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Analysis of TPACK Integration in the Preparation of Teaching Modules for Prospective Mathematics Education Teachers at the Islamic University of Riau

Tria Wulandari*, Sri Rezeki

Mathematics education, Islamic University of Riau, Jl. Kaharuddin Nst No.133, Pekanbaru, 28284

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* Corresponding author:

E-mail: triawulandari@student.uir.ac.id

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ABSTRACT

This study aims to describe the ability to integrate TPACK (Technological Pedagogical And Content Knowledge) in the preparation of teaching modules for prospective mathematics education teachers. This type of research is quantitative descriptive. The data collection technique used is observation in the form of documentation studies of 41 teaching modules made by prospective mathematics education teachers at UIR in the microteaching course and using interview techniques to find out more about students' knowledge. The data used in the study is the ability to integrate technology in the TPACK of prospective teachers which includes TK (Technological Knowledge), PK (Pedagogical Knowledge), CK (Content Knowledge), TPK (Technological Pedagogical Knowledge), TCK (Technological Content Knowledge), PCK (Pedagogical Content Knowledge), and TPACK (Technological Pedagogical Content knowledge). This study uses quantitative data analysis techniques, namely descriptive statistical data analysis. The results of this study indicate that, TK prospective teachers (29.8%) are in the poor category, PK prospective teachers (59%) are in the sufficient category, CK prospective teachers (53.6%) are in the sufficient category, TPK prospective teachers (7.3%) are classified as not good, TCK prospective teachers (4.8%) are in the poor category, PCK prospective teachers (63.4%) are in the good category, and TPACK prospective teachers (19.9%) are classified as not good.

1. Introduction

Technology is a tool that can facilitate the implementation of human daily activities, both in work and in education (Maritsa et al., 2021). Technology is the result of scientific progress that is developing in the field of education. Therefore, it is very important for the world of education to utilize technology in the learning process (Maritsa et al., 2021). Learning does not always have to be done in the

classroom. Teachers can utilize internet technology and technological applications to assist in the learning process.

Teachers have a very important role in the learning process. It is hoped that in teaching and learning activities, teachers are able to create a conducive atmosphere so that students can easily understand the material. Therefore, it is important for teachers to have adequate competence so that learning can take place effectively. Teachers must have basic scientific abilities and special skills, which include standards of pedagogical ability, individual ability, educational ability, and social ability (Aspi M. & Syahrani., 2022). In line with Law Number 14 of 2005 concerning Teachers and Lecturers, Article 10 states that the competencies that teachers must have include pedagogical competence, professional competence, personality competence, and social competence.

Pedagogical ability is one of the competencies that plays an important role in determining the success of a learning process. According to Amalia (2019) Pedagogical competence is the teacher's ability to manage the learning process with students, including activities that provide knowledge and understanding, design and implement learning according to teaching modules, evaluate learning outcomes, and develop the potential of students.

This TPACK ability is very important for all prospective teachers, especially for prospective mathematics teachers. According to Hanik et al., (2022) TPACK is a framework used to design a modern learning model by combining three main components, namely technological, pedagogical, and knowledge components. According to Amrina et al., (2022) TPACK consists of six knowledge components, such as TK, CK, PK, PCK, TPK and TCK. TPACK can be interpreted as the interaction or relationship between technological knowledge (such as audio, visual, internet, and others), pedagogical knowledge (which includes processes, practices, strategies, techniques, models, and so on), and knowledge of the material being taught (Islamiati & Nabar, 2023).

This concept is used to support teachers in developing and improving student learning processes. According to (Yulis & Fauziah, 2024) some teachers only use printed books, teacher guidebooks from the ministry, additional materials in the form of power points (PPT) and modules as teaching materials but have not been integrated with technology which causes students to have difficulty understanding and easily forgetting learning. Therefore, prospective mathematics teachers need to be equipped with TPACK skills to integrate technology in learning, so that they can create effective and interesting learning experiences.

TPACK ability can be measured through learning devices prepared by prospective teachers and learning implementation plans because they contain pedagogical components, namely the methods applied, content components that include the material taught, and technology that refers to the media used (Indrawan & Dwijayanti, 2024). Therefore, learning devices should include the components that make up TPACK, because these devices reflect the teaching methods applied. However, based on the results of the documentation study conducted by researchers

on Wednesday, August 1, 2024, researchers saw that devices made by prospective mathematics teachers rarely utilize information and communication technology in the learning process. This can be seen from the teaching modules they made which do not contain elements of information and communication technology in the media used. And there are still many prospective mathematics teachers who have not developed their abilities in designing learning devices that combine technology, pedagogy, and content. From these results, it can be seen that their TPACK abilities still need to be improved. Strengthened by the facts in the study (Yuni Rahayu et al., 2025) that the importance of TPACK-based teaching modules in creating inclusive and equitable learning. Therefore, prospective mathematics teachers need to be prepared to master this competency before graduating with a bachelor's degree in education, so that they can become professional teachers who are able to manage the learning process, master the subject matter, and utilize technology properly.

