

Modification of Polya's Step to Solve Math Story Problem

Isfa Hayyulbathin¹, Retno Winarni², Tri Murwaningsih³

Sebelas Maret University, Jebres, Surakarta, Jawa Tengah, Indonesia

Corresponding author: ¹isfahabee@gmail.com

²winarniuns@yahoo.com

³murwaningsih_tri@staff.uns.ac.id

Abstract. Polya's step is a problem-solving technique which was created by mathematician George Polya. Polya's problem-solving steps are usually used in solving math problems. This is because the phases in Polya's step are simple and easy to understand. Math story problems are a type of problem in math lesson which often associated with the student's every day problem. In solving a math story lesson, the students are not only required to know the final answer, but also to learn and understand the steps partaken to get the answer for the problem. This literature review is intended to discover how a modified Polya's step can be utilized to solve a math story problem. The modified Polya's step could be used to solve a math story problem in five steps, which are: 1) understand the problem; 2) devise a plan; 3) carry out the plan; 4) look back; and 5)decide a conclusion.

INTRODUCTION

Mathematics can be regarded as one of the important lessons, which is why math is taught from the elementary school level to the higher education. According to Susanto (2013: 185), math is one of disciplines which can improve the ability to think, argument, giving contribution to every problem in daily and work life, and supporting the development of science and technology. Math can be one of means to think scientifically which is required to develop the ability of thinking logically, systematically, and critically for the students. Math is also a basic knowledge which required by the students to support their achievement in various other knowledge and also giving contribution in daily life.

The mathematics lesson is a two-way learning process which built by the teacher and the students to improve the students' thinking ability and able to improve the ability to construct new knowledge towards mathematics material (Susanto, 2013: 186). The goal of math lesson is so that the students are skilled in using various concept of mathematics in daily life. Therefore, the implementation of math lesson should be done properly so that the lesson goal can be fully achieved. According to Heruman (2010: 2-3) the concept in math lesson can be divided into three groups, which are (1) implementing the basic concept of mathematics, (2) understanding the concept of mathematics, and (3) the coaching of mathematics skill. Implementing basic concept of mathematics is a new concept of math lesson which is taught to the students who do not understand the concept yet. While understanding the concept of mathematics is the next steps after implementing the concept of mathematics, where the previously implemented concept can be easily understand by the students. The coaching of mathematics concept is the next steps after implementing and understanding the concept, which aims to improve the students' ability in using various mathematics concepts.

The mathematics lesson in Elementary School generally often discuss about topics which related to the students' problem in daily life. This is intended to develop the students' ability in solving the daily problems they encounter. One of the question types in mathematics lesson is math story problem. According to Winarni (2011: 122) math story problems is math question which given with words or sentences in the form of story and related with the daily life. In solving math story problem, the students are required to not only find the final answer, but also to be able to know and understand the steps which used to find the answer to the question in the story problem.

Rahim (2015) stated that there are four steps in solving math story problems, which are (1) understand the problem, (2) create a math model, (3) do the calculation or computation, and (4) make a conclusion.

The story problems which usually are in the form of sentences sometimes give the students a hard time in solving it. The students' struggle in solving math story problems is caused by the majority of the students who do not understand how the correct steps in solving the math story problems. Several studies have been conducted to discover the students' difficulty in solving math story problems. As seen in a study by Jupri (2016) which shows that the students' difficulty in solving math story problem lie on the steps in creating math model. Layn's study (2017) shows that the mistake in solving math story problems lie on the mistake on understanding and the mistake in doing calculation. The other study result by Fatahillah et al (2017) shows the mistake in solving math story problems lie on the mistake in understanding problem, mistake in choosing the operation of calculation, mistake in calculation and mistake in making conclusion with the highest mistake percentage is on understanding the problem.

The result of studies above shows that there are many students who made mistake in solving math story problems. Thus, there needs to be an effort in solving the problem. One of the efforts which can be done to overcome the difficulty in solving math story problem is by applying Polya's steps. Polya's steps are problem-solving steps which created by mathematician George Polya. Polya's steps are often used in solving math problems. This is because the phases in the process of problem solving are quite simple, the activity in each phase is clear, and Polya's steps are often used in solving mathematics problems. Polya's steps consist of four steps which are: 1) understand the problem; 2) devise a plan; 3) carry out the plan; and 4) look back.

Polya's steps have proven to be able to use in solving story problem and math problem. This is can be seen from several study result, for example the study by Apriyanti et al (2015), which shows that the ability of solving math story problem experienced improvements after using Polya's problem-solving technique. The result of study by Olaniyan et al (2015) shows that the students who taught the Polya's problem-solving have better ability than the students who taught by using lecture method. Moreover, the result of study by Logoglu (2017) also shows that the students' success in solving math problems is improved by applying Polya's steps. Other study by Lee (2017) also shows that a lesson approach using Polya's steps significantly could improve the effectiveness of math lessons.

