



## Development of problem based learning model integrated TPACK to improve problem solving ability

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**Abstract:** This study aims to develop of Problem Based Learning model integrated TPACK to improve problem solving ability. The research method used is Dick & Carey model development research including needs analysis, product design, product development, product implementation and evaluation. The subjects of this study were grade VIII students of SMPN 2 Selong which numbered 30 students. Instruments used to collect data include product validation guidelines, product practicality questionnaires and problem-solving ability tests on geometry materials. The data collected in this study were analyzed using descriptive analysis. Based on the data analysis carried out, the product developed is classified as valid as indicated by the average product validation score by 3 experts, namely 79.4; 79,9; and 80.8. Product trials were carried out 4 times and showed that the products developed were relatively practical. The product is also classified as effective with an effectiveness percentage of 86.67%. The developed product has a potential effect in improving mathematical problem solving ability with N-Gain of 0.81 with a high category.

**Keywords:** Problem based learning; Problem solving; TPACK

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### INTRODUCTION

Demands 21st century learning is characterized by the presence of technology, which affects the management of learning and student characteristics which are a challenge for teachers. These challenges can be overcome by developing creative, critical and higher-order thinking skills (NCTM, 2000). Teachers in conducting learning have not emphasized how to develop students' thinking skills in facing and solving real problems encountered in everyday life (Yanti, 2019). PISA 2018 result, Indonesian students' mathematical literacy ranks 72 out of 78 countries with a score of 379 and an average international score of 489 (OECD, 2019). Meanwhile, TIMSS 2019, Indonesia did not participate in this study (Mullis, 2020). This problem can be overcome by choosing learning strategies that suit student characteristics and involve students actively in learning that allows students to determine how to solve the problems faced (Khaulah, 2018; Siswono, 2008). In solving mathematical problems, students are required to use thinking skills in extracting various ideas and knowledge from various sources and it takes the ability of teachers to design learning that is able to develop students' thinking skills (Waluyo, 2021).

Solving mathematical problems faced by students in everyday life can be done one day by developing students' thinking skills (Waluyo, 2020). In facing the demands of today's 21st century learning, teachers must be able to design learning that is able to develop problem solving skills. Sugiman (2019) in his research said that activities in learning that are difficult for



students to do are developing problem-solving skills. This low problem-solving ability is due to the learning carried out by the teacher is still routine, students only answer questions according to the example given by the teacher so that students are not accustomed to using their thinking skills when facing real problems that must be solved. Meanwhile, in solving mathematical problems students are required to think critically and creatively to get various ideas and ways to solve the problems faced. Problem-solving ability is the ability of students to solve learning problems faced by using various ideas and knowledge obtained from various sources in obtaining various solutions in real life (Endah, 2019). The ability to solve problems is a student activity in solving mathematical problems using ideas, knowledge, insight and experience that students have (Maimunah, 2016). The ability to solve problems is the ability of students who have previously to solve mathematical problems in learning (Ulya, 2016). Problem solving skills are the ability to train students to develop thinking skills and knowledge that allow students to explore various appropriate ways according to real problems to be solved (Rahmani, 2018). The development of problem-solving skills can be done by developing how to understand problems, creating appropriate mathematical models, choosing how to solve problems and interpreting solving solutions (Hidayat, 2018). Problem solving skills are abilities that students can use in solving problems in mathematics which are usually in the form of problems in the form of story problems and the application of mathematical problems in everyday life (Andayani, 2019). The steps taken in solving the problem include (1) understanding the problem at hand; (2) determine various ways of solving the problem; (3) Choose the most appropriate way to solve the problem, and (4) check the steps taken to solve the problem (Nur, 2018). Problem-solving ability has indicators (1) Identify known elements of the problem at hand, (2) compile a mathematical model according to the problem, (3) choose and apply mathematical problem solving strategies, (4) interpret the results of problem solving (NCTM, 2000).

