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Implementation of Problem Based Learning Integrated TPACK to Promote Students' Mathematical Reasoning Ability

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Abstrak

Penelitian ini adalah penelitian tindakan kelas yang bertujuan untuk meningkatkan kemampuan penalaran matematika siswa melalui implementasi pembelajaran TPACK. TPACK pada penelitian ini adalah kemampuan guru membuat MICROSITE untuk melaksanakan proses pembelajaran. Subjek pada penelitian ini adalah siswa kelas XI IPA 1 SMAN 1 Sarj Kab. Pasangkayu. Penelitian ini terdiri dari 2 siklus dengan tahapan merencanakan tindakan, melakukan tindakan, melakukan pengamatan, melakukan refleksi. Instrumen yang digunakan pada penelitian ini yaitu lembar keterlaksanaan pembelajaran PBL-TPACK dan tes kemampuan penalaran matematika. Hasil penelitian menunjukan bahwa pada akhir siklus 2, rata-rata aktivitas guru dan siswa berada pada kategori sangat baik dengan nilai masing-masing 89.67% dan 88.02%. Sementara itu, rata-rata skor kemampuan penalaran matematika siswa sebesar 90 dimana semua siswa tuntas. Berdasarkan hasil penelitian dapat disimpulkan bahwa kemampuan penalaran matematika siswa meningkat melalui penerapan PBL terintegrasi TPACK. Ke depannya peneliti lain dapat mengkombinasikan PBL dengan berbagai macam media teknologi pembelajaran atau platform pembelajaran daring.

Kata Kunci: Kemampuan penalaran matematika , PBL, TPACK

Abstract

This Classroom-Action Research aimed to promote students' mathematical reasoning ability as integrated with TPACK. In this study, the TPACk referred to is learning media developed by teachers using microsite. The subjects of this research were students in the eleventh grade, XI IPA 1, SMAN 1 Sarjo, Pasangkayu. 2 cycles were conducted as the research steps, such as making plans, doing the actions, doing observations, and doing several reflections. The instruments used in this research were the PBL-TPACK learning implementation sheet and mathematical reasoning ability test. The results of the study revealed that at the end of cycle 2, the average score of teacher and students' activities was in the very good category with total score of 89.67% and 88.02% respectively. Meanwhile, the average score of students' mathematical reasoning ability was 90, with the maximum total number of all students. Based on the study results, it can be concluded that students' mathematical reasoning ability increased through the implementation of integrated PBl TPACK. In further researches, other researchers can combine PBL learning with more effective technology media or online learning platforms

Keywords: *Mathematics reasoning ability, PBL, TPACK*

INTRODUCTION

Reasoning is one of the main competencies for the students in learning Mathematics (Sugandi et al., 2020). Reasoning ability should be mastered by the students in order to be able to make analysis and conclusion. Pusmendik (2022) reveals that reasoning activities consist of: 1) students' ability in asking a question, 2) students' ability in identifying and processing some information, 3) students' ability in analyzing and evaluating the reasoning activities, 4) students' ability in making reflection and evaluating their thinking abilities. On the other hand, reasoning abilities consist of several aspects, as follows: 1) students' ability in identifying patterns, 2) students' ability in making predictions, 3) students' ability in explaining how to solve problems (Aprisal & Abadi, 2018).

In high school level (SMA), reasoning skills are not only needed by students to understand some learning materials in Mathematics, but also to prepare students to the real social life, work environment, and higher education. (National Council of Teacher of Mathematics, 2009). Reasoning and Mathematics cannot be separated to each other. Good reasoning skills will make students able to understand Mathematics more easily, and by learning Mathematics students can improve and develop their reasoning skills as well (Wibowo, 2017; Tukaryanto et al., 2018; Utari & Hartono, 2019).

