

Development of Mathematics Learning Design through Problem Posing Approach for Developing Mathematical Reasoning Ability

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Abstract. This study aims to produce a mathematical learning design through a problem-posing approach that improves student's mathematical reasoning abilities with valid, practical, and effective criteria. This type of research is research and development. The subject of this development trial is students of grade VIII-9 of SMP Negeri 1 Bau-Bau. The devices and instruments that have been compiled are validated, and the validation results show that they meet the validity requirements. The practicality of the design is shown by the average percentage of achievement from the observation of teacher activities, which meets the practicality requirements. Learning design meets the requirements of effectiveness, namely the average achievement of student activities with good criteria, reasoning abilities of high category students with an average of 78,3, and the average student response to learning and worksheets is positive. Based on the result, it can be concluded that the learning design of mathematic through the problem-posing approach to improving student's mathematical reasoning ability were valid, practice, and effective.

1. Introduction

The reasoning is a significant component in mathematics, especially in solving mathematical problems. Mathematical reasoning helps students to gain an understanding of interrelated mathematical concepts and meaningful learning [1]. NCTM states that reasoning plays an important role in understanding mathematics. Mathematical reasoning is a habit of thinking, and as a habit, reasoning should be a consistent part of every student's mathematical experience [2]. The importance of reasoning is written for the purpose of learning mathematics in secondary education, so that students can use reasoning on patterns and traits, carry out mathematical manipulations in making generalizations, compiling evidence, or explaining mathematical ideas and statements.

However, the results of the 2011 study and report of the Trends in International Mathematics and Science Study (TIMSS) stated that the average cognitive domain of Indonesian students' level of reasoning at TIMSS 2011 which was followed by class VIII students was still at a low level of only 17%. The TIMSS framework on the cognitive dimension shows that the lowest percentage average achieved by Indonesian students is in the cognitive domain of reasoning level compared to the knowledge and application level [3].

One of the causes of the above conditions is because mathematics learning in the classroom refers more to teacher learning devices that are not appropriate, and the teaching and learning process is not

optimal with the methods, approaches, and evaluations that the teacher uses have not moved from conventional patterns. Learning carried out by the teacher is still teacher-centered, where the teacher is still actively involved and dominating so that students have less role in learning. Students are passive in constructing their understanding to build new knowledge. This results in the low mathematical reasoning abilities of students. In addition, in the learning process, students still use textbooks borrowed from the library. The questions in the textbook only contain routine questions that only develop students' knowledge and abilities in numeracy, but have not developed students' mathematical reasoning abilities.

A similar case is also a phenomenon that occurs in SMP Negeri 1 Bau-Bau. Based on the results of researchers' observations of grade VIII, data obtained that the learning carried out by the teacher is still teacher-centered, where the teacher is still actively involved and dominates so that students lack a role in learning. In addition, the problems (questions) given in learning have not been able to help develop students' mathematical reasoning abilities. The questions given to students only contain routine questions that only develop students' knowledge and ability to count. Based on the results of the initial investigation through tests of students' mathematical reasoning abilities against 29 students of grade VIII-9 SMP Negeri 1 Bau-Bau obtained information that three students have good mathematical reasoning abilities, 19 students have tried to use their reasoning abilities, but the results are still partially correct and students others did not complete the test as a whole. There were even two students who were unable to complete the test. This illustrates that the reasoning ability of VIII-9 grade students of SMP Negeri 1 Bau-Bau is still in the low category.

Based on this phenomenon, it is necessary to have improvements in learning, especially in circle material, namely by arranging other learning design alternatives that are student-centered and can facilitate students to use the desired reasoning abilities. One of the student-centered learning and helping students in developing reasoning abilities is problem-posing [4]. Problem posing is a learning process that includes the activity of arranging problems from a given problem, making strategies to solve new problems, and linking information obtained based on the problems that have been given. Silver gives the term problem-posing applied to three different forms of mathematical cognitive activity, namely (1) pre-solution posing that is making questions from the situation or information provided, (2) within-solution posing that is the making of questions by reformulating questions as they have been resolved, and (3) post solution posing that is making questions by modifying the objectives or conditions of questions that have been solved to make a new problem [5].

