JPPIPA 12(5) (2026)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Improving Mathematics Teachers' Competence Through a Technological Pedagogical Content Knowledge Model Assisted by Microsoft Mathematics

Masdelima Azizah Sormin [1,2*], Yus Mochammad Cholily[1], Dwi Priyo Utomo[1], Baiduri[1], Riski Baroroh[3], Elisa[4]

[1] Doctoral of Education, University of Muhammadiyah Malang, Indonesia
[2] Department of Mathematics Education, Muhammadiyah University of South Tapanuli, Indonesia
[3] Department of Economic Education, Muhammadiyah University of South Tapanuli, Indonesia
[4] Department of Physics Education, Muhammadiyah University of South Tapanuli, Indonesia

Received: January 14, 2026
Revised: April 11, 2026
Accepted: May 25, 2026
Published: May 31, 2026

Corresponding Author:
Masdelima Azizah Sormin
masdelima@um-tapsel.ac.id

DOI: 10.29303/jppipa.v12i5.14278

Abstract: This study aims to improve the professional competence of Mathematics teachers in the Teacher Professional Program (PPG) through the application of the Technological Pedagogical Content Knowledge (TPACK) model assisted by Microsoft Mathematics. This research is a classroom action research (CAR) conducted in two cycles. Each cycle consisted of planning, action, observation, and reflection stages. The subjects of this study were 16 in-service PPG participants who are mathematics teachers, selected using purposive sampling technique. Data were collected through teacher professional competence tests and teacher activity observation sheets. Data analysis was performed quantitatively using descriptive statistics and qualitatively using interactive analysis techniques. The results showed that in Cycle I, the completion rate of the teacher professional competence test only reached 50% (8 out of 16 teachers passed) with a percentage of teacher activity observation of 62.5%, which had not met the success indicator (≥80%). After reflection and improvement in Cycle II, the completion rate of the teacher professional competence test increased to 81.25% (13 out of 16 teachers passed) with the percentage of teacher activity observation reaching 83.62%. The improvement in professional competence from Cycle I to Cycle II was 31.25%, while the improvement in teacher activity was 21.12%. These results indicate that the TPACK model assisted by Microsoft Mathematics is effective in improving teachers' understanding of the material, pedagogical abilities, and the integration of technology in mathematics learning. The Technological Pedagogical Content Knowledge (TPACK) model assisted by Microsoft Mathematics has proven to be effective and successful in improving the professional competence of Mathematics teachers in the Teacher Professional Program (PPG). The application of this model is recommended as an alternative strategy for sustainable professional development for mathematics teachers.

Keywords: Mathematics Teachers; Microsoft Mathematics; Teacher Competence; Technological Pedagogical Content Knowledge.

Introduction

In the global era of the digital revolution, teachers are required to deeply integrate technology into the learning process. However, the level of Technological Pedagogical Content Knowledge (TPACK) competency of Mathematics teachers, particularly in the Teacher Professional Program (PPG), remains a major challenge in Indonesia in responding to the era of the industrial revolution 4.0. TPACK is a 21st-century teacher knowledge framework that is useful for supporting teaching skills (Hardanti et al., 2024; Njiku, 2024; Ovilia

How to Cite:
Sormin, M., Cholily, Y. M., Utomo, D. P., Baiduri, B., Baroroh, R., & Elisa, E. (2026). Improving Mathematics Teachers' Competence Through a Technological Pedagogical Content Knowledge Model Assisted by Microsoft Mathematics. *Jurnal Penelitian Pendidikan IPA*, *12*(5), 607–616. https://doi.org/10.29303/jppipa.v12i5.14278

et al., 2023; Santos & Castro, 2021). TPACK is the integration of technological knowledge, pedagogical knowledge, and content knowledge in a subject area (Barut et al., 2021). This global challenge is reinforced by international findings showing that technology integration is often hampered by teachers' pedagogical capacity. A balanced combination of technology, pedagogy, and content understanding is the key to mastering technology without adequate understanding of pedagogy and content can actually reduce the effectiveness of learning and create significant competency gaps (Hadi et al., 2023; Mishra & Koehler, 2006; S. Rahayu et al., 2024; Santos & Castro, 2021).

This research is logically crucial because low TPACK competence among mathematics teachers directly reduces the quality of STEM human resources. If unresolved, this competency gap will widen Indonesia's education quality gap with developed countries and hinder the achievement of SDG 4 (quality education). Moreover, without proper intervention, the government's large investments in educational technology infrastructure (e.g., computer labs and internet access) will remain underutilized, as teachers lack the pedagogical skills to leverage them. Thus, enhancing teacher TPACK through an integrated model like TPACK assisted by Microsoft Mathematics is not just a technical requirement but a strategic necessity to prepare future generations for 21st-century challenges.

Field facts show that schools and teachers in Indonesia still face problems, including teacher standards, mastery of material, and low media and technology literacy (Ammade et al., 2020a; Lestary et al., 2023; S. Rahayu et al., 2024; Suyamto et al., 2020a). Furthermore, the worrying reality concerns mathematics teachers' TPACK competencies. Technology integration in mathematics learning in Indonesia is often superficial, such as simply using PowerPoint or showing videos without in-depth pedagogical strategies to facilitate understanding of mathematical concepts. Technology has not been utilized to create interactive learning environments and solve complex mathematical problems. As a result, mathematics learning becomes less contextual and unable to facilitate the development of students' higher-order thinking skills (HOTS).

