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Analysis of Integration Technological Pedagogical Content Knowledge (TPCK) of Preservice Mathematics Teacher in Planning the Learning Process

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ABSTRACT

Background: Professional teachers are required to master pedagogical and technological content knowledge well. However, in reality there are still many teachers who have not been able to integrate technology into PCK as a form of learning innovation. Therefore, preparation is needed for preservice teachers so that they have more abilities in facing the world of work. P**urpose:** This study aims to analyze the ability of prospective mathematics teachers to integrate technology into pedagogical content knowledge in planning the process of learning mathematics. **Method:** This study used descriptive qualitative method. As for the subject of this research are 23 students of Mathematics teacher candidates for Semester V, Islamic University of Riau. The TPCK analysis is carried out on learning device documents designed by preservice teachers in integrating technology. Analysis was carried out on three aspects, including: technological knowledge (TK), technological Content Knowledge (TCK) and Technological Tedagogical Knowledge (TPK). The procedures in data analysis include data collection, data reduction, data presentation, and data verification. **Findings:** The results showed that: the ability of preservice teachers in technology (TK) in designing learning process documents was in the very good category, the ability of preservice teachers in how preservice teachers' understanding of technology and content (TCK) influenced each other was in good criteria. Likewise in the TPK aspect, preservice teachers are in good criteria. **Conclusion:** Preservice teachers are already able to integrate technology into pedagogical content knowledge when making plans for implementing mathematics learning in the good category.

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1. INTRODUCTION

Mathematics learning that takes place in schools reflects the professional quality of teachers. In addition, professional teachers know all the potential that supports learning to run effectivelyn (Chen & Jang, 2018). An active and effective learning process requires teacher professionalism to master material, pedagogy, and technology (Xiang, 2014); (Rafi & Sabrina, 2019).

The development of technology in today's modern era can no longer be avoided its influence on the world of education. The world of education is required to adapt technological developments in improving the quality of education, especially in the learning process. Teachers have an important role in the learning process. There are 4 competency standards that must be possessed by teachers in Indonesia, namely pedagogical competence, social competence, personal competence, and professional competence (Suripah, Suyata, & Retnawati, 2018).

Pedagogic competence is one of the competencies that determines the success of a lesson. Pedagogic competence is the teacher's ability to manage learning, starting from designing learning activities, carrying out learning, to evaluating learning (Kurniawan & Astuti, 2017). Furthermore, the competence that must be possessed by teachers is professional competence. Professional competence is the ability to master the subject matter (Suripah et al., 2018). Along with the rapid development of technology, teachers are required to be able to improve their professional competence. Teachers besides having the ability to teach in class are also able to integrate the use of technology in learning. the use of technology in the learning process can help improve the quality of learning, and can increase student motivation and learning outcomes. Basic knowledge requirements that must be possessed by prospective mathematics teachers to integrate technology, namely by having technological knowledge, knowledge about pedagogy, and knowledge about content (Subali & Handoyo, 2021).

For this reason, from the start, Shulman has realized the importance of technology in learning, but according to (Xiang, 2014) the technology at that time was not as sophisticated as it is now. Therefore, a new conceptual framework was developed, namely technological pedagogical content knowledge (TPCK). The researchers used the TPCK framework to explore the use of ICT in learning mathematics (Matthew J . Koehler , Punya Mishra, 2013); (Jang & Tsai, 2013); (Liang & Luo, 2016). Other studies have also examined aspects of teacher age, teaching experience (Chuang & Ho, 2015)and gender, where these three factors affect the TPCK component. Based on research results (Karatas, Tunc, Yilmaz, & Karaci, 2017); (Lai & Lin, 2018), that Technology Knowledge (TK), Pedagogical Knowledge (PK), and Technological Pedagogical Knowledge (TPK) as well as Technological Content Knowledge (TCK) have a positive effect on teachers.

TPCK is the knowledge needed to integrate technology in the learning process (Rahayu, 2020). According to (Mishra & Koehler, 2006),TPCK is a form of knowledge that is interconnected between content, pedagogy, and technology. TPCK is divided into 8 components, namely: (1) Technology Knowledge (TK), knowledge about the use of technology, (2) Pedagogical Knowledge (PK), knowledge about pedagogy or learning strategies, (3) Content Knowledge (CK), knowledge about content or subject matter, (4) Pedagogical Content Knowledge (PCK), knowledge of strategies or how to teach subject matter, (5) Technological Pedagogical Knowledge (TPK), teacher knowledge of how to teach using technology, (6) Technological Content Knowledge (TCK)), knowledge of conveying material through technology, (7) Technological Pedagogical and Content Knowledge (TPCK), knowledge of how to teach subject matter using technology.

TPCK is very important for prospective mathematics teachers, because prospective mathematics teachers are required to be able to integrate technology into the learning process in accordance with the subject matter and learning strategies used according to the character of the students ((Sintawati & Indriani, 2019). Integrating TPCK in learning mathematics can make it easier for students to understand

the mathematical concepts being taught by the teacher, especially mathematical concepts that are abstract, difficult and need visualization to understand these concepts (Rafi & Sabrina, 2019).

The ability of prospective teacher TPCK can be seen from the learning tools they made themselves (Supriyadi, Bahri, & Waremra, 2018). The ability of prospective teacher TPCK can be seen from the design of the implementation of learning because it contains a pedagogic component, namely the method used, content component, namely the material being taught and technology, namely the media used (Innaha, 2018). Therefore, learning tools should be able to contain the components of the TPCK, because the learning tools that are prepared by prospective teachers are a reflection of the way they teach.