Even though the results of the studies above show that Polya's steps can improve the students' ability in solving math story problem, there is incompatibility between Polya's steps and the steps in solving math story problem. Polya's steps are finished at steps number 4: look back, while the steps in finishing math story problem must have a conclusion. This is why the Polya's steps needs to be modified by adding on more steps to precisely complete the math story problem. The step is making a conclusion and connect the answer with the question.

REVIEW OF LITERATURE

Polya's Steps

Polya's steps are steps which are used to solve problem and was created by mathematician George Polya. According to Lee Chun-Yi (2015), Polya's method centered on the teacher whose goal is to support the students to explain the problem-solving ideas related to the lessons. The simple Polya's steps and the clear problem-solving phase make the Polya's steps often used to solve math problem. The advantage of Polya's problem-solving model is that it made the students to be more careful in understanding the steps and process of solving problem, and could provide a neatly arranged framework to solve a long and complex problem which could help the students to organize their effort in solving problem (Apriyanti, et al, 2015). Gopinath (2017) also described the implementation of Polya's steps which requires the student to think analytically make the problem-solving result be more efficient.

George Polya, in his book *How to Solve It* (1957), formulates four steps which can be used to solve problems which are understand the problem; devise a plan; carry out the plan; and look back. Each of the Polya's steps can be described as follows:

1. Understand The Problem
 - a. You have to understand the problem
 - b. What is known? What is unknown? What must be found?
 - c. Is it possible to fulfill the condition? Is the condition adequate to determine the unknown data? Or it contradicts?
2. Devise A Plan
 - a. Find the relation between the known data and unknown data. You probably have to consider additional problem if there are no direct connection. You must have a plan to achieve the solution.
 - b. Do you ever encounter this problem before? Or do you encounter the same problem with a little difference?

- c. Do you know a related problem? Do you know any useful theorem?
 - d. See the unknown, and try to think similar problem or the similarity in unknown data.
 - e. The following is the problem which related to your problem and has been solved before. Can you use it? Can you use the result? Can you use that method?
 - f. If you cannot solve the proposed problem, try to solve several related problems with a more general or specific problem. Or it can be done with the similar problem.
3. Carry Out The Plan
 - a. Carry out your plan
 - b. Check every step whether the steps which you have done are correct? Can you prove that it is correct?
 4. Look Back
 - a. Check the resulting solution
 - b. Can you check the result? Can you check the argument?
 - c. Can you achieve a different solution? Can you see it at a glance?
 - d. Can you use the result or method on several other problems?

In short, Subyanti (2004: 16) described the Polya's step can be summarized as follows:

1. Understand the problem
In this step, the students are directed to understand what they don't know or what is being asked. The understanding about the unknown can decide what will be achieved in the final step.
2. Devise a plan
In this step, the activity is to find the relation between what is known and what is being asked. The expected ability is for the students could decide the example of unknown data. In other word, in this step the students are required to be able to create mathematical sentence.
3. Carry out the plan
In this step the student carry out the plan which has been devised before by using planned formulas or steps. In this step the students also need to make sure that the step used in solving problem is the correct step.
4. Look back
This step is used in checking and making sure that the problem-solving step and the result is in correspond with the initial plan of solving problem. If the result is not in accordance with the initial plan, then there need to be a recheck to achieve a corresponding result.

Math Story Problem

Mathematics is one of subjects which able to improve the students' ability in critical thinking. That is why there are various types of question in math lesson which could stimulate the student to think critically. One of question types in math lesson is math story problem. According to Wijaya (2008: 14) story problem is one of the questions in the form of easy-to-understand and meaningful sentence. Rahardjo (2011: 18) added that math story problem is one of question which related to daily problems and could be solved with mathematical sentence. While Ashlock (2003:80) stated that math story problem is a question in the form of description test which is an implementation of a learning material or subject related to the students' daily life problem. Therefore, the story problem can indirectly diagnose the students' ability in solving a problem. Based on the opinions above, it can be concluded that math story problem is a type of question in mathematic lesson in spoken or written form which is related to the students' daily life problems.

Through math story problem, the students' ability in problem solving can be trained well. In the lesson which is based on problem solving, the teacher acts as a mentor and facilitator in the teaching and lesson in the classroom so that the teacher is not only the source of learning for the students. According to Beige (2008) through learning problem-solving, the students learn about how to deepen their understanding about the concept of mathematic through the chosen issues and real problems. Atteh et al (2017) mentioned that there are several benefits which the student would receive through lesson on problem-solving which are (1) helping the students understand that mathematics is developed through the process of sense, (2) deepen their understanding about mathematics ideas and methods it's based on, and (3) bring out the students' interest. Moreover, the development of mathematics problem-solving ability could also prepare the students to think logically, systematically analytic, critically, and creatively (Surya et al, 2017).