The Technology Acceptance Model (TAM) by Davis (1989), updated by (Rughoobur-Seetah & Hosanoo, 2021), states that perceived ease of use and perceived usefulness are key factors in teachers' technology adoption. However, (C. Schmid & Schiffels, 2021) found that positive perceptions alone are insufficient; teachers need direct experience integrating technology into specific content. The expanded TPACK theory by Njiku (2024), emphasizes that TPACK development must be subject-specific. In mathematics, showed that technological knowledge (TK) contributes the least compared to pedagogical knowledge (PK) and content knowledge (CK) among Indonesian mathematics teachers (Hardanti et al., 2024). Vygotsky's social constructivism, adapted by S. Rahayu (2024), supports that technology-assisted learning should be collaborative and provide scaffolding, where Microsoft Mathematics can bridge students' zone of proximal development (ZPD) (S. Rahayu et al., 2024). Realistic Mathematics Education (RME) by Gravemeijer (2020) reinforces that technology like Microsoft Mathematics helps visualize realistic problems, making them easier to understand. Finally, a meta-analysis by Hadi (2023) confirms that effective TPACK professional development should last at least 6 months, be integrated into a learning community, and focus on specific content, not just one-day workshops (Hadi et al., 2023).

With a curriculum that emphasizes digital literacy and learning differentiation, learning is dynamic and influenced by changing times, and one of the most influential factors is the teacher (Albar et al., 2022; Ammade et al., 2020b; Santos & Castro, 2021). This curriculum requires teachers not only to be proficient in mastering the material (content knowledge) but also to be skilled in selecting and using appropriate technology to create a personalized, adaptive, and interactive learning experience for each student. Without mastering TPACK into meaningful learning practices, it has the potential to hinder the improvement of the quality of Indonesian mathematics education amidst the wave of the digital revolution (Hidayati et al., 2021; E. M. Rahayu et al., 2023; Sativa et al., 2023). Thus, adopting new or creative technologies in teaching is challenging. However, simply adopting technology will not be enough to meet student demands. Therefore, improving the quality of education can be achieved in various ways, including improving the competence of teachers and prospective teachers, changing the curriculum, improving the quality of education learning and assessment, provision of teaching materials, and adequate facilities and infrastructure. Of all these methods, improving the competence of teachers/prospective teachers is crucial, considering that teachers are the spearhead of learning (Hartati, 2019). Teachers are one of the strategic elements in the process of improving the quality of education because teachers have a role in facilitating student learning so that they can achieve the expected quality (Barut et al., 2021; Hartati, 2019; Suyamto et al., 2020b). However, in reality, in this era of globalization, it cannot be denied that there are still many teachers who have not mastered information technology (in terms of learning media) optimally, even though this can make it easier for teachers to convey material or information to students (Intyassandy et al., 2022). Therefore, a teacher is required to have knowledge of how to teach a subject to their students by integrating content knowledge with the curriculum, learning, and student characteristics. This allows teachers to effectively teach students to maximize their knowledge and skill acquisition.

Various efforts to improve TPACK competency have been widely researched, but still leave gaps. Technological Pedagogical Content Knowledge (TPACK) is the effectiveness of lesson delivery with technology integration (Santos & Castro, 2021). Effective TPACK must be integrated and sustainable, not just a short workshop (Hadi et al., 2023). Meanwhile, the research results show that students' TPACK competencies are classified as high (Zulfikar, 2023). However, they acknowledge that research into the pedagogical content knowledge (PCK) aspects specific to mathematics is still limited. Graham et al. found that although teachers' self-reported TPACK increased during specific professional development programs, their level of technology use remained teacher-centered, rather than engaging students in the use of technology for learning (M. Schmid et al., 2021).

Thus, previous research has not fully addressed the deep integration of specific technologies with the complexities of mathematics content and pedagogy. Teachers need to combine different knowledge dimensions to effectively teach with technology. These include the three core components of pedagogical knowledge (PK), content knowledge (CK), and technological knowledge (TK) *(M. Schmid et al., 2021; Suyamto et al., 2020a).* Where teachers are asked to combine three core components, namely pedagogical knowledge (PK), content knowledge (CK), and technological knowledge (TK). According to Chai et al., the TPACK framework is primarily used to assess teacher competency levels and design teacher professional development activities aimed at building TPACK (M. Schmid et al., 2021). The TPACK model, as proposed by Mishra and Koehler (Mishra & Koehler, 2006), is built upon three interconnected knowledge domains. These include Pedagogical Knowledge (PK), which encompasses understanding teachingmethodologies rooted in educational theory; Content Knowledge (CK), which entails a teacher's comprehension of subject matter content and its scope; and Technological Knowledge (TK), which involves familiarity with the application of hardware and softwarein the classroom learning environment (Fitriyah et al., 2025). One of the many digital technologies in learning, Microsoft Mathematics is an educational program created for the Microsoft Windows operating system that helps users solve math problems (Intyassandy et al., 2022; Sormin et al., 2023).

Microsoft Mathematics offers a strategic yet underexplored potential solution within the TPACK framework for PPG teachers. Microsoft Mathematics is software developed by Microsoft and available for free download. This program allows users to perform computational mathematical operations with the help of a program (Intyassandy et al., 2022; Rabi et al., 2022). This application is equipped with features for visualizing abstract concepts such as calculus and 3D geometry. Using Microsoft Mathematics can improve students' conceptual understanding of mathematics. Furthermore, this strategy increases student engagement and creates effective, positive outcomes, as well as helping students improve their arithmetic performance on standardized tests. According to Hindawi, their research shows that students who learn mathematics using Microsoft Mathematics perform better perform higher on exams than their peers, and the use of Microsoft Mathematics increases students' confidence in mathematics (Rabi et al., 2022; Salsabila et al., 2024). This research aims to address this gap by making teachers active participants in developing integrative competencies. Its novelty lies in the development of a contextual and specific TPACK model, utilizing Microsoft Mathematics as a core technological tool deeply integrated into pedagogical learning designs and essential mathematical content for teachers, particularly PPG mathematics teachers.