The importance of reasoning in learning mathematics has been explained in the Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 21 of 2016 concerning the content standards of elementary and secondary education, as one of the important competencies that students must master is Mathematical reasoning ability (Minister of Education and Culture of the Republic of Indonesia, 2016). In line with this regulation, in the 2013 Curriculum, reasoning is one of the competencies that must be developed by students (Fithriyyati & Maryani, 2018). On the other hand, reasoning activities are one of the six (6) dimensions that can build the true values of Pancasila in students' souls (Purwanto, Yusmin, & Yamin T, 2023). Materials about reasoning ability designed in the Indonesia Independent Curriculum (Kurikulum Merdeka) has an important role in helping students to optimize and strengthen the concepts learned (Kemendikbudristek, 2022).

However, the importance of reasoning ability in mathematics and real life is not in line with the real conditions of teaching and learning mathematics, especially for Indonesian students. Meanwhile, reasoning is one of the aspects of high-level abilities based on Programme for International Students Assessment (PISA) (Vebrian et al., 2021). According to PISA (2022), the mathematical abilities acquired by Indonesian students are still relatively low, which the mathematics scores of Indonesian students were still 70 (Kemendikbudristek, 2023). Research by Vebrian et al., (2021) identified that students' mathematical reasoning abilities were still in the low category for all indicators measured. The indicator for performing mathematical manipulation and constructing arguments only reached 42.88%. Meanwhile, in the indicator for making conclusions, only 41.36% of students were able to provide correct conclusions. Other studies have also found that students' mathematical reasoning abilities in solving PISA-equivalent problems in geometry content are also still relatively low (Asdarina & Ridha, 2020).

Various factors that influences Indonesian students' mathematical reasoning abilities to be in low category is the first, the learning resource that does not facilitate students to carry out reasoning activities in the school. Utari & Hartono (2019) revealed that the textbooks used by students did not fully provide opportunities for students to solve problems that require reasoning abilities. The second factor is that students are not involved in solving problems that require critical reasoning skills (Vebrian et al., 2021). The third factor is the learning processes in the classroom, such as the way teachers respond, choose learning models, and implement learning also determine student achievement (Rahmawati & Suyanto, 2014). Therefore, teachers must have good mathematical skills and good classroom management in order to help students develop their reasoning abilities as well (Wijaya et al., 2021).

Problem-based learning (PBL) is one of the learning models that can be used by teachers to improve students' mathematical reasoning skills (Sari et al., 2020; Sugandi et al., 2020; Nurlinda et al., 2024). In line with that, another opinion states that PBL is a model designed to help students improve their thinking skills and solve mathematical problems that require critical reasoning (Sumartini, 2015). In PBL learning, the materials presented to the students are in the form of non-routine problems in the real world (Awan et al., 2017). In addition, non-routine problems are not only in the form of arithmetic calculations but require reasoning abilities to solve them (Sugandi et al., 2020). In PBL, teachers act as facilitators and mediators to help students construct and solve problems effectively. PBL has several learning steps including: 1) finding problems, 2) organizing problems, 3) conducting group investigations, 4) presenting work results, 5) making reflection or evaluating the problem-solving process (Lestari et al., 2021). Dewi & Nurjanah (2022) stated that PBL has five stages, namely: 1) finding problems, 2) planning solutions, 3) implementing the plans for problem solving, 4) presenting the results, 5) making reflection or evaluating the results. Hence, it reveals that by implementing PBL, students will involve their high-level thinking skills in solving the problems. Students are not only required to solve problems but also students must be able to provide arguments for the problem-solving solutions revealed.