The learning model that teachers can choose that allows students to develop their thinking skills is the Problem Based Learning (PBL) model. PBL is a learning model that involves students actively in learning and has the potential to improve their mathematical problem-solving skills (Sianturi, 2018). In PBL the students' thought process can be developed through the presentation of real problems so as to overcome the difficulties encountered (Puccio, 2005). PBL can encourage students to think independently, explore various strategies and steps in solving math problems (Krestiw, 2017). The use of PBL can increase student creativity in determining strategies in problem solving (Adams, 2010). PBL is a learning model that begins with giving real problems and focuses on how to solve the right problems (Effendi, 2019; Hariawan, 2014; Paryanto, 2020; Sugianto, 2019; Muharomah, 2020). Learning with PBL, teachers can facilitate students in developing thinking skills, motivating and encouraging students to be involved in groups in solving problems (Bahrudin, 2020). In PBL, students can use their previous experience in solving real problems at hand. Learning with PBL is carried out by steps: (1) providing real problems encountered by students every day; (2) students are asked to analyze the real problem given; (3) students explore various appropriate ways for problem solving; (4) students apply the most appropriate strategies to solve problems (Muslich, 2007). Huda (2014) states that PBL has the syntax (1). Understand the problem; (2). Explore various problem-solving strategies; (3) Discuss strategies that have been found in the group; (4) Establish appropriate strategies to solve problems; (5) Implement problem-solving strategies; (6) Interpret the results of problem solving.

In the current industrial era 4.0 and the rapid development of technology, teachers are required to be able to design learning by integrating various knowledge ranging from technological knowledge, pedagogical knowledge, and mastery of the material to be learned or known as TPACK, namely technological, pedagogical, and content knowledge. TPACK is knowledge where teachers are expected to integrate technology in learning certain materials with certain learning strategies (Koehler, 2013). TPACK is a forum for transforming various knowledge when teachers carry out learning by utilizing certain appropriate technology (Tuithof, 2021). TPACK is knowledge that teachers need to have regarding how teachers are

able to design innovative learning by utilizing various technologies in learning certain subject matter (Farikah, 2020). To create an effective and comfortable learning environment, teachers must have competence in utilizing available technology (Akturk, 2019). TPACK is a blend of technology, pedagogy and content knowledge that is integrated in conducting classroom learning (Rahmadi, 2020). The application of TPACK in learning by teachers contributes to a paradigm change in learning (Malik, 2019). Learning with TPACK is a framework that can be used to measure teachers' ability to utilize various technologies in learning (Mishra, 2006).

The research conducted aims to develop TPACK integrated problem-based learning to improve the problem-solving ability of Junior High School. PBL Integrated TPACK is PBL learning where in implementing every step of learning teachers utilize appropriate technology such as using real problem videos, android When students explore ideas, delivery of material with power points, internal access, and other forms that are in accordance with the material being learned. Learning with TPACK integrated PBL is carried out with steps: (1) Orientation of real problems by presenting them in the form of videos or narrations presented with power points; (2) Ask students to analyze real problems by asking open-ended questions; (3) Students explore various ways of solving problems using their android and other learning resources and discuss them in groups, the teacher guides each group in finding ideas; (4) Strategy selection and real problem solving; (5) Students present real problem solving with power points; (6) Teachers provide reinforcement and evaluation of student activities during learning.

Based on the description above, in 21st century learning and current technological developments, innovative student-centered learning strategies are needed by integrating technology. Therefore, researchers conducted research on how to developing PBL integrated TPACK to improve students' problem-solving ability.