Based on the description above, this study aims to improve mathematics teacher competency through a technological pedagogical content knowledge model supported by Microsoft Mathematics. This model is expected to produce teachers who are not only technologically literate but also able to transform its use to explain complex concepts, design meaningful learning activities, and ultimately improve the quality of mathematics instruction in their classrooms.

Method

The type of classroom action research is in the form of a cycle of activities carried out in two cycles (Purnomo, 2011; S. Rahayu et al., 2024; Suherman, 2022; Sukardi, 2022). Each cycle consists of four classic stages: planning, action, observation, and reflection. This CAR approach was chosen because of its relevance in efforts to improve the quality of the learning process, in this context, to enhance the pedagogical and professional competencies of prospective teachers this is participatory, where researchers are directly involved in the training process provided to research subjects.

The subjects of this study were 16 participants in the Pre-Service Teacher Professional Program (PPG) (Sugiyono 2019, 2018). They were prospective mathematics teachers selected using a purposive sampling technique. This sample selection was based on the consideration that they were actively developing their professional and pedagogical competencies, thus being highly aligned with the research focus, namely the application of the Technological Pedagogical Content Knowledge (TPACK) model integrated with Microsoft Mathematics. This research was conducted at the Teacher Training Institute (LPTK) that administers the PPG program, providing an authentic context for teacher competency development.

Classroom Action Research (CAR) Flowchart for Improving Mathematics Teachers' Professional Competence through the TPACK Model Assisted by Microsoft Mathematics

Initial Preparation

- Problem Identification (low TPACK competence of PPG mathematics teachers)
- Literature Review
- Instrument Development (tests, observation sheets, questionnaires)
- Instrument Validation by 2 experts & Reliability Test (Cronbach's Alpha > 0.70)
- Determination of Research Subjects (16 in-service PPG participants, purposive sampling)

Stage 1: Cycle I Implementation

Cycle I Loop (4 stages):

1. Planning: Developing a learning plan using the TPACK model assisted by Microsoft Mathematics.
2. Action: Implementing learning using the TPACK model + Microsoft Mathematics.
3. Observation: Observing teacher and participant activities using observation sheets.
4. Reflection: Evaluating the results of competency tests & observations; if the success indicator (≥80%) has not been achieved, then proceed to Cycle II.

(If not completed)

Stage 2: Cycle II Implementation

Cycle II Loop (4 stages):

1. Re-planning: Revising the plan based on the reflection from Cycle I.
2. Action: Implementing the improved learning process.
3. Observation: Observing teacher activities (continued).
4. Reflection: Final evaluation.

Stage 3: Data Analysis

1. Quantitative Data: TPACK competency test → Descriptive statistics (mean score, completion percentage, gain score)
2. Qualitative Data: Observations & questionnaires → Interactive analysis (data reduction, data display, conclusion drawing)

Stage 4: Conclusion

TPACK Model + Microsoft Mathematics is effective in improving teachers' professional competence (improvement from Cycle I to Cycle II: 31.25% for competence, 21.12% for activities (S. Rahayu et al., 2024; Sri Astutik et al., 2021; Suherman, 2022; Sukardi, 2022).

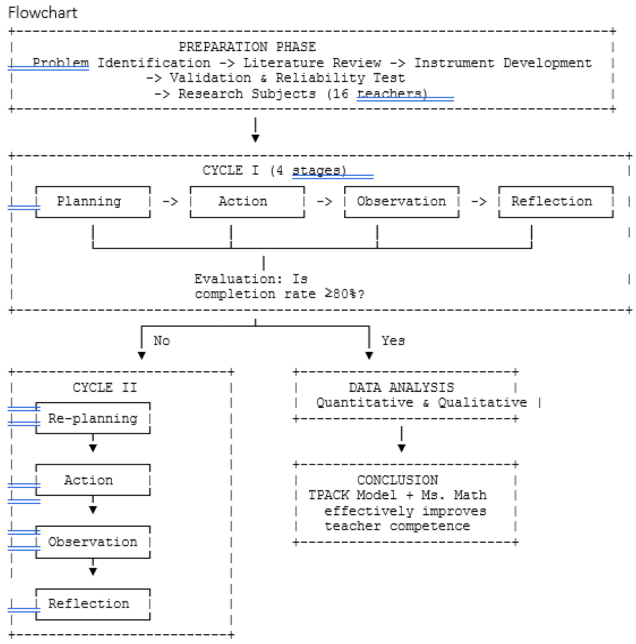

Figure 1. the Research Flowchart

The data analysis stages in this study were conducted quantitatively and qualitatively. Quantitative data, primarily derived from the TPACK ability test, were analyzed using descriptive statistics. This analysis involved calculating the average score and the percentage of participants' completion. Furthermore, to measure improvement from cycle I to cycle II, a gain score was calculated. The success of the action was determined based on the criteria of increasing the average score and achieving the "very good" category. Meanwhile, qualitative data obtained from the observation sheets and questionnaires were analyzed using interactive analysis techniques. This technique includes three main stages: data reduction by simplifying and focusing on relevant information, presenting data in narrative or tabular form to facilitate understanding, and drawing conclusions to answer the research questions.

To ensure data accuracy and reliability, instrument quality assurance and data validity were implemented. Prior to use, all research instruments (observation sheets, questionnaires, and tests) were validated by two experts in mathematics education and learning technology. The test and questionnaire instruments were also tested for reliability using the Cronbach's Alpha formula, with coefficients above 0.70 indicating reliability. For qualitative data validity, method triangulation was conducted by comparing and checking the consistency of findings from three different instruments (observations, questionnaires, and tests). This process ensured that the research findings were credible and comprehensive, thus ensuring that the conclusions regarding teacher competency improvement were accountable.