However, there are still many teachers who have not integrated technology in learning. Some teachers and candidates still experience problems in using technology in learning. In fact, the interaction of knowledge of the three is the basis of a good learning process (Chen & Jang, 2014). Therefore, teacher knowledge in integrating technology in learning is considered very important to prepare professional mathematics teachers. The problem in this study is how the integration analysis of TPCK prospective mathematics teachers in designing learning? Therefore, this study aims to describe how the integration into the TPCK of prospective mathematics teachers in designing learning.

2. METHODS

This research is a qualitative descriptive research. The subjects of this study were 39 prospective mathematics teacher students at FKIP UIR who had attended Microteaching courses. The data collection technique was carried out by means of documentation studies from Microteaching learning tools in the form of syllabi and lesson plans, while the research instrument was in the form of identification sheets. The components to be identified include TK, TCK, and TPK aspects. The data analysis techniques of this research are data collection, data reduction, data presentation, conclusion drawing, and data analysis results presentation. In this study, questionnaires will be distributed to all Semester V students at Riau Islamic University who are taking micro teaching courses. The TPCK questionnaire consists of components: (1) designing learning process documents, (2) development of reflection, (3) implementing the curriculum in the learning process, (4) integrating technology in the mathematics learning process, (5) as well as the constraints in integrating technology in mathematics learning in schools. Document studies are used to analyze the lesson plans for prospective teachers that are made. While the qualitative method in this study used a descriptive approach.

Data analysis was carried out in a qualitative descriptive manner, namely describing prospective teachers in integrating the TPCK in designing learnersand math. The data analysis includes data collection, data reduction, data presentation, and data verification. The research procedure consisted of (1) Preparation, including: observation, problem identification, determination of data sources, preparation of observation sheet instruments, presentation of teaching materials, learning strategies, and assessment documents, reflections, and lesson plans, questionnaires, interview guidelines. The final stage is the validation of the instruments given to the experts, (2) Implementation stage, distribution of TPCK questionnaires, study of learning documents, learning process documents, study of reflection documents, (3) Processing of descriptive data from observation sheets, documentation, questionnaire sheets, and interviews , the next stage in this research is to analyze the observation sheets, documentation, questionnaire sheets, and interviews. The assessment criteria for the TPCK questionnaire list are presented in Table 1.

Value Range	Criteria
81%-100%	Very good
61%-80%	Well
41%-60%	Enough
21%-40%	Not good
0%-20%	Not good

3. FINDINGS AND DISCUSSION

The aspects that are expected to appear in this study refer to the instruments that have been developed including: 6 items of technological knowledge (TK), 6 items of technological content knowledge (TCK), and 8 items of technological pedagogical knowledge (TPK). from the Microteaching learning device for prospective mathematics education teachers in the form of lesson plans documents. The assessment list is used to obtain an overview of the ability to integrate technology in the TPCK of prospective mathematics education teachers in the lesson plan. From the results of the assessment analysis on prospective teacher Microteaching learning tools, a profile of prospective teacher assessments in integrating technology is obtained. The profile for evaluating the TPCK components in the leson plan is presented in Table 2.

Based on Table 2, it is obtained that the average for the Kindergarten aspects of prospective teachers is in the very good category, that is, out of 23 people, only one prospective teacher is in the sufficient criteria, the rest are in good criteria (5 people), and very good (17 people). The TCK aspect of prospective teachers in learning tools is in good criteria, two prospective teachers are in sufficient criteria, 6 are in good criteria, and 15 are in very good criteria. The TPK aspect of prospective mathematics teachers in Microteaching learning tools is in good criteria, namely all prospective teachers are in good criteria (19 people) and very good (4 people) prospective teachers.

Table 2. Profile of Technology Integration in Pedagogical Content Knowledge (TPCK)

Subject	Rated aspect (%)				Criteria
	kindergarten	TCK	TPK	Average	
1	67	50	63	59.72	
2	67	67	75	69.44	Well
3	83	83	75	80.56	Well
4	100	83	63	81.94	Very good
5	83	83	75	80.56	Well
6	100	83	75	86.11	Very good
7	83	100	63	81.94	Very good
8	100	83	75	86.11	Very good
9	100	83	75	86.11	Very good
10	67	100	75	80.56	Well
11	83	83	63	76.39	Well
12	100	83	100	94.44	Very good
13	50	33	75	52.78	Enough
14	100	100	100	100.00	Very good
15	100	83	75	86.11	Very good
16	83	67	63	70.83	Well
17	100	83	88	90.28	Very good
18	100	100	100	100.00	Very good
19	83	67	75	75.00	Well
20	67	67	75	69.44	Well
21	100	100	75	91.67	Very good
22	100	67	63	76.39	Well
23	67	67	75	69.44	Well
Total Average	86,23	78.99	75,54	80.25	
Criteria	Very good	Well	Well	Well	

From Table 2, the average percentage of TK, TCK, and TPK abilities of prospective mathematics education teachers is obtained. Kindergarten teacher candidates (86.23%) are classified as very good.

Based on a study of learning device documents in the form of syllabus and lesson plans, it was found that prospective teachers had already integrated ICT technology in learning. This can be seen from the microteaching learning plans made by prospective teachers, where out of 20 prospective teachers have been able to use ICT in selecting learning media. there is hardware (hardware) such as laptops, computers, infocus, and cellphones to support the learning process taking place. While the software (software) there is the use of power point software to help convey the subject matter. Putria, Maula, & Uswatun, (2020) online learning is a learning process that is carried out without face-to-face but at home using the internet and other supporting tools. It is this situation that causes prospective math teachers to use conference software technology, such as Zoom, Google Meet, Google Classroom, and WA Group as communication media. This is in accordance with the opinion Suhery, Putra, & Jasmalinda, (2020) that teachers use the Zoom, Google Meet, and Google Classroom applications in carrying out online teaching and learning processes as an example of one of the views of the planned class settings in the lesson plan by one of the 06 prospective teacher subjects through a zoom meeting.