2. Methodology

The type of research used is descriptive with a quantitative approach. According to Aziza (2023) quantitative descriptive is a type of research that aims to describe or describe the characteristics of a phenomenon, population, or certain conditions using numerical data collection methods that can be measured and analyzed statistically. The subjects in this study were prospective mathematics education teachers at the Islamic University of Riau, class of 2021 who had created a teaching module for the Microteaching course, where 41 learning devices made by prospective mathematics teachers would be taken. The data collection technique that will be used in this study is using a documentation study. The instruments used in this study are identification sheets designed to analyze the independent curriculum teaching module and interviews. The assessment indicators for the teaching module are in accordance with the various components that form the integration of technology within the TPACK framework, which includes seven important elements, namely: TK, PK, CK, TPK, TCK, PCK and TPACK.

3. Results and Discussion

Based on the results of the research that has been conducted using the identification sheet, the percentage of prospective teachers' abilities in integrating technology into TPACK on Microteaching learning devices was obtained, namely:

A. Technology Knowledge

Based on Table 1, it can be seen that the PK (59%) and CK (53.6%) abilities of prospective teachers in the teaching module are included in the sufficient category, the TK (29.8) abilities of prospective teachers in the teaching module are included in the less good category, the TPK (7.3%), TCK (4.8%), and TPACK (19.9%) abilities of prospective teachers in the teaching module are included in the poor category. Meanwhile, the highest result, namely the PCK ability of prospective teachers (63.4%) is classified as good.

Table 1. Presentation of TPACK Integration Results in the Preparation of Teaching Modules for Prospective Mathematics Education Teachers at the Islamic University of Riau

No	Knowledge	%	Information
1.	Technology Knowledge	29,8	Not Good
2.	Pedagogical Knowledge	59	Sufficient
3.	Content Knowledge	53,6	Sufficient
4.	Technological Pedagogical Knowledge	7,3	Poor
5.	Technological Content Knowledge	4,8	Poor
6.	Pedagogical Content Knowledge	63,4	Good
7.	Technological Pedagogical and Content Knowledge	19,9	Not Good

Modified description of score interpretation criteria Puspita & Setyaningtyas (2022:918):

100% – 81% = Excellent

80% – 61% = Good

60% – 41% = Sufficient

40% – 21% = Poor

20% – 0% = Not Good

Based on the research results, TK ability in prospective mathematics education teachers by 29.8% is classified as less good. TK itself is the technological knowledge possessed by prospective teachers to help them in the learning process. The level of TK ability of prospective mathematics teachers can be seen from the teaching modules they compile, especially through the selection of learning media used when teaching. In the microteaching learning design of prospective teachers, there are 26 teaching modules that include information or guidelines for using software and technology in learning and there are teaching modules that integrate or recommend the use of web-based digital learning platforms, as many as 11 teaching modules explicitly integrate or recommend the use of web-based digital learning platforms.

It can be concluded that this study confirms that the integration of software, hardware, and digital learning platforms in the microteaching module has been running, although there is still room for improvement. Strengthening digital literacy and technology use skills for prospective teachers is the key to creating effective and relevant learning in today's digital era.

According to the results of the interview conducted with NS, a prospective mathematics teacher student in 2021, who stated that:

For conditions like today where the era of technology is developing very rapidly, technology is very important to use in learning because it can increase the effectiveness and efficiency of learning with technology, learning materials can be delivered in a more interesting and interactive way, so that students can more easily understand the concepts taught.

Based on this statement, it can be concluded that prospective teachers are aware of the importance of the role of technology in the learning process. Failure to keep up with technological developments risks being left behind, especially in the 21st century which demands optimal use of technology in education. The use of technology has been proven to increase the effectiveness and efficiency of teaching and learning activities. Prospective mathematics teachers are also familiar with various applications that can support learning, such as PowerPoint, Canva, and learning videos from YouTube and other platforms.