Result and Discussion

The research results are described in stages, each cycle consisting of planning, action, observation, and reflection. In this study, learning was conducted in two cycles. Based on the results of the teacher professional competency test in Cycle I, the following results were obtained:

Results of the First Cycle of Teacher Professional Competency Test

The results of the professional competency test of teachers in the teaching and learning process in cycle I through the TPACK learning model assisted by Microsoft Mathematics from 16 teachers who took the test, only 8 teachers completed the test with a percentage of 50% and 8 teachers did not complete the test with a percentage of 50% and had not met the success level of the KKM, which was 70. Based on these results, it can be concluded that the assessment set is still not in accordance with the expected criteria. For more clarity, please observe the bar chart below (Figure 2):

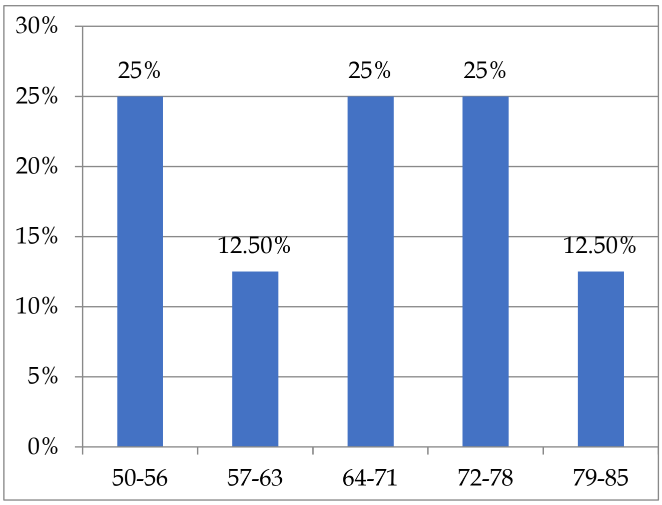

Figure 2. Results of the First Cycle of Teacher Professional Competency Test

Based on figure 2, it can be concluded that teachers' mastery of the learning material still does not meet the success level. Of the 16 teachers who took the test, none met the established criteria of ≥ 80% and require reflection for the next cycle.

Observation of Cycle 1 Action

At this stage, the researcher conducted observations to determine which team earned the most points, observed teachers' professional competence, and observed teacher performance. According to the research success indicators, improving teachers' professional competence through the TPACK learning model assisted by Microsoft Mathematics achieved 80% learning completion during the teaching and learning process. The following is a summary of the observation results.

Observation Results of Teacher Professional Competence in Cycle 1

Observation is part of the data collection process required for the research. The observer's role is to observe all activities occurring in the classroom during the implementation of the intervention. Based on these observations, the professional competence of teachers in Cycle I using the TPACK model was still considered adequate, with a percentage of 62.5%. Some teachers were quite familiar with the applied learning method, although the results were not optimal or as expected.

From these results, it can be concluded that the achieved scores did not meet the expected criteria, which is at least good with a percentage of 80% or more. Therefore, reflection is necessary for improvements in the next cycle. Future research is expected to meet the established achievement indicators. Overall, the achievement of professional competence of teachers using the TPACK learning model in the classroom in Cycle I can be seen in the following diagram (Figure 3).

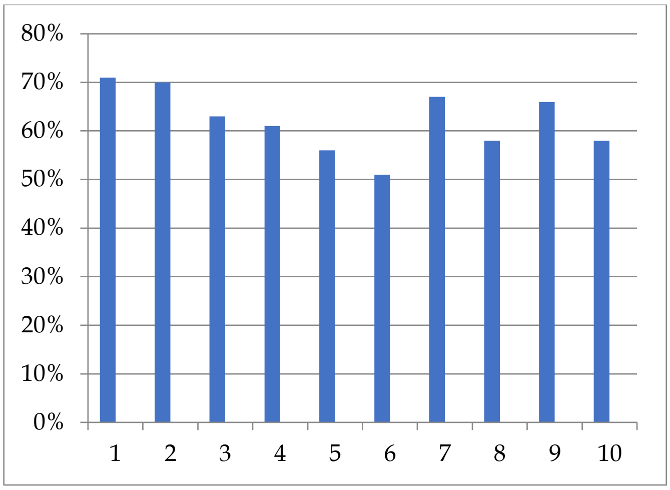

Figure 3. Results of Observation of Teacher Activities in Cycle 1

Based on figure 3, it can be seen that the teacher professional competency scores are still below 70%, which means they have not met the expected criteria of

80% or more. Therefore, reflection and follow-up are necessary in the next cycle.

Reflection on Cycle 1 Actions

Research findings in Cycle I showed that teachers' professional competence was quite good, as seen from the test results, with only 8 students achieving the Minimum Competency (KKM). Observations also showed a low level of professional competence, at 53.47%. This could be due to teachers' unfamiliarity with the TPACK learning model, which is based on Microsoft Mathematics, which is still new to the learning process.

Based on the results and issues identified in Cycle I, it is hoped that in subsequent cycles, teachers will be able to adapt to this learning model, resulting in excellent test and observation results.

Research Results for Cycle II

As with Cycle I, in the classroom action planning process for the TPACK learning model, Microsoft Mathematics assisted the researcher. The research conducted a professional competency test for teachers in Cycle II. The results showed that of the 16 teachers who took the test, 13 passed the test, representing 81.25%, and 3 failed, representing 18.75%. The results of the professional competency test indicated that the teachers' mastery of the learning material had reached the Minimum Competency Standard (KKM) of 70, which is in the "good" category. For further clarification, see the following bar chart: (Figure 4)