Figure 1. Design of Prospective Teachers in Using ICT Using Zoom

In addition, prospective teachers have also been able to guide students to practice searching for information with the Google search engine. This can be seen in one of the prospective teacher subject lesson plans 18 as shown in Figure 2 below.

E. Metode Pembelajaran

- ✓ Studi pustaka, diskusi, ceramah dan tanya jawab
- ✓ Pendekatan model CTL

F. Langkah-langkah Pembelajaran

Kegiatan Pendahuluan

- ✓ Menanyakan terkait manfaat serach engine serta kegunaanya
- ✓ Menyampaikan tujuan pembelajaran

Kegiatan Inti

Eksplorasi

Pada tahap ini Guru:

- ✓ Membimbing siswa untuk mempraktekan pencarian informasi dengan mesin pencari google

Figure 2. Example of Subject 18 lesson plan Components on Knowledge Technology Aspects The

TCK aspect of prospective teachers (78.99%) is in the good category. Judging from the learning tools developed, prospective teachers can already determine the mathematics material to be taught. As said (Maryanti, Hartati, Kurniawan, & Sukardi, 2022) before using learning media, prospective teachers first determine the material to be provided so that there is compatibility between the media and the material. The ICT media used by most prospective teachers is Power Point. The results of this study are supported by opinio (Sulaeman, 2021); (Stevani & Sucahyo, 2022) that Microsoft Power Point is the most widely used software as a learning medium. The material presented using Power Point can attract

students' attention in the learning process. Presentation of material on Power Point can be packaged as needed such as inserting text, images, animations, and videos so that learning material will be more interesting (Misbahudin, Rochman, Nasrudin, & Solihati, 2018). Due to the Covid-19 outbreak, the use of learning media has become more sophisticated (Mansyur, 2020). The process of teaching and learning and giving assignments during online learning certainly requires media as a means for learning. Zoom, Google Classroom, Google Meet and Whattsap are ICT media that are used as media for communicating between teachers and students online. The following is an example of giving assignments to the subject of prospective teachers 21 in giving assignments via WA.

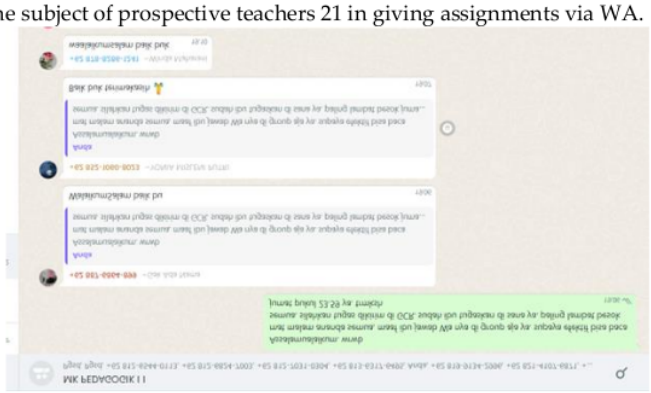

Figure 3. Example of 21 Prospective Teacher Subjects on TCK When Giving Assignments

Teachers can discuss with students like meeting face to face via Zoom and Google Meet. As for the provision of materials and assignments, you can go through Google Classroom and WhatsApp (Wijayanto, 2020). However, based on the results of this study there are still preservice teachers who have not written down the activity steps on the media learning tools used for giving student assignments. Therefore, it is necessary to plan carefully in the selection of learning media so that it can be put to good use.

Furthermore, the TPK aspect of preservice teachers (75.54%) is included in the good criteria. ICT media used by prospective mathematics education teachers in learning tools include Power Point, Zoom, Google Classroom, Google Meet and WhatsApp. The use of ICT media in the learning process can facilitate the process of communication between teachers and students (Cholik, 2017). ICT media used as a medium for communicating with students are Zoom, Google Classroom, Google Meet and WhatsApp. This is due to the spread of the corona virus which has an impact on the learning process activities. In accordance with theCircular Letter Number 4 of 2020 Concerning the Implementation of Education Policies in the Emergency Period of the Spread of Coronavirus Disease (COVID-19), that the spread of the corona virus is increasing, the learning process is carried out from home through online or distance learning. The online learning process can continue to run well through the use of ICT technology as a learning medium. In RPP Microteaching prospective teachers of mathematics education, ICT learning media are also adapted to the chosen model, approach and method. Then place the use of ICT technology in learning steps according to the chosen model, approach and learning method. However, there are still learning devices that use non-ICT media such as blackboards. This is because the Microteaching learning device is designed by prospective mathematics education teachers when the teaching and learning process is carried out face-to-face. Besides that, also the content of the material being taught tends to be manual explanation procedures. Even the statement items related to prospective teachers on the use of ICT according to the characteristics of students have the lowest criteria. This is supported by previous research studies that, teacher experience in understanding the characteristics of students is very necessary (Rahmi & Samsudi, 2020). Meanwhile, prospective teachers do not have much experience in understanding the characteristics of students.

The obstacles faced by prospective teachers in designing learning include the lack of supporting infrastructure for learning media in practical schools, inadequate internet network support. These findings are supported by research studies that have also been conducted previously by (Susanti & Suripah, 2021; Suripah, Firdaus, & Novilanti, 2022) that one of the obstacles faced by prospective teachers and professional teachers in integrating technology in learning is the availability of internet networks. Apart from that, learning media and facilities that support technology in schools are still not optimal.