In addition, when facing obstacles, both in terms of technical and internet networks, prospective mathematics teachers have prepared alternative solutions so that the learning process continues. This is in line with the opinion of (Ummah, 2024) who stated that teachers are one of the main pillars of implementing the independent curriculum in education. Syahrijar et al., (2023) also emphasized that the availability of adequate facilities and infrastructure, such as laptops, computers, smartphones, and other hardware, is very important in supporting learning. Therefore, educational institutions and lecturers need to continue to encourage prospective teachers to be able to design innovative, adaptive, and digital technology-based teaching modules.

B. Pedagogical Knowledge

Based on the research results, it was found that the PK ability of prospective mathematics education teachers was 59.5% included in the sufficient category. PK is the teacher's knowledge of the process and practice or teaching and learning methods. The assessment of the PK ability of prospective mathematics teachers was carried out through an analysis of the teaching modules created by prospective teachers in the microteaching course.

A total of 17 teaching modules show the use of learning approaches or strategies that adapt the material to the characteristics of students. A total of 35 teaching modules present a systematic learning design, consisting of a complete series of learning from the introduction, core, to the conclusion. A total of 20 teaching modules support active and dialogic interactions between teachers and students. A total of 22 teaching modules include assessment instruments or methods used to measure student learning outcomes. A total of 27 teaching modules present relevant and innovative learning strategies. The use of these strategies shows the efforts of prospective teachers to improve the effectiveness of mathematics learning with an approach that is appropriate to the needs and characteristics of students.

In line with the results of the interview with EAP, prospective mathematics teacher students stated that:

I chose Discovery Learning because this method integrates direct experience and active interaction, such as discussions and experiments, which can increase students' motivation and understanding. With digital technology, the discovery process becomes more interesting and relevant in today's era.

AZ, one of the interview respondents also stated:

I chose the PBL strategy because group-based learning makes students more actively involved and responsible for their learning process. In today's era, where

information is very easy to access, the ability to apply and process information through collaboration is very important.

These results indicate that although the PK ability of prospective mathematics teachers is still in the sufficient category, there are indications that they have begun to integrate pedagogical aspects in the preparation of teaching modules, especially in terms of adjusting the material to student characteristics, preparing a systematic learning flow, and using methods that encourage active interaction and assessment of learning outcomes. However, improvements are still needed so that this PK ability can reach the good or very good category, especially in the development of more innovative learning strategies and more comprehensive evaluations. in line with the concept of Pedagogical Knowledge put forward by Shulman (in Marisa et al., 2025) which emphasizes the importance of mastering effective learning methods and practices by teachers. According to a study conducted by Janah (2022), good PK ability will make it easier for prospective teachers to design meaningful and interactive learning.

C. Content Knowledge

Content Knowledge is knowledge about content. The CK knowledge of prospective teachers can be seen through the teaching module, namely the material to be taught from all the abilities measured, the CK ability of prospective mathematics education teachers obtained a percentage of 53.6% which is included in the sufficient category.

There are 25 teaching modules showing strong mastery of concepts and in accordance with applicable curriculum standards. There are 14 teaching modules providing alternative delivery of materials that aim to make it easier for students to understand the subject matter. There are 27 teaching modules adopting a variety of learning approaches to help students understand the relationship between various concepts in the field of study being studied.

Based on the results of the interview with AZ, a prospective mathematics teacher student stated that:

To prepare the material, I usually think about the material to be discussed, then I look for a video or make a video, then after showing the video I make a quiz or Q&A, to test the material about the video that was just shown. After that I stimulate their reasoning, then later they can find a conclusion And usually I also prepare a PPT too.

TAM, one of the interview respondents also stated that:

The source of learning materials is usually from school books, if from books less I take it from the internet, YouTube, and other references.

In this case, it shows that the teaching modules developed by prospective teachers have met important criteria in effective learning, namely good mastery of concepts, use of varied learning media, and application of learning approaches that support comprehensive understanding of concepts. In line with research by Nengsih et al., (2024) which states that quality teaching modules can help teachers achieve learning goals effectively. This provides a positive picture of the readiness of

prospective teachers in compiling quality teaching materials and being able to support an active and meaningful learning process. Overall, these results indicate that training and coaching for prospective teachers in compiling teaching modules has been going well, but still needs to be improved, especially in the development of learning media and variations in methods in order to reach the increasingly diverse learning needs of students.

D. Technological Pedagogical Knowledge

The results of the study showed that the Technological Pedagogical Knowledge ability of prospective mathematics education teachers is still relatively low, with only 7.3% being categorized as poor. This is reflected in the teaching modules they create, where the selection and use of appropriate technology to support learning strategies is still very limited.