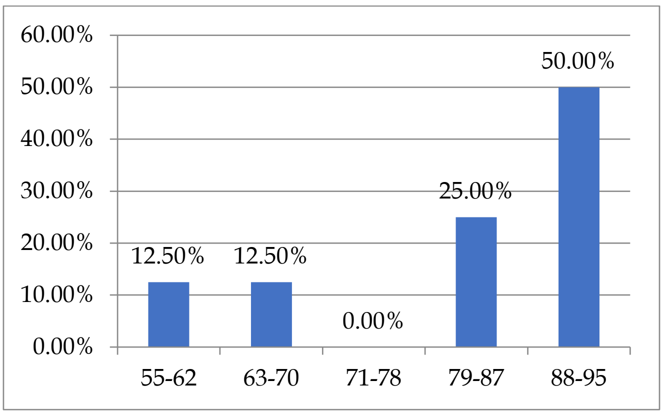

Figure 4. Results of the Cycle II Teacher Professional Competency Test

From figure 4, the results of the teacher professional competency test in cycle II can be seen that the success indicator has reached ≥ 80%, namely in the interval 63-70 with a percentage of 12.5%, 71-78 with a percentage of 0%, 79-87 with a percentage of 25% and the interval 88-95 with a percentage of 50%. So the improvements made to the learning process meet the needs to achieve the expected criteria and teachers have experienced improvements in the learning process from the previous cycle.

Cycle II Action Observation

At this stage, the researcher conducted observations to determine which team earned the most points, observed the teachers' professional competencies, and conducted observations. According to the research success indicators, "Improving teachers' professional competency through the TPACK learning model assisted by Microsoft Mathematics achieved 80% completion in the learning process." Therefore, the following is a summary of the observation results regarding teachers' professional competency using the TPACK model.

Observation Results for Teacher Activities in Cycle II

The results of observations of teacher professional competency in Cycle II showed an improvement compared to the previous cycle. Using the TPACK model with Microsoft Mathematics, the teacher achieved a very good score with a percentage of 83.62%.

From these results, it can be concluded that the achieved score met the expected criteria, which is at least good with a percentage of 80% or more. Therefore, it can be concluded that the observations conducted in Cycle I for improvement in Cycle II were successful and met the expected criteria for achievement indicators, falling within the very good category. Therefore, observations of teacher activities were discontinued in Cycle II. The overall achievement of teacher activities in Cycle II can be seen in the following diagram (Figure 5).

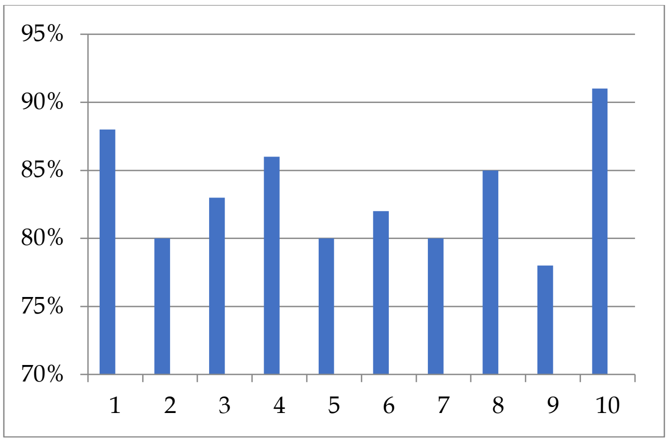

Figure 5. Results of Observation of Teacher Activities in Cycle II

Based on figure 5, the results of observations of teacher activity in Cycle II were already in the good category, with a percentage of 80% and increasing with an average percentage above 90%. This indicates that teachers were enthusiastic about the learning implemented by the researcher. Therefore, the qualification score obtained was in the "very good" category, reaching 80%. The results were in line with expectations, so this cycle was terminated.

Overall, the actions taken clearly demonstrated improvements in Cycle II and met the established success indicators. Therefore, the classroom action research was declared terminated.

Discussion

The results of this study are in line with the findings of various previous studies on the development of mathematics teachers' TPACK. Njiku (2023), in his research on the development of mathematics teachers' TPACK through observation rubrics, found that the TPACK framework is effective in assessing and developing teachers' competence to teach with technology (Mutarutinya et al., 2024b, 2024a). This finding is reinforced by Dilling, Schneider, Weigand, & Witzke (2024), who developed the MPC (Media-Pedagogy-Content) model as an extension of the TPACK model to describe the professional digital competence of mathematics teachers (Selisko & Dilling, 2025). Their research emphasizes the importance of concrete experience and reflection in the development of teachers' digital competence.

Furthermore, Smiling & Hollebrands (2025), in their research on active participation in mathematics teachers' TPACK through MOOCs, showed that active engagement in technology training significantly enhances teachers' TPACK knowledge (Prawiranegara et al., 2025). This is relevant to the findings of this study, where reflection and improvement in Cycle II successfully increased teachers' professional competence substantially.

Specifically in the context of the Teacher Professional Program (PPG), research by Mariani Dian (2025) on TPACK-based learning media design training for teachers in the PPG Daljab 2023 cohort showed that there was an increase in teachers' knowledge and skills by 9.36% after participating in the workshop. The study recommends longer training durations and active simulations for more optimal results. Meanwhile, research by Yuli (2024) on Mathematics Professional Teacher Education (TPE) Participants Viewed from TPACK analyzed the perceptions of in-service PPG participants regarding mathematics teacher professionalism based on the TPACK framework, finding that the greatest challenge for teachers is integrating technology pedagogically when facing students with different orientations.

Dilling (2024), in an explicative case study on the use of virtual reality technology in mathematics learning, illustrated the importance of considering concrete situational experiences that open new reflective levels in analyzing the development of mathematics-specific digital competence (Selisko & Dilling, 2025). These findings support the classroom action research approach taken, where reflection is a key component in each cycle.

Thus, this study strengthens and enriches previous findings by demonstrating that the TPACK model assisted by Microsoft Mathematics not only significantly improves teachers' professional competence (an increase of 31.25%) but also enhances teachers' teaching activities (an increase of 21.12%) through continuous reflection cycles.