Various previous studies have revealed that PBL is effective in improving students' mathematical reasoning skills. A meta-analysis study by Suparman et al. (2021) tested the effectiveness of PBL using 7 moderating variables (sample size, education level, research setting, sample selection technique, year of publication of the article, journal used, and type of publication) found that students' reasoning and problem solving improved after being taught using PBL. Other studies have shown that PBL has a strong influence on students' mathematical reasoning skills (Fitriyah et al., 2022). In line with that, Nurlinda et al. (2024) explained that PBL has a significant influence on improving students' mathematical reasoning skills. The success of teachers in using learning models, especially PBL, is greatly influenced by the teacher's knowledge, pedagogical skills, and ability to use technology. In the learning process, these three teacher abilities are known as TPACK (technological, pedagogical, content knowledge). TPACK is a proper way for teachers to share learning materials using technology. Integration of technology in learning is currently a requirement for teachers as a habit due to online learning during Covid-19. TPACK is the beginning to change the paradigm and way teachers teach (Fakirah & Firdaus, 2020). TPACK is a combination of teachers' ability to use and develop technology-based learning and teachers' ability to determine the appropriate learning model or strategy (Waluyo & Nurani 2021). Research by Ayunda et al., (2022) that PBL learning based TPACK can improve students' high-level thinking skills. Through PBL learning based TPACK, learning objectives can be achieved well. In line with that, other studies have revealed that PBL learning with the TPACK approach has an effect on students' mathematical abilities, especially students' problem-solving abilities and mathematical literacy (Marliani et al., 2023). The results of other studies also explain that the implementation of the TPACK approach PBL model using interactive media can improve teacher activity, student activity, and students' mathematics learning outcomes (Amalia & Radiansyah, 2023). Therefore, teachers are not only required to have and improve their professional skills, pedagogical skills, personal skills, social skills but also teachers must improve their abilities in the field of technology related to learning. Based on the problems and descriptions, the purpose of this study is to improve students' mathematical reasoning skills by implementing problem-based learning integrated with TPACK.

METHOD

In conducting this classroom action research, two schemes proposed by Kemmis & Taggar were implemented. In addition, two cycles were conducted as well. The Kemmis and Taggart model was chosen in this study because this model is considered quite effective as a guide to improving the learning process and improving students' mathematics learning achievements. Each cycle consists of four steps, such as making plans, conducting the actions, conducting observations, and conducting several reflections or evaluations. The subjects of this research were students of the eleventh grade, XI IPA 1 of SMA Negeri Sarjo with total number of 25 students. The reasoning ability indicators used in this study are: 1) identifying patterns, 2) predicting results, 3) providing appropriate arguments. Meanwhile, the steps of the PBL integrated TPACK learning model used in this study are as follows:

Table 1. Steps in PBL-TPACK

No	Step	Teacher's Activity	Students' Activity
1	Problem orientation	The teacher divides the students into several groups consisted of 3-4 members, and gives instructions to the students.	The students are gathered based on the group. Each group has to open the microsite link to access the learning material and the learning activities.
2	Designing some plans before solving the problem	The teacher gives instructions to every group to make plans before designing strategies to solve the problem.	Each group has to open the microsite, and open LKPD.
3	Solve the problem	The teacher gives time and guidance if there are any difficulties in each group.	The students work with their own group to solve the problem based on their previous plans.
4	Presentation	The teacher facilitates the representative of the group to present the results of their discussion.	Every group has to submit their assignment in the 'Submission' menu. Hence, the assignments can be accessed anywhere and anytime.
5	Reflection	The teacher gives a reflection related to what they have learned, and guides the students to fill in the microsite.	The students do the instruction to fill in the 'Reflection' menu on the microsite.

One of the advantages of learning by implementing PBL integrated with TPACK is that students do not need to take notes and focus more on understanding the materials, since the materials used in PBL-TPACK learning is presented not only in the form of online learning subject, but also in the form of learning videos that can be accessed anytime and anywhere by students.

The instruments used in this study consisted of a mathematical reasoning ability test, a questionnaire for students, and an observation sheet for the implementation of learning. The data analysis technique for this study consisted of:

The score of students' mathematical reasoning ability was calculated using this formula:

$$score = \frac{the\ number\ of\ scores\ obtained\ by\ students}{total\ score} x100$$

Table 2. Criteria of Students' Mathematical Reasoning Ability

Score	Criteria
90-100	Very High
80-89	High
70-79	Medium
60-69	Low
0-59	Very Low

Implementation of PBL-TPACK Learning Process

$$\text{Percent} = \frac{\text{the number of learning steps implemented}}{\text{total number of learning steps}} x 100\%$$

Table 3. Implementation of PBL-TPACK Learning Process Criteria

Score	Criteria
86-100	Very Good
76-85	Good
66-75	Medium
51-65	Not good
≤ 50	Failed

After the data was collected and analyzed, the implementation of PBL integrated with TPACK learning effectively improved students' mathematical reasoning skills if it met the following criteria:

1. 75% or more of students in class XI IPA 1 SMAN 1 Sarjo are in the high category for mathematical reasoning skills.
2. 85% or more of the PBL-TPACK learning steps are implemented well.