Although in general TPK ability is low, there are several teaching modules that have integrated technology into learning in an innovative and interactive way, there are 4 teaching modules. In addition, 3 teaching modules have the potential to improve understanding of mathematical concepts in more depth through collaboration and exploration of technology. And as many as 5 teaching modules provide technology-based learning experiences that are relevant to real-world contexts.

Based on the results of the interview with NS, prospective mathematics teacher students stated that:

The use of technology does play an important role in increasing learning efficiency because it can save time and energy, especially in terms of administration and distribution of materials. However, its effectiveness is highly dependent on the readiness of teachers and students in operating the technology and the availability of adequate infrastructure

Based on the statement above, the low TPK ability indicates the need to improve the competence of prospective teachers in choosing and utilizing technology effectively in mathematics learning. Good mastery of technology is very important so that prospective teachers can develop innovative, interactive, and relevant learning strategies to the needs of today's students. More intensive training and mentoring related to the use of technology in technology-based learning and assessment need to be a focus in teacher education programs.

This finding is in line with the research results of Herizal et al., (2022) which shows that the mastery of technology and its integration into pedagogy by prospective mathematics teachers still needs to be improved, besides that in the lecture process it also needs to be emphasized. Although prospective teachers have a positive attitude towards technology, practical abilities in integrating technology into learning, especially in the assessment aspect, are still lacking, therefore according to research conducted by Aisyah et al., (2024) states that the importance of a balance between theory and practice in teacher education to improve teaching readiness. Therefore, the development of TPK abilities must be an integral part of the teacher education curriculum so that graduates are ready to face the demands of 21st

century learning and Society 5.0. Overall, the results of this study emphasize the importance of strengthening Technological Pedagogical Knowledge as part of the TPACK competency of prospective mathematics teachers to support an effective, innovative, and relevant learning process with current technological developments.

E. Technological Content Knowledge

Technological Content Knowledge is knowledge about the use of technology to deliver learning materials. The use of technology as a learning medium can make it easier for students to understand abstract material concepts, especially mathematics learning materials (Novilanti & Suripah, 2021:358). The results of the study showed that only 4.8% of prospective mathematics teachers had TCK abilities in the poor category. Judging from the teaching modules in the microteaching course for prospective mathematics teachers, it was found that there were 4 teaching modules that provided digital resources that enriched the understanding of teaching materials. Furthermore, there are 2 teaching modules that have included examples or technology-based simulations that clarify the relationship between theory and practice.

As with the statement from the interview results by TAM, stating that:

I utilize various applications and mathematics learning software to make the material more interactive, such as GeoGebra for visualizing geometric concepts. In addition, I always relate the material to real examples in everyday life, for example calculating a shopping budget or measuring land area, so that students can more easily understand and feel the benefits of mathematics.

EAP, one of the respondents also stated that:

In my opinion, the application that can be used for teaching is a learning video platform such as YouTube

The minimal use of advanced visualization technology (such as animation and AR) in teaching modules indicates the limited knowledge or skills of prospective teachers in selecting and applying technology that is appropriate to the needs of complex mathematical material. In fact, technology like this has been proven effective in helping students build a deeper conceptual understanding in line with the statement of Hadi et al., (2024) that Augmented Reality media can be an effective learning approach to improve learning outcomes. It can be concluded that the low TCK ability of prospective mathematics teachers indicates the need for intervention in the teacher education curriculum, especially in the integration of mathematics learning technology. Strengthening TCK will encourage prospective teachers to be more creative and innovative in delivering material, so that it can improve the quality of mathematics learning in the future.

F. Pedagogical Content Knowledge

PKK is knowledge about how to teach material in a certain way (Sutamrin et al., 2022). Before carrying out actual learning, prospective teachers must have pedagogical competence and mastery of the material (Solihin et al., 2021). It takes a process to produce prospective teachers who are skilled in teaching (Suripah et al., 2018).

Based on the results of the study, the Pedagogical Content Knowledge ability of prospective mathematics teachers is in the good category with a percentage of 63.4%. This shows that the majority of prospective teachers have adequate abilities in integrating content knowledge and pedagogy to design and implement mathematics learning effectively. Data from the teaching modules in the microteaching course show that prospective mathematics teachers are able to design quality teaching modules, which reflect a strong relationship between learning content and the pedagogical strategies used. A total of 26 teaching modules show a match between material and learning strategies, which is important so that the methods used can facilitate student understanding optimally. In addition, 27 teaching modules contain effective learning strategies that can improve student understanding. There are 32 teaching modules that include evaluation methods relevant to the material and learning objectives. Supporting learning resources such as Student Worksheets (LKPD) are also available in 27 teaching modules. A total of 18 teaching modules have clear learning objectives and are in accordance with curriculum standards, especially the Merdeka curriculum.