The results of the study show that problem-posing can give rise to a positive attitude towards mathematics learning [6]. Problem posing provides an opportunity for students to be able to think freely and independently in solving problems so they can overcome anxiety in mathematics learning [7]. Other studies also reveal that there is a relationship between problem-posing and problem-solving [8]. Problem posing can stimulate metacognition skills to implement problem-solving strategies well [9].

The problem-posing approach can be carried out individually or cooperatively. Mathematical problems raised by students individually will provide space for students to give questions and less weighted level of completion. However, mathematical problems raised and solved by students cooperatively can be more weighty, especially for the level of problem-solving. Therefore, in order to support learning that can actively involve students, problem-posing needs setting in cooperative learning.

In addition to referring to all the advantages of the problem-posing approach, the fundamental reason for using problem-posing in this study is because, in some studies and existing ones, learning is rarely developed in circle material using problem posing learning focused on reasoning. Therefore, it is necessary to research the problem-posing approach with cooperative settings to develop students' reasoning abilities.

Starting from all the descriptions described above, the writer intends to develop a circle material learning design with a problem-posing approach to obtain a circle material design that is valid, practical, and effective for grade VIII junior high school students. This development research is

expected to be useful for various parties, including growing the spirit of cooperation and student responsibility to develop mathematical, conceptual reasoning abilities, improving quality for schools that are the object of research in mathematical skills and as a reference for teachers in effective learning design develop students' reasoning abilities. The product that will be produced in this study is the design of circle material learning based on the problem-posing approach with cooperative settings.

2. Method

2. 1. Development Procedure Method

The development of learning design with a problem-posing approach to circle material is based on the design of learning proposed by Isman [10]. The design steps consist of input, process, output, and feedback. Input is the primary step in learning planning because it provides information to the teacher about the effectiveness of learning. The input step is done to determine the fundamental problems needed in developing the learning design. This step involves identifying learning problems and finding the right solution to overcome the problem. The input step consists of five stages, namely: identifying problems, material, objectives, learning methods, and learning media. After identification, then draft the learning tools and instruments (prototypes) needed. Learning tools include Learning Plans and Student Worksheets. While the compiled instruments include (1) teaching aids validation sheet, (2) teacher activity observation sheet, (3) student activity observation sheet, (4) reasoning ability test of circle material, and (5) student response questionnaire.

The process step consists of three stages, namely a prototype test, redesigning learning activities, and learning activities. The design of the learning product (prototype) that has been prepared in the input step will be carried out as a prototype test/validated by experts (validators). Three validators validated the prototype. Based on the results of validation from experts, learning products are redesigned according to input/suggestions from experts, so that a product that is valid for use is obtained. The valid learning product is then tested in a learning activity. The trial was conducted in five meetings. At each meeting also carried out observation activities on the implementation of learning and student activities.

The output step consists of two stages, namely (1) assessment, carried out by implementing an assessment tool to determine the level of success of the learning objectives, (2) analysis of results (evaluation), which provides an overview of what students have learned during learning. This step is used to determine the extent of the effectiveness and practicality of the learning process implemented.

The final step in this development is feedback or revising the devices that have been developed based on data collected during the implementation phase. Through the results of the analysis, if the prototype i ($i \geq 2$) has reached the practical and effective category, a final prototype is obtained. If the prototype has not yet reached the practical or effective category, then the prototype must be revised and tested again.

2. 2. Data Analysis Technique

The data obtained in this study will be analyzed based on the classification of design assessment criteria, namely valid, practice, and effective [11]. Analysis of the data from the validation of learning tools and instruments was done by looking for the average of each criterion and the average of each aspect in the validation sheet until finally, the average total validator assessment of each learning device was obtained. Analysis of the data used by modifying the analysis process from Parta with calculates the average total validity of all aspects (VR), and determines the validity category with very valid criteria ($4 \leq VR < 5$), valid ($4 \leq VR < 3$), less valid ($3 \leq VR < 2$), and invalid ($1 \leq VR < 2$). Learning tools and instruments are categorized as valid if the average score of all assessment aspects of the validators has a minimum validity value of 3[12].