RESULT AND DISCUSSION

This classroom action research was conducted in the eleventh grade, XI IPA 1 of SMAN 1 Sarjo. XI IPA 1 consists of 25 students. This classroom action research was conducted for 2 cycles. The first cycle consisted of 3 meetings and the second cycle consisted of 2 meetings. The activities of this research were adjusted to the subjects taught in XI IPA 1 SMAN 1 Sarjo. During the research, starting from the first meeting in cycle 1 to the second meeting in cycle 2, the learning activities were always followed by all students of class XI IPA 1. During the research, the teacher or implementer of the learning process was a mathematics teacher, Mr. Supriadi, S.Pd., M.Pd. Gr. Meanwhile, the researcher acted as an observer assisted by two students.

The research was conducted based on the classroom action research framework developed by Kemmis & Taggart. Each cycle in this classroom action research consists of four stages, namely planning actions, taking actions, observing, and reflecting. The description of activities in each cycle is described as follows.

Description of Cycle 1

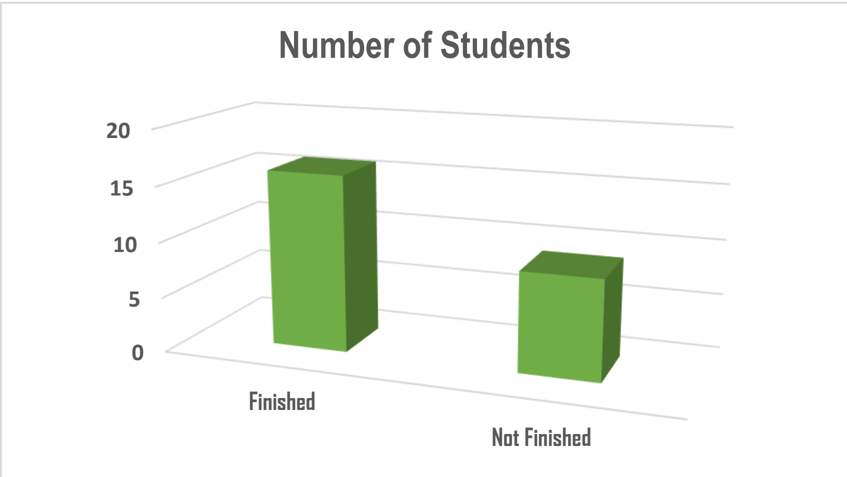
The first stage in this study was to conduct preliminary observations of the class that would be the setting of the research. In addition, there were several things that needed to be prepared by the researcher and the teacher. These preparations consisted of: 1) determining learning materials, 2) compiling learning devices. The learning devices used in this study included teaching modules and student worksheets (LKPD). The teaching modules were designed by implementing problem based learning (PBL) model integrated with TPACK. At this stage, the teacher also created a Google microsite and uploaded all teaching materials into the microsite. Finally, at the planning stage, the researcher compiled a research instrument consisting of a mathematical reasoning ability test and an observation sheet for the implementation of learning.

The second stage in this study was to take action. Before the PBL-TPACK learning model was implemented, the researcher first conducted a pre-test on students' mathematical reasoning abilities. The results of the pre-test are as follows:

Table 4. The Result of Students' Pre-Test in Mathematical Reasoning Ability

Total number of students	Category
25	Not passed
0	Passed

Based on Table 4, it is obtained that students' mathematical reasoning ability is still relatively low. This condition can be identified from the 25 students who took the pre-test, no students passed or met the minimum standard of 72. Cycle 1 in this study was carried out for three meetings. Learning was carried out in accordance with the teaching module that had been prepared previously. The learning carried out was problem-based learning (PBL) integrated with TPACK. Learning carried out by the teacher presents a problem context that is close to students' lives to understand the mathematical concepts being taught. The problem is solved by students on student worksheets accessed via a Microsite link. On this Microsite link, LPKD has been provided for students and electronic teaching materials that help students solve the mathematics problems. The existence of a Microsite developed by the teacher shows that Mathematics teachers at SMAN 1 Sarjo have been able to develop competencies in the field of technology to help carry out effective and enjoyable learning. After the three meetings were carried out in cycle 1, there was an increase in students' mathematical reasoning ability. The results of the cycle 1 post-test can be seen in the following picture.