These results confirm that prospective mathematics teachers are on the right track in developing PCK, but there is still room for improvement, especially in expanding the number of teaching modules that have very clear learning objectives and are consistent with the curriculum. Strengthening microteaching training and developing more innovative and contextual teaching modules can be a focus for improving the quality of prospective teachers' PCK. In addition, developing more varied evaluation strategies and using more interactive learning resources can enrich students' learning experiences and support the achievement of more optimal learning outcomes (Tria Rahayu et al., 2023).

In accordance with the results of the interview conducted with AZ, he stated that: I always study the material in depth before teaching, starting from reading textbooks, additional references. In addition, I also try to work on sample questions or simulations to really understand the concepts that will be conveyed to students.

Overall, the PCK abilities of prospective mathematics teachers as depicted in the teaching module show good readiness in designing and implementing mathematics learning. Integration between material mastery, pedagogical strategies, evaluation, and curriculum suitability are the main indicators of the success of prospective teachers in developing content pedagogical competencies (Anggie Iim Setyoningsih & Hariyatmi, 2024). Strengthening these aspects will contribute to improving the quality of mathematics learning in the future.

G. Technological Pedagogical and Content Knowledge

TPACK is knowledge about how to use technology in learning activities so that it can help teachers in delivering learning materials (Yurinda & Widyasari, 2022). The results of the study showed that the TPACK ability of prospective mathematics education teachers was classified as low in the poor category, which was 19.9%. This indicates that most prospective teachers still have difficulty in integrating

technological, pedagogical, and content knowledge effectively in the mathematics learning process.

The data shows that out of 27 teaching modules, the use of technological tools is demonstrated. 9 teaching modules provide technology-based learning activities that support effective mastery of the material. Only 2 teaching modules provide instructions on the use of technology in implementing learning strategies. A total of 11 teaching modules help students develop critical thinking skills through the use of technology.

Based on the results of the interview with NS, it states that:

I have not tried to use technology actively in teaching mathematics. If there is technology, it is usually only used for presentations, without linking it to the learning strategies that I use.

In line with AZ statement in the interview:

I usually only make PPT slides by writing material from books without many variations or interesting visual additions. I rarely think about how to make the content relevant or interesting to students, so presentations often feel monotonous and less interactive

The low TPACK ability is an important signal that the development of prospective teacher competencies in integrating technology, pedagogy, and content must be further strengthened. Mathematics education study programs need to design more intensive and structured curricula and training to improve prospective teacher skills in using technology effectively in learning. Training that focuses more on the use of interactive and integrative digital applications, as well as the development of teaching modules that combine technology with appropriate pedagogical strategies, is very much needed. In line with research conducted by Fahira & Putra (2024) states that the potential for increasing TPACK competencies is very large and can be achieved through practical experience, additional training, and deeper learning. In addition, the use of subsequent courses and strategic curriculum adjustments can be optimized to strengthen each TPACK component effectively.

Overall, the results of this study confirm that the mastery of TPACK of prospective mathematics education teachers still needs to be improved, especially in the aspect of integrating technology with pedagogy and material content. Improving this ability is very important to prepare prospective teachers who are able to face the challenges of 21st century learning by optimally utilizing technology to improve the quality of mathematics learning. Efforts to strengthen TPACK will support the creation of more effective, interactive, and relevant learning to the needs of today's students (Nurkhairo Hidayati et al., 2025)

4. Conclusion

Based on the results and discussion of the study, it can be concluded that the TPACK ability of prospective mathematics teachers in compiling teaching modules still needs to be improved in several main aspects. The PCK ability of prospective

teachers stands out with a good category, indicating that the majority of prospective teachers are able to integrate content and pedagogical knowledge in designing effective mathematics learning. However, the PK and CK abilities are still in the sufficient category, indicating the need for further strengthening in mastering learning methods and teaching materials. Meanwhile, the TK, TPK, TCK, and TPACK abilities as a whole are still classified as poor to not good. This is reflected in the limited integration of technology in teaching modules, both in media selection, learning strategies, and material delivery. Although prospective teachers have realized the importance of the role of technology in learning and have become familiar with various supporting applications, practical mastery and integration of technology into the learning process still need to be significantly improved.

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