Improving Teachers' Creativity in Mathematics Learning

Improvements in teacher professional competence in mathematics learning can be seen from the results of the teacher professional competence test conducted using the TPACK learning model assisted by Microsoft Mathematics. The test was administered after the learning process was completed at the end of each cycle, with five questions presented in each cycle. In Cycle I, the teacher professional competence test achieved a score of 50%, categorized as sufficient. Because the teacher professional competence test did not meet the success indicator, learning continued in Cycle II. In Cycle II, the score was 81.25%, categorized as good. These results indicate that the level of teacher professional competence in Cycle II met the success indicator, which is 80% or higher, with a Minimum Competency (KKM) of 70. More details on these results can be seen in Table 1.

Table 1. Improving Teacher Professional Competence

Activity	Completed Amount	Completion Percentage	Improvement
Siklus I	8 People	50%	31.25%
Siklus II	13 People	81.25 %	

Table 1 shows the percentage increase in teacher professional competence in each cycle. In cycle I, only 8 teachers out of 16 teachers who took the test obtained a passing score. In cycle II, 13 out of 16 teachers obtained a passing score. For a clearer understanding of the increase in teacher professional competence from cycle I to cycle II, the following bar chart can be seen (Figure 6).

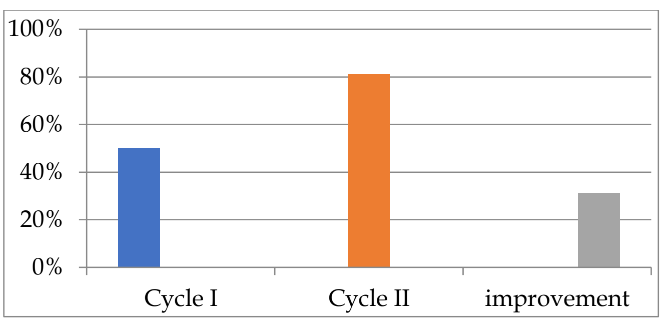

Figure 6. Improving Teacher Professional Competence

From Picture 5, it can be seen that the increase in the results of the teacher professional competency test in cycle I was at 50% and in cycle II it reached above 80% with an increase of above 30% which indicates that the TPACK learning model assisted by Microsoft mathematics can increase teacher professional competency by 81.25%. From the results above, the reflection carried out in cycle I for improvement in cycle II was declared successful.

Improvement in Teacher Activity

When viewed from the perspective of teacher activity in Cycle I, it did not meet the expected criteria. Teacher activity in Cycle I only achieved 61.25%, which is still within the sufficient criteria. Meanwhile, in Cycle II, the results showed an improvement from Cycle I, achieving 83.62%, which is categorized as very good. These results indicate that teacher activity has reached the very good category. For more details, see Table 2.

Table 2. Increase in Teacher Activities

Number	Activity	Completion Percentage	Improvement
1	Siklus I	62,5%	21.12%
2	Siklus II	83;62 %	

Table 2 shows the percentage increase in teacher activity in each cycle. In cycle I, the percentage was 62.5%, and in cycle II, it was 83.62%, categorized as very good. For more clarity on the increase in teacher activity, see the diagram below (Figure 7).

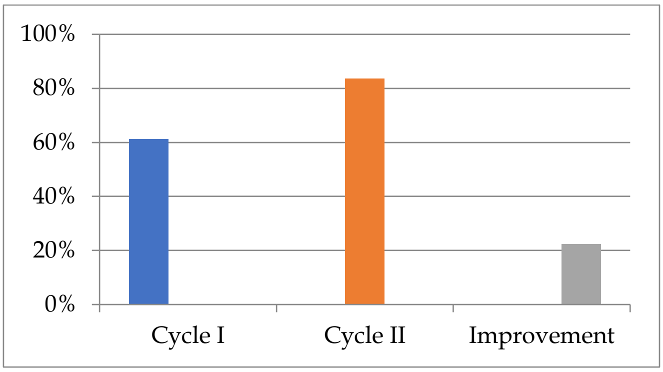

Figure 7. Increase in Teacher Activities in Cycle I and Cycle II

From Picture 6, it is clear that the results obtained in cycle I did not reach the expected research target of 60%≤80%. Meanwhile, in cycle II, teacher activity had increased and the results obtained had reached the expected criteria with a percentage of ≥80% with an increase of over 20%. Therefore, it can be concluded that the reflection carried out in cycle I and for improvements in cycle II were declared successful.

As with previous research related to the variables studied, the average mathematics learning outcomes of students through Microsoft Mathematics-based AIR learning were obtained at 76.66% of 30 students who took the test or met the minimum completeness criteria (KKM), which was 75%. And for the results of student activities, the overall percentage value was 81%, and for the results of student activities, the overall percentage value was 80% (Sormin et al., 2023). The results of this study indicate that t count > t table, namely 3.156 > 1.71 so that H0 is rejected. This indicates that the learning achievement of first-year students taught using Microsoft Mathematics media in the School Mathematics II subject is higher than that of students taught without using the media (Mayasari et al., 2021). The results of the study indicate that the TPACK ability of PPG students at the PAUD level is included in the very good category based on the average value obtained (Sativa et al., 2023).

Research Limitations

The research conducted using the TPACK learning model, supported by Microsoft Mathematics, as an effort to improve teachers' professional competence, has limitations. These limitations include teachers' lack of understanding of how to solve math problems creatively and quickly, requiring the researcher to first address other math subjects. Furthermore, the time allocated by the school limited the research to the core material taught.

Conclusion

The TPACK model assisted by Microsoft Mathematics is proven effective in enhancing the professional competence of Mathematics teachers in the PPG program, marked by an increase in test mastery from 50% (Cycle I) to 81.25% (Cycle II) and an improvement in teacher activity from 61.25% to 83.62%.

Acknowledgment

The authors would like to express their gratitude to the University of Muhammadiyah Tapanuli Selatan for facilitating the implementation of this study. Special thanks are extended to the in-service PPG student teachers for their cooperation and active participation throughout the research process.

