOD

The aim of this study is to investigate the Technological Pedagogical Content Knowledge (TPACK) exhibited by prospective mathematics educators enrolled in microteaching courses. Consequently, a survey research methodology is adopted to facilitate this examination. The adoption of a survey research design is predicated upon its efficacy in elucidating diverse trends or viewpoints prevalent within a given population, achieved through the systematic sampling of a targeted subject of inquiry (Cohen et al., 2017).

The research population comprises prospective mathematics teacher students enrolled at a university situated in Banten, Indonesia. Specifically, the research participants encompass six students enrolled in the sixth semester of the Mathematics Education program. Employing a purposive sampling technique, individuals selected for inclusion in the study are prospective educators currently undergoing the microteaching course, having fulfilled prerequisite coursework that encompasses foundational concepts in technology utilization, pedagogical principles, as well as both elementary and advanced mathematics subjects.

Data collection is facilitated through the administration of a test meticulously crafted to elicit insights pertaining to the seven constituent elements of TPACK proficiency among prospective mathematics educators. The test instrument utilized is structured around multiple-choice questions, with the formulation of indicators for these inquiries rooted in the foundational tenets of the TPACK framework (Ball et al., 2016).

The data obtained from the completion of the test was analyzed using descriptive statistics, involving the determination the percentage of student responses for each question. Additionally, the mean and standard deviation of each variable in the TPACK were calculated. Subsequently, data analysis included categorizing student scores for each TPACK variable into low, moderatem and high level. The process of grouping student scores for prospective teachers into three categories involved: 1) Summing up the scores of all students; 2) Calculating the mean and theoretical standard deviation; 3) Establishing the boundary limits of the groups, where the upper group comprised students with scores exceeding the average plus one standard deviation, the medium group included students with scores between the average minus one standard deviation and the average plus one standard deviation, and the low group consisted of students with scores below the average minus one standard deviation. Concisely outlined in Table 2.

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Table 1. Indicators of TPACK Measurement

Component	Indicator
Technological Knowledge (PK)	Understanding various technological elements, including technology usage, technological advancements, and aspects related to the Internet.
Content Knowledge (CK)	Mastering facts, concepts, principles, and procedures of a mathematical topic.
Pedagogical Knowledge (PK)	Understanding learning theories, cognitive development of students, and how to apply them in the classroom to support the 4C skills.
Pedagogical Content Knowledge (PCK)	Being able to connect learning theories with mathematical content that supports the 4C skills.
Technological Content Knowledge (TCK)	Being able to integrate technology with various mathematical content.
Technological Pedagogical Content Knowledge (TPACK)	Able to integrate technology in the planning of learning, implementation of learning, and evaluation of mathematics learning that is appropriate for the learners.
Technological Pedagogical Knowledge (TPK)	Able to effectively integrate technology in the process of planning, implementation, and evaluation of learning to facilitate the learning of mathematics materials that are suitable for the characteristics of the learners.

Table 2. Criteria for grouping TPACK scores

Categorization	Score range
Low	$x < (\mu - 1{,}0\sigma)$
Medium	$(\mu - 1{,}0\sigma) \leq x < (\mu + 1{,}0\sigma)$
High	$(\mu + 1{,}0\sigma) \leq x$

RESULTS AND DISCUSSION

Following the validation procedure, the question items were formulated within a Google Form platform. As delineated in the preceding chapter, the Technological Pedagogical Content Knowledge (TPACK) instrument was disseminated among 16 students in their sixth semester enrolled in the Mathematics Education Study Program at one of University in Banten, Indonesia. The data derived from the submissions via the aforementioned form will be subject to analysis aimed at scrutinizing the profiles of prospective mathematics educators across each constituent dimension of TPACK.

Technological Knowledge (TK)

Technological Knowledge (TK) denotes a comprehensive comprehension of technology's application and deployment. It encompasses various facets, including proficiency in technology usage, awareness of technological advancements, and understanding of internet-related issues. The assessment of these facets involved posing three inquiries to the students. The summative depiction of students' TK proficiency concerning each query is delineated in Table 3.

Table 3. Overview of Technological Knowledge (TK)

Question	Frequency		Percentage (%)	
	0	1	0	1
TK1	7	9	43.75	56.25
TK2	6	10	37.5	62.5
TK3	6	10	37.5	62.5

In Table 3, it is evident that the number of students responding correctly to all questions surpasses those who answered erroneously, signaling a commendable degree of technological acumen among the

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student cohort. The tabulated data in Table 4 demonstrates this trend. Notably, a mere 5 out of 16 respondents exhibit a low level of Technological Knowledge, with the majority displaying a moderate proficiency level, constituting 68.75% of the sample. These observations align with the findings of Njiku, Mutarutinya, & Maniraho (2020), which assert a robust positive correlation between Technological Knowledge (TK) and the Technological Pedagogical Content Knowledge (TPACK) perception among mathematics educators.