4. CONCLUSION

Technology Knowledge(TK) prospective mathematics teachers are in very good criteria. Technological Content Knowledge (TCK) for prospective mathematics teachers in learning planning is quite good. Meanwhile Technological Pedagogical Knowledge (TPK) for mathematics teacher candidates in learning tools is in good criteria. In one of the statement items related to the use of ICT as a communication medium, all prospective teachers who were the subject of the study had used ICT and all used WA, as an effective communication tool. This research is only at the documentation study stage on the Microteaching learning device for prospective mathematics teachers in the form of a lesson plan. Therefore, it is hoped that at the next stage, a picture of the ability of prospective teachers to integrate technology in TPCK can be obtained through direct observation of learning.

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Conflicts of Interest

We have no conflicts of interest to disclose with any parties.

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ABSTRACT

Professional teachers must master pedagogical and technological content knowledge (TPCK) to innovate in teaching. However, many teachers struggle to integrate technology effectively. Preparing preservice teachers with these skills is essential for their readiness in the workforce. This study analyzes the ability of preservice mathematics teachers to integrate technology into pedagogical content knowledge when planning mathematics lessons. This research employs a descriptive qualitative approach. The subjects were 23 fifth-semester preservice mathematics teachers from Universitas Islam Riau. TPCK analysis was conducted on their lesson planning documents, focusing on three aspects: Technological Knowledge (TK), Technological Content Knowledge (TCK), and Technological Pedagogical Knowledge (TPK). Data analysis followed four stages: data collection, reduction, presentation, and verification. Findings indicate that preservice teachers demonstrated very good competency in technological knowledge (TK) when designing learning plans. Their ability to integrate technology with subject content (TCK) was rated as good. Similarly, their understanding of using technology in pedagogy (TPK) was also classified as good. These results suggest that preservice mathematics teachers are capable of integrating technology into pedagogical content knowledge effectively, though there is room for improvement in refining their strategies. Preservice teachers exhibit good competence in TPCK when designing mathematics lesson plans, highlighting their readiness to apply technology in future teaching. Further research should explore strategies to enhance their technological integration skills in practical teaching settings.

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1. INTRODUCTION

The role of technology in education is very important to improve the quality of learning and expand access to education, especially in this digital era. By using various digital devices and platforms, teachers can deliver material in a more interactive and engaging way. In addition, technology can help provide a more flexible learning experience through e-learning (Ulanday, Centeno, Bayla, & Callanta, 2021). However, the main challenges faced by teachers in integrating technology are a lack of technical skills, limited access to devices or adequate internet connections, and resistance to change from some teachers who are not used to technology-based learning methods. In addition, the need to constantly update knowledge and skills in the face of very rapid technological developments is also a challenge in itself (Puspitasari, Utari, Rohim, & Sudadi, 2023).

Specific research problems in the context of education often focus on the gap between theory and practice, especially in developing the professional skills of preservice teachers. Although many studies have explored various pedagogical approaches, there is still a lack of research that identifies the practical challenges that aspiring teachers face in applying these theories in the actual classroom. One of the main gaps is the lack of focus on the readiness of preservice teachers to deal with the diversity of student needs, such as differences in ability levels or diverse socio-economic backgrounds (Gheyssens, Coubergs, Griful-Freixenet, Engels, & Struyven, 2022). In addition, many aspiring teachers face difficulties in adapting more innovative teaching methods due to limited resources, inadequate training, or lack of support from the educational institutions where they study. More research is needed to address these barriers and ensure that preservice teachers are prepared to implement effective learning in the field. In addition, professional teachers are needed to know all the potentials that support learning so that it runs effectively (Chen & Jang, 2018). An active and effective learning process requires the professionalism of teachers to master the material, pedagogy, and technology (Xiang, 2014); (Rafi & Sabrina, 2019). The development of technology in the modern era can no longer be avoided for its influence on the world of education.

The four main competencies needed by teachers in Indonesia, especially related to pedagogical and professional competencies, include: (1) Pedagogic competence, which includes teachers' ability to design, implement, and evaluate effective learning by taking into account the characteristics and needs of students. (2) Professional Competencies, which requires teachers to master the subject matter in depth and continue to update their knowledge in accordance with the latest scientific and technological developments. (3) Social Competence, which includes teachers' ability to communicate and interact with students, parents, and peers, as well as build relationships that support students' social and emotional development. (4) Personal competence, which requires teachers to have integrity, emotional maturity, and a positive attitude that supports the formation of students' character, as well as providing an exemplary example in daily life (Suripah, Suyata, & Retnawati, 2021).

Pedagogical competence plays a crucial role in determining the success of a lesson. It refers to a teacher's ability to manage the learning process, including designing activities, implementing instruction, and evaluating outcomes (Gess-Newsome et al., 2019). In addition to pedagogical competence, teachers must also possess professional competence, which involves mastering subject matter knowledge (Suripah, Suyata, & Retnawati, 2018).

With the rapid advancement of technology, teachers are increasingly required to enhance their professional skills by integrating technology into their teaching. Beyond classroom instruction, they must be able to effectively incorporate technology to improve the quality of learning. The use of technology in education not only enhances instructional effectiveness but also boosts student motivation and learning outcomes.

For preservice mathematics teachers, a strong foundation in technological knowledge, pedagogy, and content is essential for integrating technology into their teaching practices (Subali & Handoyo, 2021). Mastering these areas ensures that future educators can create innovative and engaging learning experiences that align with modern educational needs.