## METHOD

The research method used is development research ADDIE model that is (1) do needs analysis, (2) do product design, (3) do product development, (4) implement and evaluate product design (Dick & Carey, 2001). At the need analysis stage, researchers conduct a needs analysis by conducting interviews with mathematics teachers regarding the application of the learning strategies used and providing questionnaires to students about students' feelings after participating in mathematics learning. Meanwhile, at the product design stage, researchers make product designs based on preliminary data obtained through interviews and observations. Products designed in the form of TPACK integrated PBL learning design on geometry material include the formulation of learning objectives, the formulation of learning achievement indicators, the formulation of learning steps with TPACK integrated PBL, and evaluation tools used to measure the achievement of learning objectives. Meanwhile, researchers at the product implementation and evaluation stage, researchers conduct product trials to find out whether the product design developed effectively can improve problem-solving capabilities. This study involved 30 grade VIII A students of SMPN 2 Selong, East Lombok. Research instruments used (1) product validation instruments, (2) product effectiveness instruments, (3) essay test instruments on geometry materials. Product validation instruments with indicators (a) accuracy of the formulation of learning objectives, (b) suitability of the material used, (c) use of appropriate language, and (d) time allocation. Product effectiveness instruments with indicators include (a) suitability of the formulation of learning objectives, (b) suitability of indicators with learning objectives, (c) use of language, (d) implementation of learning designs, (e) accuracy of time allocation, (f) use of technology in every step of learning. Meanwhile, the test instrument is in the form of an essay test on geometry material totaling 5 questions to measure students' problem-solving abilities with indicators 1) the ability to understand problems; 2) the ability to choose problem-solving strategies; 3) problem-solving ability, and 4) the ability to re-examine the solution method used (Winarti, 2017). Product design is validated by 3 experts, namely linguists, learning technologists and material experts. The next step, do product trials for 4 meetings on geometry

material. The criteria for validity, practicality and product effectiveness are presented in [Table 1](#).

**Table 1.** Criteria for validity, practicality and product effectiveness of developed Learning Models

Interval	Criteria
$85,0 < X$	Very Valid, Very Practical
$70,0 < X \leq 85,0$	Valid, Practical
$X \leq 70,0$	Invalid, Impractical

Furthermore, to test whether the product developed is effective, field trial is carried out on grade VIII A students of SMPN 2 Selong on geometry material. The trial was conducted for 4 meetings by mathematics teachers. The implementation of learning involves partner teachers to see the achievement of learning by using predetermined product effectiveness indicators. Then, to find out whether the product developed has the potential to improve mathematical problem solving skills, students are given an essay test on geometry material at the end of learning. Product design effectiveness indicators are set with criteria that at least 85% of the 30 students who take part in the learning get a geometry test score of at least 70. Furthermore, N-Gain calculation was carried out using the One Group Pretest Posttest Design is a research design where research subjects are given pretest before treatment and posttest after treatment to measure whether the product developed has the potential to improve students' mathematical problem solving skills on geometry material.

## RESULTS AND DISCUSSION

### Needs Analysis

Needs analysis in the form of preliminary studies by conducting interviews with 3 mathematics teachers related to the learning that has been carried out. The interview results show (1) the teacher carrying out learning has not been student-centered, only giving sample questions and describing questions according to examples, has not developed thinking skills and problem-solving skills; (2) the use of technology by teachers has not been maximized because teacher camps related to the use of learning technology are still lacking and limited technological facilities by both teachers and students; (3) Teachers expect the preparation of facilities related to the use of technology such as computer labs, laptops and internet access in schools. Needs analysis is also carried out by giving questionnaires to students about learning that is stiffened by the teacher with the results of (1) monotonous and unfun learning and mathematics lessons are still scary lessons (2) learning is still routine, namely delivering material, giving examples and practice questions, has not sought the development of real thinking and problem solving skills; (3) learning has not utilized technology so that learning is not interesting and not varied due to limited facilities owned by teachers, students and schools. Based on the data from the analysis above, researchers tried to conduct research by developing TPACK integrated PBL learning on geometry material to improve the mathematical solving ability of junior high school students.

### Product Design

The product developed is in the form of a mathematical learning design with integrated problem-based learning TPACK. Problem Based Learning integrated TPACK model syntax developed with steps such as [Table 2](#).