Author Contributions

All authors contributed to writing this article.

Funding

No external funding

Conflicts of Interests

No conflict interest.

References

Albar, R., Susilawati, S., & Fatmawati, D. P. (2022). Penerapan Media Pembelajaran Berbasis Augmanted Reality Pada Materi Phytagoras Untuk Meningkatkan Literasi Matematika Siswa. *Seminar Nasional Pendidikan Matematika Tahun* 2022, 3(1).

Ammade, S., Mahmud, M., Jabu, B., & Tahmir, S. (2020a). TPACK Model Based Instruction In Teaching Writing: An Analysis On Tpack Literacy. *International Journal Of Language Education*, 4(1), 129–140. https://doi.org/10.26858/ijole.v4i2.12441

Ammade, S., Mahmud, M., Jabu, B., & Tahmir, S. (2020b). TPACK Model Based Instruction In Teaching Writing: An Analysis On Tpack Literacy. *International Journal Of Language Education*, 4(1). https://doi.org/10.26858/ijole.v4i2.12441

Barut, M. E. O. B., Wijaya, A., & Retnawati, H. (2021). Hubungan Pedagogical Content Knowledge Guru Matematika Dan Prestasi Belajar Siswa Sekolah Menengah Pertama. *Pythagoras: Jurnal Pendidikan Matematika,* 15(2). https://doi.org/10.21831/pg.v15i2.35375

Fitriyah, S. N., Sutadji, E., & Indra Dewi, R. S. (2025). Enhancing Primary School Teachers' Professional Competence Through The Technological Pedagogical Content Knowledge (TPACK): A Systematic Literature Review. *Pertanika Proceeding,* 1(2). https://doi.org/10.47836/pp.1.2.023

Hadi, F. R., Anggrasari, L. A., & Maruti, E. S. (2023). Pendampingan Program Satu Guru Tiga Media Sebagai Kreativitas Dalam Mengembangkan Media Berbasis Tpack (Technological Pedagogical And Content Knowledge). *Jmm (Jurnal Masyarakat Mandiri),* 7(1). https://doi.org/10.31764/jmm.v7i1.11803

Hardanti, P., Murtinugraha, R. E., & Arthur, R. (2024). Studi Literatur: Pemanfaatan Pendekatan Tpack (Technological, Pedagogical, And Content Knowledge) Pada Pengembangan E-Modul Pembelajaran. *Jurnal Teknologi Pendidikan*, 1(3). https://doi.org/10.47134/jtp.v1i3.307

Hartati, T. (2019). *Techonological Pedagogical Content* Knowledge (Tpack) Dalam Rangka Peningkatan Kualitas Pembelajaran Mahasiswa PPG SD Prajabatan. *Edutech*, 18(2). https://doi.org/10.17509/e.v18i2.15092

Hidayati, N., Setyosari, P., & Soepriyanto, Y. (2021). Kompetensi Technological Pedagogical Content Knowledge (Tpack) Guru Kimia. *Jurnal Kajian Teknologi Pendidikan*, 1(4).

Intyassandy, D. S. L., Destiniar, D., & Septiati, E. (2022). Development Of Mathematics E-Book On Pythagorean Theorem Material. *Pythagoras Jurnal Pendidikan Matematika,* 17(1). https://doi.org/10.21831/pythagoras.v17i1.44968

Lestary, R., Dewi, C., Pitriani, L., Hutasuhu, R. P., & Siagian, T. A. (2023). Respon Guru Dan Siswa Smp Negeri 17 Kota Bengkulu Terhadap Media Pembelajaran Lcr Math Berbasis Android Pada Materi Teorema Pythagoras. *Jurnal Penelitian Pembelajaran Matematika Sekolah (Jp2ms),* 7(1). https://doi.org/10.33369/jp2ms.7.1.37-46

Mayasari, N., Hasanudin, C., Fitrianingsih, A., Jayanti, R., Setyorini, N., Kurniawan, P. Y., & Nurpratiwiningsih, L. (2021). The Use Of Microsoft Mathematics Program Toward Students' Learning Achievement. *Journal Of Physics: Conference Series,* 1764(1). Https://Doi.Org/10.1088/1742-6596/1764/1/012132

Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A Framework For Teacher Knowledge. *In Teachers College Record* (Vol. 108, Number 6, Pp. 1017–1054). Teachers College, Columbia University. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Mutarutinya, V., Balimuttajjo, S., Mjenda, M. A., Wakhata, R., Mukuka, A., & Njiku, J. (2024a). Assessment In Mathematics Education. https://doi.org/10.4018/979-8-3693-2873-6.ch006

Mutarutinya, V., Balimuttajjo, S., Mjenda, M. A., Wakhata, R., Mukuka, A., & Njiku, J. (2024b). Assessment In Mathematics Education: An Inquiry Into Methods And Skills Assessed In The Era Of Globalization. *In Impacts Of Globalization And Innovation In Mathematics Education*. https://doi.org/10.4018/979-8-3693-2873-6.ch006

Njiku, J. (2024). Assessing The Development Of Mathematics Teachers Tpack Through An Observation Rubric. *Education And Information Technologies,* 29(2). https://doi.org/10.1007/s10639-023-11901-7

Ovilia, R., Rosita, N., & Putri, M. A. (2023). Penguatan Tpack Bermodel Samr Berbasis Mobile-Aided Instruction Bagi Guru Smpn 2 Padang Panjang. *Adbi Humaniora*, 5(1).

Prawiranegara, I., Ardiansyah, & Mohehu, F. (2025). Mahadewa Journal Of Education. "The Role Of Artificial Intelligence Utilization And Digital Literacy In Students' Independent Learning." 2025. *Indonesian Journal Of Educational Development (Ijed*), 6(1).