While teachers' pedagogical and professional competencies encompass a wide range of basic skills, in the modern educational era, the ability to integrate technology effectively is becoming an increasingly crucial skill. For this reason, from the beginning, Shulman has realized the importance of technology in learning, but according to (Xiang, 2014). Technology was not as sophisticated as it is now. Therefore, this integration is clearly captured through the TPCK (Technological Pedagogical Content Knowledge) framework. TPCK is a knowledge that emphasizes the importance of combining pedagogical knowledge, subject matter, and technology in the learning process of mathematics (Liang & Luo, 2016). In this context, teachers are not only required to master effective teaching methods, but also to be able to utilize technology to support learning that is more interactive and relevant to students' needs (Chuang & Ho, 2015). TPCK requires teachers not only to be familiar with various technological tools, but also to understand how these technologies can be applied appropriately in teaching according to the characteristics of the material and the needs of students. Thus, TPCK is the key to overcoming challenges and preparing teachers who are ready to face dynamic changes in the world of education.

TPCK is the knowledge needed to integrate technology in the learning process (Erduran & Ince, 2018). According to (Mishra & Koehler, 2006), TPCK is a form of knowledge that is interconnected between content, pedagogy, and technology. TPCK is divided into 8 components, namely: (1) Technology Knowledge (TK), knowledge about the use of technology, (2) Pedagogical Knowledge (PK), knowledge about pedagogy or learning strategies, (3) Content Knowledge (CK), knowledge about content or subject matter, (4) Pedagogical Content Knowledge (PCK), knowledge about strategies or how to teach subject matter, (5) Pedagogical Knowledge Technology (TPK), teachers' knowledge about how to teach using technology, (6) Knowledge of Technology Content (TCK), knowledge of delivering material through technology, (7) Pedagogical Knowledge and Technology Content (TPCK), knowledge of how to teach subject matter using technology.

Preservice mathematics teachers are required to be able to integrate technology into the learning process according to the character of students (Sintawati & Indriani, 2019). Integrating TPCK in mathematics learning can make it easier for students to understand mathematical concepts taught by teachers, especially mathematical concepts that are abstract and difficult and require visualization to understand these concepts (Rafi & Sabrina, 2019). The ability of TPCK preservice teachers can be seen from the learning tools they make themselves. The ability of preservice TPCK teachers can be seen from the design of learning implementation because it contains a pedagogic component, namely the method used, the content component, namely the material taught, and technology, namely the media used (Innaha, 2018). Therefore, learning tools must be able to contain TPCK components, because the learning tools prepared by preservice teachers are a reflection of the way they teach.

This research related to TPCK is important because it contributes significantly to overcoming the gap that exists in understanding how preservice mathematics teachers design learning tools that integrate TPCK. Although many studies have highlighted the importance of pedagogical and professional skills in education, there is still a lack of research specifically addressing how preservice math teachers combine pedagogical knowledge, content, and technology in designing effective teaching materials. By understanding this process, this research provides new insights that can help improve the quality of teacher training, especially in preparing them to use technology optimally in mathematics learning. This contribution is not only relevant for the development of TPCK theory, but also provides practical implications for the improvement of the teacher education curriculum, which in turn will improve the quality of mathematics education in Indonesia. The problem in this study is how to analyze the integration of TPCK mathematics teacher candidates in designing learning? Therefore, this study aims to describe how integration into the TPCK of preservice mathematics teachers in designing learning.

2. METHODS

This research is a qualitative descriptive research. The subjects of this study were 39 preservice mathematics teacher students at FKIP Universitas Islam Riau (UIR) who had attended Microteaching

courses. The data collection technique was carried out by means of documentation studies from Microteaching learning tools in the form of syllabi and lesson plans, while the research instrument was in the form of identification sheets. The components to be identified include TK, TCK, and TPK aspects. All components related to the aspects of kindergarten, TCK, and TPK have previously been validated in terms of validity, validity constructs, and expert validation to 3 lecturers for material, media, and language experts. After getting input and suggestions from experts, both materials, media and linguists, the researcher then makes revisions based on the input and suggestions given. After all components are declared valid, the researcher uses instruments that have been declared valid to take field data.

The data analysis techniques of this research are data collection, data reduction, data presentation, conclusion drawing, and data analysis results presentation. In this study, questionnaires will be distributed to all Semester V students at Universitas Islam Riau who are taking microteaching courses. The TPCK questionnaire consists of components: (1) designing learning process documents, (2) development of reflection, (3) implementing the curriculum in the learning process, (4) integrating technology in the mathematics learning process, (5) as well as the constraints in integrating technology in mathematics learning in schools. Document studies are used to analyze the lesson plans forp reservice teachers that are made. While the qualitative method in this study used a descriptive approach.

Data analysis was carried out in a qualitative descriptive manner, namely describing preservice teachers' integration of TPCK in designing students and mathematics. Data analysis includes data collection, data reduction, data presentation, and data verification. The research procedure consists of (1) Preparation, including observation, problem identification, determination of data sources, preparation of observation sheet instruments, presentation of teaching materials, learning strategies, and assessment documents, reflections, and lesson plans, questionnaires, interview guidelines. The last stage is the validation of the instruments given to the experts, (2) The implementation stage, the distribution of TPCK questionnaires, the study of learning documents, learning process documents, and reflection document studies, (3) Descriptive data processing from observation sheets, documentation, questionnaire sheets, and interviews, the next stage in this study is to analyze observation sheets, documentation, questionnaire sheets, and interviews.

The assessment of each component of technology integration through the lesson plan is carried out by giving a score on a scale of four. The meaning of scoring is: 1: less, 2: enough, 3: good, and 4: very good. To calculate individual kills, it can be done with the following formula.

$$N = \frac{total\ score}{Number\ of\ items\ x4} X100$$

Meanwhile, to analyze the percentage of achievement in each assessed aspect of integrating technology into the lesson plan, the calculation was performed by determining the total scores obtained by preservice teacher students—the subjects of the research—divided by the number of respondents, multiplied by the maximum score, and then multiplied by 100%. The complete calculation follows this formula:

$$P_j = \frac{\sum_i^n = JS_i}{N\ x\ maximum\ score} X100\%$$

Information:

P_j= percentage of mastery of the aspect to -j

JS_i= the number of scores of preservice teachers in the i aspect

i = number of items for item j

N = number of research subjects

The assessment criteria for the TPCK questionnaire list are presented in Table 1.