**Table 2.** Problem Based Learning Integrated TPACK Model Syntax

No	Phase	Teacher Activities	Student Activities
1	Orientation to the problem	The teacher divides a group of 3-5 students, Teachers provide real problems related to geometry material through videos and give open-ended questions	Pay attention to the teacher's explanation of the problem to be solved.
2	Disclosure of opinion	Teachers facilitate students in exploring ideas and ideas.	Students explore different ways of solving problems using android and other learning resources, and the teacher directs each group during the idea discovery process
3	Evaluation	Teachers guide students in problem solving, guide problem solving by utilizing technology	Each group member actively discusses his or her findings and determines the most appropriate way to solve the problem and the teacher facilitates group discussion
4	Implementation	Teachers facilitate individually and in groups in finding solutions to problems	Each group representative presented a problem solving using a power point and another group provided responses and documentation was carried out by group members
5	Presentation	Teachers guide and direct students in presenting and providing reinforcement	Representatives of each group presented the results of the problem solving carried out, while the other group gave responses
6	Reflection	The teacher evaluates all problem-solving activities carried out by students and together with students draws conclusions to get concepts related to the problems solved by students	Students draw conclusions based on problems solved under the guidance of the teacher

### Product Validity

At this stage, validation of product designs developed by validators or experts is carried out. The scores of validation results by linguists, material experts and learning technologists are shown as **Table 3**.

**Table 3.** Results of Validation of Developed Product Design

Aspect	Linguist	Material expert	Technologists
Identity product	90,0	92,0	90,0
Learning objectives	85,0	83,0	84,0
Attainment indicators	75,0	78,0	73,0
Material mastery	80,0	78,0	78,0
Learning models	80,0	81,0	83,0
Syntax precision	85,0	83,0	84,0
Technology selection	75,0	78,0	79,0
Technology utilization	70,0	72,0	76,0
Assessment instruments	76,0	81,0	82,0
Language accuracy	78,0	73,0	79,0
Average Score	79,40	79,90	80,80
Conclusion	Valid	Valid	Valid



From Table 3 above, the product developed, namely the TPACK integrated PBL model, is included in the valid category by both linguists, material experts and learning technology experts. Furthermore, the product design developed will be tested in class VIII A SMPN 2 Selong for 4 meetings to measure the practicality and effectiveness of the product.

### Practicality of Products

The practicality of the product in the form of TPACK integrated PBL learning design is based on the implementation of learning carried out by the teacher as shown by the teacher's response during learning with the product developed using predetermined practicality criteria. Data on teacher responses using TPACK integrated PBL learning design are presented in Table 4.

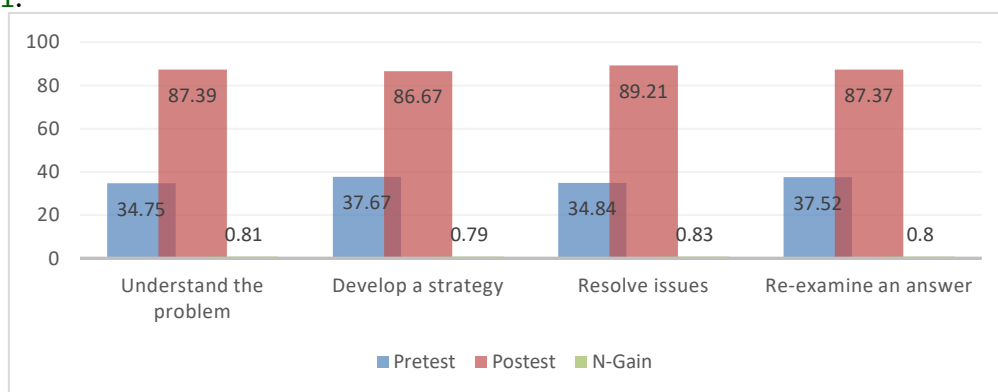
**Table 4.** Teacher Response to the Developed Learning Design

Aspects	Meeting			
	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>
Indicator Formulation	85,0	81,0	82,0	84,0
Ability to motivate	83,0	86,0	81,0	82,0
Presentation of the problem	82,0	84,0	79,0	74,0
Presentation of material	82,0	80,0	78,0	75,0
Technology utilization	78,0	81,0	81,0	79,0
Application of learning	79,0	75,0	76,0	78,0
Technology integration capability	81,0	78,0	79,0	82,0
Assessment conducted	84,0	82,0	82,0	81,0
Ability to manage classes	85,0	83,0	78,0	78,0
Reinforcement and conclusion	76,0	82,0	75,0	75,0
Average	81.50	81.20	79.10	78.80
Conclusion	Practical	Practical	Practical	Practical

Referring to the data presented in Table 4, it can be said that the learning design is the TPACK integrated PBL model in the practical category of both meetings 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> and meeting 4<sup>th</sup>.