Table 4. Profile of Technological Knowledge (TK) mastery

Category	Frequency	Percentage (%)
Low	5	31.25
Moderate	8	50
High	3	18.75

Content Knowledge (CK)

In this section, the assessment focuses on the students' proficiency in mastering mathematical content, encompassing concepts, procedures, and principles within the domain of mathematics. Content knowledge serves as a foundational element in various theoretical frameworks concerning the requisite expertise for effective teaching, posited as a fundamental prerequisite for pedagogical competence (Copur-Gencturk & Tolar, 2022). Given the central role of this proficiency in the instructional process, particularly for prospective mathematics educators tasked with imparting mathematical concepts, the findings reveal that among the three provided questions, only one (Question 1) was answered correctly by 12 students (Table 5). This outcome underscores a moderate level of mastery in mathematical content among the cohort, as depicted in Table 6. Notably, only two individuals demonstrate a high level of proficiency in this regard, while the majority exhibit moderate or low levels. Such findings suggest an overall inadequacy in the students' mastery of mathematical content.

Table 5**.** Overview of Content Knowledge (CK)

Question	Frequency		Percentage (%)	
	0	1	0	1
CK1	4	12	25	75
CK2	8	8	50	50
CK3	7	9	43.75	56.25

Table 6. Profile of Content Knowledge (CK) mastery

Category	Frequency	Percentage (%)
Low	6	37.5
Moderate	8	50
High	2	12.5

Pedagogical Knowledge (PK)

To assess Pedagogical Knowledge (PK), students were presented with four questions targeting pedagogical skills. Broadly, indicators of pedagogical knowledge encompass comprehension of learning-teaching theories, cognitive developmental stages of students, and their practical application within the classroom context. Such proficiency constitutes a foundational skill requisite for all educators. Unlike the preceding technological skills assessment, the evaluation of pedagogical ability reveals a mixed distribution of correct and incorrect responses among students. This disparity in performance is evident in the analysis of pedagogical mastery among prospective mathematics teachers, summarized in Table 7. Moreover, in terms of categorization, a notable minority falls within the low proficiency bracket, while the majority exhibit moderate proficiency levels. Additionally, a substantial contingent of students demonstrates high proficiency, as illustrated in Table 8.

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Table 7. Overview of Pedagogical Knowledge (PK)

Question	Frequency		Percentage (%)	
	0	1	0	1
PK1	7	9	43.75	56.25
PK2	9	7	56.25	43.75
PK3	10	6	62.5	37.5
PK4	6	10	37.5	62.5

Table 8. Profile of Pedagogical Knowledge (PK) Mastery

Category	Frequency	Percentage (%)
Low	3	18.75
Moderate	9	56.25
High	4	25

Pedagogical Content Knowledge (PCK)

This proficiency pertains to the adept integration of learning-teaching theories with mathematical content. To assess this capability, four questions were administered, addressing knowledge of the Curriculum for Mathematics concerning learning trajectories, understanding of Student Understanding within Mathematics with belief structures, familiarity with Instructional Strategies for Mathematics involving constructivist learning principles, and comprehension of Assessment for Mathematics methodologies. The outcomes reveal that 12.5% of students exhibit a high level of proficiency, whereas 50% demonstrate moderate proficiency, with the remaining 37.5% displaying low proficiency (refer to Table 10). Upon examining the distribution of students' responses, it is notable that only one question elicits a greater number of incorrect responses than correct ones (refer to Table 9).

Table 9. Overview of PCK Knowledge

Question	Frequency		Percentage (%)	
	0	1	0	1
PCK1	8	8	50	50
PCK2	11	5	68.75	31.25
PCK3	8	8	50	50
PCK4	8	8	50	50

Table 10. Profile of Pedagogical Content Knowledge (PCK) Mastery

Category	Frequency	Percentage (%)
Low	6	37.5
Moderate	8	50
High	2	12.5

Technological Content Knowledge (TCK)

Technological Content Knowledge (TCK) delineates an understanding of the reciprocal influence and limitations imposed by technology and content domains upon each other. Within the realm of mathematics education, TCK elucidates the application of technology in tandem with mathematical content. As part of their educational journey, prospective mathematics teachers employ Geogebra for learning purposes, particularly in graphics, geometry, and statistics. The assessed indicators encompass the capacity to effectively integrate technology across diverse mathematical domains. Detailed insights into the mastery of TCK among aspiring mathematics educators, alongside the stratification of their proficiency levels, are presented in Table 11.