Table 1. The assessment criteria for the TPCK questionnaire

Value Range	Criteria
81%-100%	Very good
61%-80%	Good
41%-60%	Enough
21%-40%	Not good
0%-20%	Not good

3. FINDINGS AND DISCUSSION

The aspects examined in this study are based on the developed assessment instruments, which include six items measuring Technological Knowledge (TK), six items assessing Technological Content Knowledge (TCK), and eight items evaluating Technological Pedagogical Knowledge (TPK). These aspects are derived from the Microteaching learning materials designed for preservice mathematics education teachers, specifically in the form of lesson plan documents. The assessment checklist is used to evaluate the ability of preservice mathematics education teachers to integrate technology within the Technological Pedagogical Content Knowledge (TPCK) framework in their lesson plans. Through the analysis of assessments conducted on preservice teachers' Microteaching learning tools, a comprehensive profile of their ability to integrate technology is generated. The evaluation of TPCK components within the lesson plan is summarized in Table 2.

Table 2. Profile of Technology Integration in Pedagogical Content Knowledge (TPCK)

Subject	Rated aspect (%)				Criteria
	TK	TCK	TPK	Average	
1	67	50	63	59.72	Enough
2	67	67	75	69.44	Good
3	83	83	75	80.56	Good
4	100	83	63	81.94	Very good
5	83	83	75	80.56	Good
6	100	83	75	86.11	Very good
7	83	100	63	81.94	Very good
8	100	83	75	86.11	Very good
9	100	83	75	86.11	Very good
10	67	100	75	80.56	Good
11	83	83	63	76.39	Good
12	100	83	100	94.44	Very good
13	50	33	75	52.78	Enough
14	100	100	100	100.00	Very good
15	100	83	75	86.11	Very good
16	83	67	63	70.83	Good
17	100	83	88	90.28	Very good
18	100	100	100	100.00	Very good
19	83	67	75	75.00	Good
20	67	67	75	69.44	Good
21	100	100	75	91.67	Very good
22	100	67	63	76.39	Good
23	67	67	75	69.44	Good
Total Average	86,23	78.99	75,54	80.25	
Criteria	Very good	Good	Good	Good	

Based on Table 2, it is obtained that the average for the TK aspects of preservice teachers is in the very good category. That is, out of 23 people, only one preservice teacher is in enough criteria. The rest are in good criteria (5 people), and very good (17 people). The TCK aspect of preservice teachers in learning tools is in good criteria. Two preservice teachers are in enough criteria, 6 are in good criteria, and 15 are in very good criteria. The TPK aspect of preservice mathematics teachers in Microteaching learning tools is in good criteria, namely all preservice teachers are in good criteria (19 people) and very good (4 people) preservice teachers.

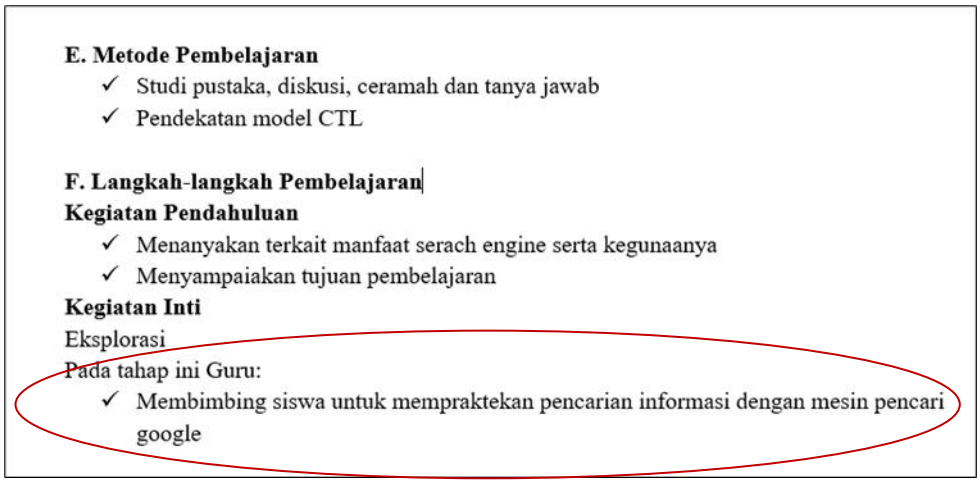
From Table 2, the average percentage of preservice mathematics education teachers' abilities in Technological Knowledge (TK), Technological Content Knowledge (TCK), and Technological Pedagogical Knowledge (TPK) is presented. The TK proficiency of preservice teachers is categorized as very good, with an average achievement of 86.23%. An analysis of lesson plan documents, including syllabi and instructional plans, indicates that preservice teachers have successfully integrated ICT technology into their teaching. This is evident in their microteaching lesson plans, where all 20 preservice teachers demonstrated the ability to incorporate ICT in selecting instructional media.

The integration of technology includes both hardware, such as laptops, computers, projectors, and mobile phones, and software, particularly PowerPoint, to facilitate content delivery. According to Putria, Maula, and Uswatun (2020), online learning is a process conducted remotely using the internet and other supporting tools. This necessity has driven preservice mathematics teachers to adopt various communication technologies, such as Zoom, Google Meet, Google Classroom, and WhatsApp groups, to facilitate their teaching. This aligns with Nayar and Akmar's (2020) findings, which emphasize the use of Zoom, Google Meet, and Google Classroom in online teaching as part of planned classroom settings within lesson plans.