Purnomo, B. H. (2011). Metode Dan Teknik Pengumpulan Data Dalam Penelitian Tindakan Kelas (Classroom Action Research). *Jurnal Pengembangan Pendidikan,* 8(1).

Rabi, F., Fengqi, M., Aziz, M., & Ihsanullah, M. (2022). The Impact Of Microsoft Mathematics Visualization On Students Academic Skills. *Education Research International*, 2022. https://doi.org/10.1155/2022/5684671

Rahayu, E. M., Rahayu, E. Y., & Irawan, N. (2023). Technological Pedagogical Content Knowledge (Tpack) In The Instruction Design Of The Participants In Teacher Profession Education: A Narrative Inquiry Case Study. *Kwangsan: Jurnal Teknologi Pendidikan*, 11(1). https://doi.org/10.31800/jtp.kw.v11n1.p312--327

Rahayu, S., Harisnawati, H., Sriwahyuni, Y., Hidayah, A., & Saputra, H. (2024). Peningkatan Profesional Guru Melalui Penelitian Tindakan Kelas Guru Sma 2 Gunung Talang Kabupaten Solok. *Jurnal Pengabdian Masyarakat Bangsa,* 1(11). https://doi.org/10.59837/jpmba.v1i11.618

Rughoobur-Seetah, S., & Hosanoo, Z. A. (2021). An Evaluation Of The Impact Of Confinement On The Quality Of E-Learning In Higher Education Institutions. *Quality Assurance In Education*, 29(4). https://doi.org/10.1108/qae-03-2021-0043

Salsabila, E., Hermin, F., & Permana, A. A. (2024). Development Of E-Tracer Study At Faculty Of Mathematics And Natural Science, State University Of Jakarta, Indonesia. *Aip Conference Proceedings,* 2982(1). https://doi.org/10.1063/5.0184818

Santos, J. M., & Castro, R. D. R. (2021). Technological Pedagogical Content Knowledge (Tpack) In Action: Application Of Learning In The Classroom By Pre-Service Teachers (Pst). *Social Sciences And Humanities Open,* 3(1). https://doi.org/10.1016/j.ssaho.2021.100110

Sativa, F. E., Musaddat, S., Amrullah, L. W. Z., & Wahab, A. D. A. (2023). Profil Kemampuan Tpack Mahasiswa Ppg Dalam Jabatan Kategroi 1 Jenjang Paud. *Jurnal Mutiara Pendidikan*, 3(2). https://doi.org/10.29303/jmp.v3i2.4800

Schmid, C., & Schiffels, S. (2021). Bleiglas: An R Package For Interpolation And Visualisation Of Spatiotemporal Data With 3d Tessellation. *Journal Of Open Source Software,* 6(60). https://doi.org/10.21105/joss.03092

Schmid, M., Brianza, E., & Petko, D. (2021). Self-Reported Technological Pedagogical Content Knowledge (Tpack) Of Pre-Service Teachers In Relation To Digital Technology Use In Lesson Plans. *Computers In Human Behavior*, 115. https://doi.org/10.1016/j.chb.2020.106586

Selisko, T. J., & Dilling, M. (2025). The Opposition To Inclusive Education: Authoritarianism And Social Darwinism And Their Impact On Exclusive Attitudes In Education. *International Journal Of Changes In Education*. https://doi.org/10.47852/bonviewijce52024575

Sormin, M. A., Agustina, L., Samosir, B. S., Herawati Parapat, L., Khairunnisa, K., & Karimah, A. (2023). Comparative Study Of Water Based On Microsoft Mathematics With Traditional Learning. *Naturalistic: Jurnal Kajian Dan Penelitian Pendidikan Dan Pembelajaran*, 8(1). https://doi.org/10.35568/naturalistic.v8i1.4092

Sri Astutik, Subiki, & Singgih Bektiarso. (2021). Pelatihan Penelitian Tindakan Kelas (Ptk) Bagi Guru Sman Panarukan Situbondo. *Jurnal Inovasi Penelitian Dan Pengabdian Masyarakat*, 1(1). https://doi.org/10.53621/jippmas.v1i1.5

Sugiyono 2019. (2018). *Sugiyono- Metode Penelitian Kuantitatif Kualitatif Dan R&D (Sutopo (Ed.); Edisi Kedua).* Alfabeta. Metode Penelitian.

Suherman, A. (2022). Upaya Meningkatkan Kemampuan Menulis Puisi Menggunakan Metode Akrostik (Penelitian Tindakan Kelas). Silampari Bisa: *Jurnal Penelitian Pendidikan Bahasa Indonesia, Daerah, Dan Asing*, 5(1). https://doi.org/10.31540/silamparibisa.v5i1.1720

Sukardi. (2022). *Metode Penelitian Pendidikan Tindakan Kelas Implementasi Dan Pengembangannya*. In Hukum Perumahan.

Suyamto, J., Masykuri, M., & Sarwanto. (2020a). Analisis Kemampuan Tpack (Technolgical, Pedagogical, And Content, Knowledge) Guru Biologi Sma Dalam Menyusun. *Jurnal Pendidikan IPA*, 9(1).

Suyamto, J., Masykuri, M., & Sarwanto, S. (2020b). Analisis Kemampuan Tpack (Technolgical, Pedagogical, And Content, Knowledge) Guru Biologi Sma Dalam Menyusun Perangkat Pembelajaran Materi Sistem Peredaran Darah. *Inkuiri: Jurnal Pendidikan IPA*, 9(1). https://doi.org/10.20961/inkuiri.v9i1.41381

Zulfikar, M. (2023). Kompetensi Tpack Calon Guru Pendidikan Jasmani Sekolah Dasar. Cokroaminoto *Journal of Primary Education*, 6(2), 146–153. https://doi.org/10.30605/cjpe.622023.2584