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Table 11. Overview of Technological Content Knowledge (TCK)

Question	Frequency		Percentage (%)	
	0	1	0	1
TCK1	7	9	43.75	56.25
TCK2	8	8	50	50
TCK3	8	8	50	50
TCK4	7	9	43.75	56.25
TCK5	7	9	43.75	56.25

The data depicted in Table 11 underscores a commendable mastery of Technological Content Knowledge (TCK) among prospective mathematics educators. A predominant portion of students exhibited correct responses, with half of the cohort attaining a high TCK proficiency level. This pattern implies that a substantial proportion of aspiring mathematics teachers possess the adeptness to seamlessly integrate technology with mathematical content (Table 12).

Table 12. Profile of Technological Content Knowledge (TCK) Mastery

Category	Frequency	Percentage (%)
Low	2	12.5
Moderate	6	37.5
High	8	50

Technological Pedagogical Content Knowledge (TPACK)

This capacity is multifaceted, encompassing the integration of technology and instructional strategies tailored to specific mathematical topics. In the pursuit of three-dimensional learning, prospective mathematics educators utilize PowerPoint, leveraging features such as animations and three-dimensional imagery. Six questions were deployed to evaluate this proficiency. The findings detailing the mastery of Technological Pedagogical Content Knowledge (TPACK) are presented in Table 13.

Table 13. Overview of Technological Pedagogical Content Knowledge (TPACK)

Question	Frequency		Percentage (%)	
	0	1	0	1
TPACK1	10	6	62.5	37.5
TPACK2	5	11	31.25	68.75
TPACK3	5	11	31.25	68.75
TPACK4	6	10	37.5	62.5
TPACK5	4	12	25	75
TPACK6	4	12	25	75

Table 14 illustrates that over fifty percent of students are classified within the high proficiency category. Evidently, the mastery of Technological Pedagogical Content Knowledge (TPACK) among prospective mathematics educators appears commendable. The findings suggest a robust comprehension among students regarding their capacity to effectively integrate technology within the mathematics learning paradigm, coupled with suitable pedagogical methodologies or frameworks.

Table 14. Profile of Technological Pedagogical Content Knowledge (TPACK) Mastery

Category	Frequency	Percentage (%)
Low	1	6.25
Moderate	2	12.5
High	13	81.25

Technological Pedagogical Knowledge (TPK)

This expertise encompasses the adept incorporation of technology within the planning, execution, and evaluation phases of mathematics instruction, tailored to the diverse needs of learners. The assessment questions are designed to gauge the application of technology in instructional settings and

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the judicious selection of suitable technological tools for assessment purposes. The research findings reveal a prevalent distribution of students within the high proficiency category, with comparable numbers in other proficiency tiers. This distribution is elucidated in Table 16, where six students are classified as high-level, five as moderate-level, and five as low-level. Moreover, the data presented in Table 15 highlights a notably high percentage of correct responses to one of the four assessment questions (Question TPK1).

Table 15. Overview of Technological Pedagogical Knowledge (TPK)

Question	Frequency		Percentage (%)	
	0	1	0	1
TPK1	5	11	31.25	68.75
TPK2	10	6	62.5	37.5
TPK3	10	6	62.5	37.5
TPK4	8	8	50	50
TPK5	11	5	68.75	31.25

Table 16. Profile of Technological Pedagogical Knowledge (TPK) Mastery

Category	Frequency	Percentage (%)
Low	5	31.25
Moderate	5	31.25
High	6	37.5

In observing the tables delineating the component profiles and integrations within the TPACK framework, no discernible prevalence of low proficiency levels is evident. Instead, four out of the seven components exhibit a moderate level of proficiency (namely TK, CK, PK, and PCK), while the remaining components demonstrate a high level of proficiency (specifically TCK, TPACK, and TPK). This suggests that students have effectively integrated the triad of TPACK domains, thereby indicating a commendable grasp of the intricacies encompassed within the framework.

Building upon the preceding discourse, an exhaustive evaluation of the Technological Pedagogical Content Knowledge (TPACK) proficiencies among prospective mathematics educators has been expounded. Across the spectrum of TPACK components, it is evident that students primarily demonstrate mastery levels spanning from moderate to high, with scant representation in the low proficiency bracket. To augment these findings, descriptive statistical analyses pertaining to each facet of TPACK are further elucidated in Table 17.