Data on the practicality of design is data that describes the implementation of the design. This data is obtained from observing teacher activities through teacher activity observation sheets. The steps used in analyzing the results of teacher activity observations, namely (1) summing the scores of each meeting, (2) calculating the percentage average score (AS) of each meeting, and (3) making conclusions from the results of analysis of teacher activity observations, with the percentage criteria of

the average score of the results of observations, namely (a) very good, if the percentage of average score (AS) is greater than 85; (b) is good, if the average score (AS) is greater than 70 but less than 85; (c) is quite good, if the average score (AS) is greater than 55 but less than 70; (d) not good, if the average score (AS) is greater than 40, but less than 55; and (e) is not good if the percentage of average score (AS) is less than 40. Learning design is categorized as practical if the implementation of design through teacher activities is included in the minimum criteria either.

The effectiveness of the design is measured by three indicators, namely student activity, tests of circle material reasoning abilities, and student responses. The steps used to analyze the observations of student activities, namely (1) summing the scores of each meeting, (2) calculating the percentage average score (AS) of each meeting, and (3) making conclusions from the results of observations of student activity analysis, with the percentage criteria of the average score of the results of observations, namely (a) very good, if the percentage of average score (AS) is greater than 85; (b) is good if the average score (AS) is greater than 70 but less than 85; (c) is quite good, if the average score (SR) is greater than 55 but less than 70; (d) not good, if the average score (AS) is greater than 40, but less than 55; and (e) is not good if the percentage of average score (AS) is less than 40.

The results of the reasoning ability test data in the form of the final learning test score were analyzed by steps (1) write the scores of each student, (2) calculating the achievement of reasoning for each student, (3) calculating the total achievement of all students reasoning (SR), (4) make conclusions from the results of analysis of reasoning ability tests with the criteria of reasoning ability, namely (a) very high if the average SR is greater than 85; (b) high, if the average SR is greater than 70 but less than 85; (c) moderate, if the average SR is greater than 55 but less than 70; (d) low if the average SR is greater than 40 but less than 55; and (e) very low if the average SR is less than 40.

Student questionnaire responses are used to measure students' opinions on student worksheets and learning activities. Student response questionnaire results in the form of scores were analyzed by steps (1) recap the score of each student, (2) convert the average score of each student into the range 0 - 100, ($\bar{S}_i$), (3) calculate the average score for all respondents, and (4) make conclusions based on criteria in response, ie, accept (positive response) or reject (negative response). For this reason, the range of scores of 0 - 100 is only divided by two, namely $0 < x \leq 50$ and $51 < x \leq 100$. The criteria for student response in learning are determined by (a) If $\bar{S}_i > 50$, then said the second subject gives a positive response, (b) If $\bar{S}_i \leq 50$, then the subject is said gave a negative response. While the class response is determined by (a), the class response is said to be positive if $\bar{S} > 50$, (b) the class response is said to be negative, if $\bar{S} \leq 50$.

Learning design is categorized as effective if the following indicators are achieved (a) Student activities in learning are good or very good, (b) students' reasoning abilities are high or very high, (c) positive class responses.

3. Results and Discussions

3.1. Input Step

This research was conducted on SMP Negeri 1 Bau-Bau in 2014. The activity in the input step begins with a discussion with the teacher of mathematics study at SMP Negeri 1 Bau-Bau, reviewing the supply of teaching materials for students of eight grade of SMP Negeri 1 Bau-Bau, observing the characteristics of students in learning, and study of the learning model. Based on the results of the identification of the problem, it was concluded that most students experienced difficulties in involving mathematical reasoning. This happens because of the lack of use of the problem as a stimulus that can train students' mathematical reasoning activities, especially in circle material. Therefore, the goal students want to achieve in this learning is to improve students' reasoning abilities in circle material.

Observing the condition of problem identification requires an effort to overcome these problems by determining methods/approaches that can actively involve students in learning activities and be able to develop aspects of students' reasoning. One of the lessons that can engage students actively in learning activities is the problem-posing approach. Based on the situation, Stoyanova classifies the problem-posing approach into three types, namely (1) free problem posing that is the submission or making of

questions freely based on the situation of daily life both in school and outside school related to the content of mathematics, (2) semi-structured problem posing that is the submission of questions or questions based on an "open-ended" situation and students are invited to explore it, and (3) structured problem posing that is submission of problems by creating new problems based on problems given by the teacher and solving the problems [4].