Moreover, the findings of this study support global research trends, affirming the increasing necessity of technology in education. Preservice teachers must develop the ability to integrate technology effectively into lesson planning and instructional processes (Janssen, Knoef, & Lazonder, 2019). Local challenges add unique complexities to this process, particularly in designing lesson plans suited for online instruction. One example, demonstrated by Preservice Teacher 06, illustrates the adaptation of online learning through Zoom meetings, as shown in Figure 1.

Figure 1. Design ofpreserviceTeachers in Using ICT Using Zoom

In addition,preservice teachers have also been able to guide students in practicing searching for information with the Google search engine. This can be seen in one of the preservice teacher subject lesson plans 18 as shown in Figure 2 below.


E. Metode Pembelajaran

- ✓ Studi pustaka, diskusi, ceramah dan tanya jawab
- ✓ Pendekatan model CTL

F. Langkah-langkah Pembelajaran

Kegiatan Pendahuluan

- ✓ Menanyakan terkait manfaat serach engine serta kegunaanya
- ✓ Menyampaikan tujuan pembelajaran

Kegiatan Inti

Eksplorasi

Pada tahap ini Guru:

- ✓ Membimbing siswa untuk mempraktekan pencarian informasi dengan mesin pencari google

Figure 2. Example of Subject 18 lesson plan Components on Knowledge Technology Aspects The

The TCK aspect of preservice teachers was measured at 78.99%, placing it in the good category. Based on the learning tools developed, preservice teachers demonstrated the ability to select appropriate mathematical content for instruction. According to Maryanti, Hartati, Kurniawan, & Sukardi (2022), selecting the right material before using learning media ensures alignment between content and instructional tools.

Among the various ICT tools available, most preservice teachers primarily use Microsoft PowerPoint as their learning medium. This finding aligns with Sulaeman (2021) and Stevani & Sucahyo (2022), who state that PowerPoint is the most widely used software for instructional purposes. PowerPoint allows teachers to present material in an engaging format by incorporating text, images, animations, and videos, making learning more interactive (Misbahudin, Rochman, Nasrudin, & Solihati, 2018).

The COVID-19 pandemic accelerated the advancement of learning media (Mansyur, 2020). Online learning requires effective digital platforms for teaching, communication, and assignment submissions. Platforms such as Zoom, Google Classroom, Google Meet, and WhatsApp became essential tools for teacher-student interactions. Below is an example of how preservice teachers utilized WhatsApp for assignment distribution, demonstrating the integration of technology in remote learning.

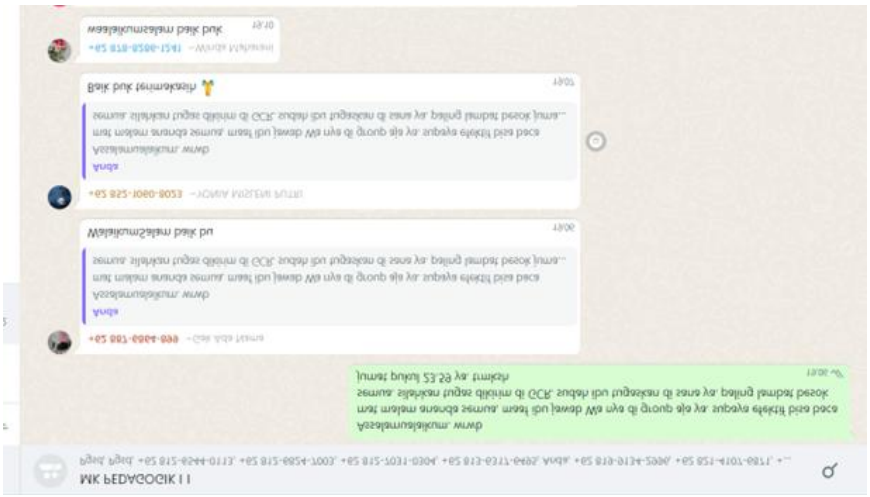


Figure 3. Example of 21preserviceTeacher Subjects on TCK When Giving Assignments

Teachers can discuss this with students by meeting face-to-face via Zoom and Google Meet. As for the provision of materials and assignments, you can go through Google Classroom and WhatsApp (Wijayanto, 2020). However, based on the results of this study, there are still preservice teachers who have not written down the activity steps for the media learning tools used for giving student assignments. Therefore, it is necessary to plan carefully in the selection of learning media so that it can be put to good use.

The TPK aspect of preservice teachers was measured at 75.54%, placing it in the good category. Various ICT media, including PowerPoint, Zoom, Google Classroom, Google Meet, and WhatsApp, were utilized in the learning process. The use of ICT tools facilitates communication between teachers and students (Cholik, 2017). During the COVID-19 pandemic, these platforms became essential due to the shift to online learning. In line with Circular Letter No. 4 of 2020 regarding Education Policies During the COVID-19 Emergency, online and distance learning were mandated to mitigate the spread of the virus. The integration of ICT in education enabled learning to continue effectively despite the disruptions.

In Microteaching lesson plans, preservice mathematics teachers adapted ICT learning media to match their selected teaching models, approaches, and methods. They strategically placed ICT tools within the learning steps to align with their instructional strategies. However, some lesson plans still incorporated non-ICT media, such as blackboards, particularly in face-to-face teaching scenarios. This preference is often influenced by the nature of the subject matter, which sometimes requires manual explanation procedures.

One challenge identified was the limited ability of preservice teachers to adapt ICT use to student characteristics, which was rated at the lowest level. Rahmi & Samsudi (2020) emphasize that understanding student characteristics is crucial for effective teaching, yet preservice teachers often lack sufficient experience in this area. This highlights the need for more training and exposure to help future educators tailor technology integration to diverse student needs.