Picture 1. Posttest of Students' Mathematical Reasoning Ability Cycle 1

Picture 1 shows that there is a significant increase in students' mathematical reasoning ability after the implementation of PBL learning integrated with TPACK. It can be seen that there was 16 students who have achieved the minimum value that had been designed for students' mathematical reasoning ability. Hence, there are 64% of the number of students in Class XI IPA 1 who have met the research success criteria.

The third stage in cycle 1 is observation. Observation is carried out with the aim of observing the ongoing learning process, whether it is in accordance with the PBL-TPACK learning steps. This activity is also part of the observer to identify learning deficiencies during cycle 1. The activities of teachers and students during the learning process are explained as follows.

Table 5. The Implementation Learning of Cycle 1

The Observation Results	Meeting 1	Meeting 2	Meeting 3	Average
Teacher's Activities	66.55%	78%	85%	76.52%
Students' Activities	62.33%	74.26%	80.85%	72.48%

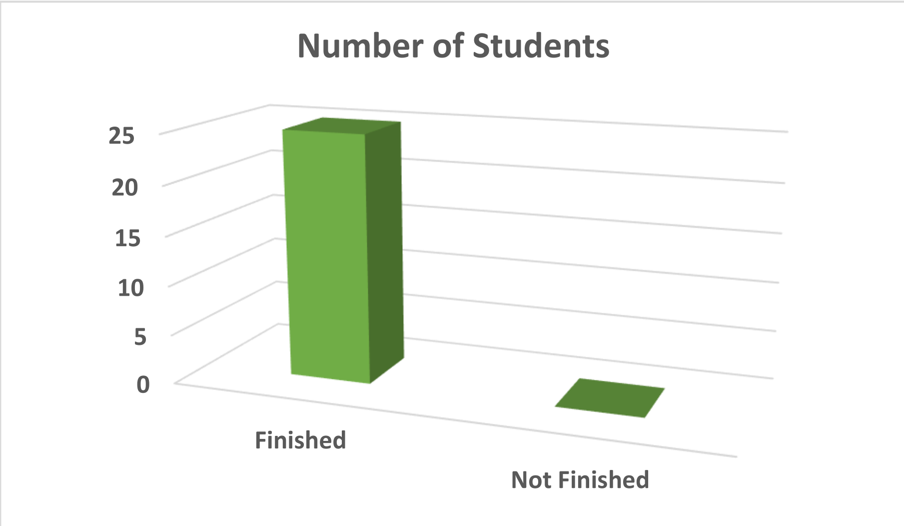
Based on the results of Cycle 1 reviewed from students' mathematical reasoning abilities and the implementation of learning, it can be concluded that the expected results have not reached the target. There are several reflection results found by researchers, including: students still have difficulties in understanding the learning that is applied, the students still need help other to solve problems, the time duration is not optimal to conduct the learning steps completely, and the teachers need to add a reflection menu and other additional menus to identify student difficulties at each meeting.

Description of Cycle 2

Overall, the implementation of cycle 2 is the same as the stages in the first cycle. First stage iof cycle 2 is planning stage. The teacher has made several preparations before implementing learning since the learning process is carried out properly. Based on the results of reflection in cycle 1, the teacher has added new menu on the microsite. The menus include the reflection menu and learning video menu. Another preparation made by the teacher is to revise the teaching module and the available time can be optimized properly in conducting the learning. The following is a display of the microsite that was improved based on reflection on cycle 1.