The problem-posing approach referred to in this study is to reformulate the problem with a number of changes to make it more straightforward and understandable in order to solve the problem and be implemented with a cooperative learning model. The steps in learning include (1) identifying learning objectives and motivating students (2) forming groups (3) presenting problems (4) submitting new problems based on the problems given (5) guiding student answers by evaluating problem-solving processes (6) feeds back and forth, (7) giving awards. The teaching media used in this development are student worksheets. Student worksheets are used to support the purpose and application of problem-posing learning so that it makes it easier for students to carry out learning activities.

Then to support the implementation of the learning design in the context of the problem, learning tools and instruments were developed. This initial design produced a draft in the form of a prototype learning tools of circle material through a problem-posing approach. Learning tools consist of Learning Plans and Student Worksheets. While the instruments compiled consist of (1) learning device validation sheet and instrument, (2) teacher activity observation sheet, (3) student activity observation sheet, (4) reasoning ability test of circle material, and (5) response questionnaire students.

3.2. Process Step

Three validators validate the design of the learning tools and instruments that have been compiled in the input step (prototype 1). The validator evaluates based on the criteria on the validation sheet. The results of learning tools and instrument validation are presented in Table 1

Table 1. Validation Results

No	Learning tool/Instruments	Average Validation	Category
1.	Learning Plans	4,4	Valid
2.	Worksheet	4,6	Valid
3.	Teacher's Handbook	4,5	Valid
4.	Teacher Observation Sheet	4,5	Valid
5.	Student Observation Sheet	4,5	Valid
6.	Student Questionnaire	4,6	Valid
7.	Reasoning ability test of circle material	4,5	Valid

Based on the specified criteria, the validation results from the validators of the learning tools and instruments are categorized as valid [12]. In addition to giving an assessment based on the statements on the validation sheet, the validator gives suggestions and notes. Suggestions and notes from the validator will be used as material to revise the prototype. Based on suggestions from the validator, the learning tools and instruments need to be revised slightly. After revising the next step, a field trial was conducted on the prototype.

The trial was carried out according to the draft in the lesson implementation plan with the number of students 29 people, every 17 men and 12 women divided into six groups that had mixed abilities. During the learning process, researchers were assisted by observers who were tasked with observing student activities and teacher activities during the learning process using observation sheets. In learning, each student is given a student worksheet completed by submitting a problem through group discussion, and the results are presented alternately by several groups at each meeting. After learning for the subject of the circle is completed, then carried out tests of the circle material reasoning.

3.3. Output Step

The implementation of the learning design results of the trial are presented in Table 2

Table 2. Teacher Activity					
Activity	I	II	III	IV	IV
Average	89,5%	92%	91,5%	91,5%	95,5%

Overall the average design implementation of each learning is greater than 89%. This shows that based on the criteria specified, the implementation of the design is included in the practical category.

The results of data analysis from the observation sheet of student activities are presented in the following table.

Table 3. Student Activity					
Activity	I	II	III	IV	IV
Average	85%	86,5%	82%	85%	86%

The results of observations conducted by two observers showed that the average activity result was higher than 80%. This shows that based on the criteria specified, student activities meet good categories.

Based on the results of tests and reasoning level criteria obtained information that there are four students whose grades do not meet the minimum criteria of high reasoning (medium). In addition, the level of reasoning for all students, which has an average of 78,3. So it can be concluded that the level of reasoning for all students is in the high category. Student response data obtained through student response questionnaire sheets filled out by students at the end of the trial. The results of the analysis of student response data indicate that the average student response to the learning process and student worksheets is 100%. This can be interpreted that students' responses to the learning process and worksheets are positive.

Based on the results of the analysis, student activities showed good categories, students' reasoning abilities showed good levels and positive student responses. Overall, this shows that the design belongs to the effective category.

3.4. Feedback Step

Based on the analysis of the results of the trial data, in general, the level of achievement of the development of learning tools and instruments meets the good category. The following table shows the results of the recapitulation of the design of the problem-posing approach to the cooperative setting through the Isman model

Table 4. Results of developing learning designs

Indicator	Output	Category
Validity	Valid instruments and learning tools	Valid
Practicality	The implementation of learning is a good category	Practical
Effectiveness	Student activity is in good category, high category student reasoning, and positive student response	Effective

The instruments and research instruments are categorized as valid, meaning the instruments and devices are feasible to use. This valid criterion is fulfilled because the learning tools and instruments are arranged based on the curriculum in the school, and the components developed have been in

accordance with the established indicators. The practical criteria indicate that the learning steps described in the design and device are easy to understand and easily implemented by the teacher. While the design of learning meets the effective category means that the design and learning tools developed have achieved the expected goal of being able to develop students' mathematical reasoning abilities [11]. Although the results of the development of learning design mathematics through problem-posing approach with the cooperative setting have met the criteria of valid, practical, and effective, there are still some parts of the product that receive special attention and need to be revised slightly. The product revision was based on practitioners' experience and observer input during the trial implementation.