### Product Effectiveness Stage

Trials on 30 students of grade VIII A SMPN 2 Selong, East Lombok obtained pretest and posttest scores on students' problem-solving abilities on geometry material as presented in Figure 1.



**Figure 1.** Pretest and Posttest Scores on Material Geometry

The results of the posttest on 30 students showed that 87.67% of students obtained a problem-solving ability score on geometry material  $\geq 75$ . That is, the trials carried out have met the criteria for the effectiveness of the product developed, namely there are at least 80% of all students given problem-solving ability tests get a minimum score of 75. Furthermore, testing is carried out whether the product developed, namely the TPACK integrated PBL model, has the potential to improve problem-solving capabilities in geometry materials. The test was

carried out by calculating N-Gain, which is the difference between pretest and posttest students' problem-solving abilities on geometry material. Referring to [Figure 1](#), the average N-Gain for each aspect of mathematical problem solving ability is 0.81 in the high category. So, the product in the form of a TPACK integrated PBL model has the potential to improve students' mathematical problem solving skills on geometry material.

Learning with the TPACK integrated PBL model begins with giving real problems through video or text presented with power points. Furthermore, the teacher gives open questions and students are asked to conduct an analysis based on the problems given and then students explore various knowledge and ideas as well as the right way to solve the problems faced using android, laptops connected to the internet and discuss them in groups. At this stage the teacher facilitates students and directs the discovery process that students carry out both individually and in groups. Next, students present the resulting work and other groups give responses. The series of activities carried out by teachers and students in learning like this where technology is used in digging up various necessary information is believed to train students in developing students' thinking skills, collaboration skills, communication skills and mathematical problem solving skills. This is in line with research that states that teachers need to involve students actively in learning so that students are interested in the subject matter and cause curiosity ([Andana, 2014](#)). Other research states that learning with PBL by utilizing technology in it encourages students to conduct group discussions and develop mathematical problem solving skills ([Muhammad, 2018](#)).

One of the demands of 21st century learning today is the ability of teachers to integrate technology in learning ([NCTM, 2000](#)). In addition, teachers also need to understand when and on what material, as well as which technology is appropriate when learning. As stated by [Guerrero \(2010\)](#), Teachers need to choose the right technology when learning certain content so that it can help make it easier for students to understand the subject matter. Another research on the importance of technology integration states that TPACK integration is one of the creative solutions that teachers need to do in learning ([Sutrisno, 2012](#)). Next, [Mairisiska \(2014\)](#) stated that the integration of TPACK in learning is able to improve students' critical thinking skills and mathematical problem solving skills. Another study states that the integration of TPACK in learning is a solution to overcome the obstacles faced by students in learning materials ([Beri, 2021](#)). The integration of TPACK in learning can optimize learning activities and has the potential to improve students' thinking skills ([Archambault, 2010](#)). The integration of TPACK in learning certain material by choosing certain learning strategies needs to pay attention to student characteristics ([Khine, 2017](#)). In the integration of TPACK in learning, teachers need to design learning that is able to change the content of learning materials so that learning becomes more interesting and adaptive to various characteristics and abilities of students ([Purwaningsih, 2015](#)). Thus, referring to some of the research stated above, the development of a TPACK integrated PBL learning model can improve students' mathematical problem solving ability, especially on geometry material.

## CONCLUSION

Products in the form of TPACK integrated PBL learning models are developed following the ADDIE development model. Product development was carried out based on needs analysis conducted through interviews with mathematics teachers and questionnaires about learning conducted by teachers to 30 junior high school students in East Lombok. Based on expert validation in the fields of language, material and technology, the product in the form of TPACK integrated PBL learning is classified as valid. Product trials also show that the product is classified as practical and effective. The product developed also has high potential in improving students' mathematical problem solving ability on geometry material with an N-Gain value of 0.81.

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