Table 17. Summary of Descriptive Statistical Results for TPACK Knowledge

Component	Mean	Standard Deviation	Minimum	Maximum
TK	1.8125	0.834166	0	3
CK	1.8125	0.834166	0	3
PK	2	0.632456	0	4
PCK	1.8125	0.834166	0	4
TCK	2.6875	1.138347	0	5
TPACK	3.875	1.258306	0	6
TPK	2.25	1.290994	0	5

Table 17 illustrates that, spanning diverse dimensions such as Technological Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Content Knowledge (TCK), Technological Pedagogical Content Knowledge (TPACK), and Technological Pedagogical Knowledge (PCK), the mean scores achieved by students hover around half of the maximum attainable score. Remarkably, in the case of PCK, the average value slightly deviates below the pinnacle score.

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Among the seven constituent components comprising TPACK, two components surpass the ideal average score, specifically Technological Content Knowledge (TCK) and Technological Pedagogical Content Knowledge (TPACK). This dataset suggests a commendable proficiency in TCK among prospective mathematics educators relative to the remaining five components constituting TPACK. Analogous to the elucidation of other proficiencies, the commendable performance in TPACK proficiency can be attributed to the influential factor of TCK. This underscores the reciprocal relationship between technological mastery and subject matter comprehension, wherein technology facilitates the creation of novel representations for distinct content domains. This underscores the prospective educators' cognizance that the judicious utilization of certain technologies can engender transformative pedagogical practices, thereby augmenting students' comprehension and engagement with specific content domains (Santos & Castro, 2021). Nonetheless, in order to become proficient users of technology, it is imperative for educators to possess a comprehensive understanding of pedagogical principles and methodologies intricately linked with the constructive integration of technology in content delivery. This entails familiarity with the pedagogical underpinnings that render instructional concepts more comprehensible and the ways in which technology can enhance the learning process. Naturally, the efficacy of learning outcomes is contingent upon the instructor's adeptness in mastering subject matter, orchestrating learning activities, and seamlessly integrating technology into the educational environment to bolster the learning experience (Alhamid & Mohammad-Salehi, 2024).

Their proclivity towards the domains of Technological Content Knowledge (TCK) and Technological Pedagogical Content Knowledge (TPACK) may stem from inherent internal factors among educators, including their preferred learning styles and attitudes towards diverse sources of knowledge, as posited by Alhamid & Mohammad-Salehi (2024). This inclination towards technology adoption may engender a teaching style characterized by heavy reliance on technological mediums for content delivery, potentially shifting the role of the instructor away from a central position, as discussed by Safari et al. (2014). However, empirical evidence is requisite to substantiate this conjecture regarding the relationship between TPACK proficiency and teaching methodologist.

The research findings substantiate the assertion that the Technological Pedagogical Content Knowledge (TPACK) proficiency exhibited by prospective mathematics educators is commendable. It is incumbent upon educators to persistently forge meaningful connections among diverse reservoirs of TPACK knowledge to optimize instructional delivery. This necessitates a holistic integration of technology, pedagogical expertise, and content knowledge, thereby fostering a comprehensive approach to teaching and learning (Swallow & Olofson, 2017) thereby realizing an increase in the quality of education (Nuangchalerm, 2020). In the end, technological developments can be used effectively and not excessively as a way for students to achieve success.

CONCLUSION

TPACK represents a crucial competency essential for prospective educators, poised to meet the exigencies of 21st-century education. Within the Mathematics Education program at one of University in Banten, the TPACK profile of aspiring mathematics teachers predominantly resides within the moderate proficiency tier. Delving deeper into the specifics, the Technological Content Knowledge (TCK) and Technological Pedagogical and Content Knowledge (TPACK) profiles manifest a majority of students operating at a high level, constituting 50% and 81.25% respectively. Conversely, the Pedagogical Knowledge (PK) and Technological Pedagogical Knowledge (TPK) profiles depict a majority of students situated within the moderate proficiency range, comprising 56.25% and 31.25% respectively. Notably, Technological Knowledge (TK) stands at 31.25%, Content Knowledge (CK) at 37.5%, and Pedagogical Content Knowledge (PCK) at 37.5%, indicating a prevalence of low-level proficiency among students in these domains. Moreover, the instructional approach adopted by prospective mathematics educators tends to align with technological and personalized teaching styles, wherein technology is integrated into the instructional process, tailored to the readiness levels of individual students.

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