Picture 2. Face of Microsite

Learning in cycle 2 was carried out for 2 meetings. The learning that was implemented implemented smoothly, as compared to learning in cycle 1. The obstacles encountered in cycle 1 could be overcome well by the teacher. It can be seen that students are no longer confused during the implementation of PBL integrated TPACK learning. Student group in solving problems is very good and they were able to provide appropriate arguments for the solutions prevented. Good student understanding can be seen at the end of cycle 2. The post-test score of students' mathematical reasoning ability has increased and the implementation of learning in cycle 2 is as follows.



Picture 3. Posttest of Students' Mathematics Reasoning Ability Cycle 2

Picture 3 above shows that there are 25 students who have been able to achieve the minimum score for mathematical reasoning ability. This condioton indicate all students of XI IPA 1 passed the post-test of mathematical reasoning ability in cycle 2. The average score of students' mathematical reasoning ability is 90 which is in the very high category. Thus, PBL integrated TPACK learning is effective in improving mathematical reasoning ability

Tabel 6. The Implementation Learning of Cycle 2

The Observation Results	Meeting 1	Meeting 2	Average
Teacher's Activities	85.56%	93.78%	89.67%
Students' Activities	85.56%	90.48%	88.02%

In line with Picture 3 explanation, in Table 6, the implementation of learning in cycle 2 has reached the predetermined learning effectiveness indicator. Thus, this classroom action research stopped in cycle 2.

PBL is learning that begins with giving a problem. The problem given is a problem that exists in students' life. Solving the given problem makes students able to obtain new knowledge and they are able to explain the solution (Nurlaily et al., 2019). PBL is a learning model that facilitates students to use their reasoning skills to solve problems (Wulandari & Shofiyah, 2018). The first stage of PBL is to orient students to the problem (Dewi & Nurjanah, 2022). In solving the problem, students must first understand the problem, then develop a solution plan. The solution plan will be found by students through group discussions by connecting and applying all their preliminary knowledge related to the problem (Savery, 2015). By implementing PBL, students will practice to make critical reasoning since the problems given are non-routine problems (Sugandi et al., 2020). Non-routine problems focus on training students to solve these problems using mathematical reasoning. In group discussions, students will use learning resources that have been provided using Microsite link. The learning resources available are not only in the form of readings but also learning videos. The advantage of using Microsite in PBL learning is the students can access learning resources both during learning or after learning has finished. In addition, students can also access the results of their discussions and compare them with the results of other group discussions. During the discussion, the teacher controls the discussion and provides assistance as needed to groups that have difficulties. The final stage of PBL is the presentation as the practice for students to explain solutions with appropriate arguments. In line with the results of this study, various research results explain that PBL is effective in improving students' mathematical reasoning abilities (Fitriyah et al., 2022; Kotto et al., 2022; Suryani et al., 2023; Nurlinda et al., 2024). The implementation of TPACK in the form of creating Microsite in PBL learning shows that teachers have developed and improved their abilities in implementing technology-based learning. In addition, with the tone of Microsite in PBL learning, students are able to understand the material well. More specific research shows that teachers who implement TPACK integrated PBL learning are able to improve students' high-level thinking skills. Students in solving problems using high-level thinking skills certainly require reasoning skills. Reasoning skills will help students analyze problems, plan solutions and make conclusions. The conclusions made by students certainly require students to be able to provide the right arguments for their answers. Through PBL, students will build their own knowledge through problems discussed with their group members. In the discussion, various ideas will emerge on how to solve problems so that indirectly knowledge is formed by itself. At the presentation stage, the teacher will also provide reinforcement for the concepts being studied. The role of TPACK shows the teacher's ability to use and compile learning media based technology. TPACK also provides benefits to students to focus more on learning and can access learning anytime and anywhere.

CONCLUSION

Based on the results of the study conducted in XI IPA 1 SMAN 1 Sarjo, it can be concluded that the implementation of PBL integrated with TPACK has a positive impact, such as improving students' mathematical reasoning abilities. In further researches, other researchers can combine PBL learning with more effective technology media or online learning platforms. In addition, other researchers can also explore further how to improve students' other mathematical abilities such as mathematical communication skills, problem solving skills, etc. using PBL-TPACK (Mircosite) learning.

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