The problem-posing approach through cooperative setting has been able to change the learning conditions from teacher-centered to student-centered by giving students the breadth of being more active in understanding mathematics by developing their thinking processes. The problem-posing approach with a cooperative setting has some conformity with the steps of the scientific approach in the 2013 curriculum (observing, asking, reasoning, trying, and forming networks). The step of observing is carried out in the activity of presenting the problem, the step of questioning and reasoning is carried out in the activity of submitting new problems based on the problem given, and trying and forming networks carried out in activities to guide students by evaluating the problem-solving process. Thus, the problem-posing approach with the cooperative setting can be an alternative learning model to be used in the 2013 curriculum.

4. Conclusion

The results of the development of learning design using the problem-posing approach meet the specified criteria, namely valid, practical, and effective. The learning design of mathematics through the problem-posing approach has been able to change the learning conditions from teacher-centered to student-centered. This learning provides challenges for students to learn and become more active in understanding real-world problems related to mathematics by developing mathematical reasoning abilities. Thus this research can be used as reference material or input about the design of learning that is effective in developing students' reasoning abilities as an effort to improve the quality and mathematical abilities of students in the city of Baubau.

References

- [1] Hendriana, dkk. 2017. Hard skills dan soft skills Matematik Siswa. Bandung: Refika Aditama.
- [2] Rosita. 2014. Kemampuan Penalaran dan Komunikasi Matematis: Apa, Mengapa dan Bagaimana Ditingkatkan pada Mahasiswa?. *Jurnal Euclid*, ISSN 2355-17101, vol.1, No.1, pp. 1-59
- [3] Rosnawati. 2011. Kemampuan Penalaran Matematika Siswa SMP Indonesia pada TIMMS 2011. *Prosiding Seminar Nasional Penelitian, Pendidikan dan Penerapan MIPA UNY*.
- [4] Kontrovich. 2011. An Exploratory Framework For Handling The Complexity Of Problem Posing in Small Groups Mathematical. *Journal of Mathematical Behavior*(2011). MATBEH-348; No. of Pages 13.
- [5] Sutame. 2011. *Implementasi Pendekatan Problem Posing Untuk Meningkatkan Kemampuan Penyelesaian Masalah, Berpikir Kritis Serta Mengeliminir Kecemasan Matematika*. Prosiding ISBN : 978 – 979 – 16353 – 6 – 3. Yogyakarta.
- [6] Akay & Boz. 2010. The Effect Of Problem Posing Oriented Analysis-II Course On The Attitudes Toward Mathematics And Mathematics Self-Efficacy of Elementary Prospective Mathematics Teachers. *Australian Journal of Teacher Education*, Vol 35 Issue 1: 71
- [7] Brown & Walter. 2005. *The Art Of Problem Posing Third Edition*. London: Lawrence Erlbaum Associates Publisher.
- [8] Cankoy. 2010. Effect Of A Problem Posing Based Problem Solving Instruction On Understanding Problem. *H. U. Journal of Education*, 38: 11-24.

- [9] Ghasempour, Zahra. 2013. Innovation in Teaching and Learning through Problem Posing Tasks and Metacognitive Strategies. *International Journal of Pedagogical Innovations*. 1, No. 1: 53-62
- [10] Isman. 2011. Instructional Design In Education: New Model. *TOJET: The Turkish Online Journal of Educational Technology* Vol 10 (1): 140-142
- [11] Nieveen. 2010. *An Introduction to Educational Design Research*. Netherlands: SLO Enschede.
- [12] Parta. 2009. *Pengembangan Model Pembelajaran Inquiri Untuk Penghalusan Pengetahuan Matematika Mahasiswa Calon Guru Melalui Pengajuan Pertanyaan*. Disertasi tidak dipublikasikan. Surabaya: PPs UNESA.