The obstacles faced by preservice teachers in designing learning include the lack of supporting infrastructure for learning media in practical schools, inadequate internet network support. These findings are supported by research studies that have also been conducted previously by (Susanti & Suripah, 2021; Suripah, Firdaus, & Novilanti, 2022) that one of the obstacles faced by preservice teachers and professional teachers in integrating technology in learning is the availability of internet networks. Apart from that, learning media and facilities that support technology in schools are still not optimal. In addition, the results of the reduction from the interviews obtained sub-themes as presented in the following table.

Table 3. Obstacles in Integrating Technology in Mathematics Learning

No	Sub-theme	Relationship between sub-themes
1	Infrastructure is not supportive	Limited supporting infrastructure
2	Internet/Wifi network constraints that are often not smooth	
3	Don't understand how to design media correctly	
4	In appropriate in the selection of teaching materials that are in accordance with the teaching media	Difficulties in adjusting the material and limitations in understanding existing multimedia
5	The ability to understand and use applications is still limited	

An example of the results of interviews withpreserviceteachers that support this statement is as follows.

"*… Actually, there is a lack of supporting facilities and policies*." (Preservice Teacher 7). *The internet is often not smooth, so there is a lack of enthusiasm*..." (Preservice Teacher 3, 4). If I don't really understand some applications and how to design good media, but I will continue to learn, ma'am..." (Preservice Teacher 2). *I am still confused in sorting out which material is suitable for a particular learning medium, sometimes it is still confusing*." (Preservice Teacher 10). Based on the answers of several preservice

teachers, it is indicated that the support of teaching facilities and experience has an effect on the integration of technology in learning. This is in accordance with the support of previous research that shows that the facilities, infrastructure, and experience of preservice teachers in preparing learning have a great influence on the integration of technology (Lawrence & Tar, 2018).

Teacher education programs can address identified barriers, such as infrastructure limitations, poor internet access, and lack of training, with some practical steps that are directed and integrated. Here are the steps that can be taken to overcome these problems: First, Overcome limited infrastructure, namely: Teacher education programs can provide adequate equipment, optimize the use of available infrastructure, and develop multimedia facilities. Second, overcoming the obstacles to poor internet access, namely: by developing a more stable internet network, using resources offline, providing digital learning materials. Third, training and competency development in designing learning, namely: training in designing effective learning media, the use of User-Friendly learning applications, and hands-on practice in designing media. Fourth, overcoming difficulties in adapting materials to teaching media, namely: assistance in selecting and adjusting media, and training on integrating technology in learning. Fifth, Improve the ability to use learning applications, namely providing basic skills courses in educational technology, developing competencies in technology for learning, and independent learning and access to learning resources such as online tutorials, and learning videos. Sixth, the use of a collaboration-based learning model, namely: increasing collaboration between teachers and preservice teachers, and project-based learning.

The findings on the barriers faced by preservice teachers in designing technology-based learning have significant implications for education stakeholders, including curriculum developers and policymakers. Given the challenges related to infrastructure, internet access, and limited technological proficiency, several key changes must be considered in teacher preparation programs to enhance preservice teachers' Technological Pedagogical Content Knowledge (TPCK) skills.

One necessary improvement is curriculum reform in teacher education programs. Technology should be integrated across all courses using project-based learning and hands-on approaches, with a strong emphasis on developing technological competencies. This integration ensures that preservice teachers gain practical experience in utilizing digital tools for instructional purposes.

Adjustments in education policy are also crucial. Efforts should be made to enhance infrastructure in practicum schools, allocate dedicated budgets for educational technology, and implement policies that support ongoing professional development for teachers. These changes will create a more supportive environment for both preservice and in-service teachers to incorporate technology effectively in their teaching practices.

Another key strategy is fostering collaboration with the educational technology industry. Strengthening partnerships with technology providers and offering specialized training led by educational technology experts can help bridge the gap between theoretical knowledge and practical application. This collaboration would allow preservice teachers to stay updated with emerging technological advancements and best practices in digital education.

Enhancing pedagogical approaches to technology is equally important. Teacher education programs should emphasize the effective integration of pedagogy and technology in teaching, ensuring that preservice teachers receive critical training on selecting and utilizing appropriate digital media. This approach helps educators develop strategies to use technology not just as a tool, but as an integral part of student-centered learning.

Finally, promoting 21st-century skills is essential for preparing future educators for modern teaching environments. Teacher training programs should focus on fostering digital literacy, collaborative learning, and creative problem-solving. These skills will enable preservice teachers to navigate the evolving educational landscape and adapt to new technological developments in their professional careers.

By implementing these changes, teacher preparation programs can better equip preservice teachers with the necessary skills and knowledge to overcome barriers and effectively integrate technology into their instructional practices.

4. CONCLUSION

The findings indicate that Technology Knowledge (TK) among preservice mathematics teachers is at a very good level, while their Technological Content Knowledge (TCK) in lesson planning is fairly good, and their Technological Pedagogical Knowledge (TPK) in learning tools falls within the good category. All preservice teachers in the study utilized ICT as a communication medium, with WhatsApp being the most commonly used platform. This study, however, was limited to a document analysis of Microteaching lesson plans, without direct observation of classroom implementation. Several challenges were identified in integrating technology into TPCK, including infrastructure limitations, internet access issues, and restricted technology skills. Future research should extend beyond documentation studies to include direct classroom observations to assess how effectively preservice teachers implement TPCK in real teaching environments. Additionally, educational institutions should develop training programs or workshops to enhance preservice teachers' technology integration skills, ensuring they are well-equipped to apply TPCK effectively in their future classrooms.

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