Solving math story problem is different with solving other math problem. Solving math story problem is not only about finding the final answer, but more importantly is the students are able know and understand about the steps to achieve the answer. According to Winarni (2011: 122-123), there are two approaches which the teacher can use to teach the student how to solve math story problem: model approach and translation approach. Model approach is done by teaching the students to match the situation in the story problem with the situation the students have experienced before. Meanwhile, translation approach involves the student to read the math story problem

and then translate the problem into mathematical sentence. The model approach is better fit to be used in spoken math story problem, while translation approach is better fit to be used on written math story problem.

In general, the solving math story problem can be done in several steps. Shadiq (2014: 105-108) stated that the steps which is used in solving math story problem is the same with the problem-solving steps which are: (1) understand the problem, (2) devise a plan, (3) carry out the plan, and (4) check the result, while Isdiardi (2004: 18-19) stated that the steps that must be taken to solve story problem are (1) read the problem and find the problem which must be solved, (2) draw a figure if needed, (3) decided the math operation which will be used, (4) write the mathematical sentence which figures the connection in the problem, (5) estimate the answer, (6) calculate and check the calculation step, and (7) compare the answer with the answer estimation. Rahim (2015), in short, mentioned four steps which could be taken to solve math story problem which are (1) understand the question, (2) create a math model, (3) conduct the calculation, and (4) make a conclusion.

Based on the opinions above, it can be concluded that the steps in solving story problem can be described as follows:

1. Understand the problem in question

The understanding about the problem in story problem can be done by reading the question carefully and understanding the connection between words and numbers in the question. After that, the students could find what is known and asked in the question.

2. Devise a problem solving plan

Devising the problem-solving plan is done by writing out the mathematical sentence from the problem in question. After discovering what is known and asked in the problem, then the student can decide the calculation operation which will be used to find the answer.

3. Solve the problem

In this step, the student must able to complete the mathematical sentence and the calculation operation which has been formulated before. The student will conduct the computation with the correct formulas and steps.

4. Decide the conclusion of the answer

After the computation result is achieved, there should be a rechecking of the computation result which has been conducted before. Next, the student will make a conclusion of the answer and connect the answer with what been asked in the question.

METHODOLOGY

This study is a literature review by collecting and reviewing literature consist of international journals, national journals, and books. A literature review was conducted to find out how Polya's step can be used to solve math story problems. Based on the literature review, the authors found Polya's steps that were slightly less in line with the math story problems steps. Therefore, the author tries to modify Polya step that is adjusted to solve the problem of math story.

RESULT AND DISCUSSION

Relation Between Polya's Step and Math Story problem

Polya's steps are steps which used to solve problem. While math story problem is a type of math problem/question which related to solving problem in daily life. Polya's steps have been often implemented in solving math story problem or solving a mathematic problem. Several studies have shown that Polya's steps are effective in improving the students' ability in solving math story problem and ther ability to solve problem in general. A research by Marlina (2013) shows that Polya's step can help the students in solving story problem and it could also improve the students' study result in solving math story problem. The research by Ifanali (2014) also resulting in conclusion about the implementation of Polya's step which can improve the ability in solving math story problem. Logoglu (2017) found that the student's success in the process of solving mathematics problem is improved by applying Polya's step accurately. On the other hand, a research by Lee Chien I (2017) concluded that a lesson approach using Polya's method significantly could improve the effectiveness of mathematics lesson.

Several researches above indicated that Polya's steps are appropriate to be used in solving math story problem which is closely related to problem-solving. Polya's steps are appropriate to be used in solving story problem because the syntax of Polya's steps and the steps in solving math story problem is almost similar. Polya's steps consist of four steps, while the steps in solving math story problem also consist of four steps. The syntax of Polya's step and steps in solving math story problems is as follows:

TABLE 1 :Syntax of Polya’s Step and Steps in Solving Math Story Problems

Polya’s Step	Steps in Solving Mathematics Story Problem
Understand the problem	Understand the problem in question
Devise a plan	Devise a problem-solving plan
Carry out the plan	Solve the problem
Look back	Decide the conclusion of the answer

The table above shows that there are similarities and difference between Polya’s steps and the steps in solving math story problem. The difference can be seen in the fourth step between the two. The last step in Polya’s steps is look back, while the last step of the steps in solving math story problem is to decide a conclusion of the answer. Example of Polya’s step implementation to solve math story problem is as follows:

Question

A park has a length of 32 m and a width of 24 m. Around the park will be installed lamps with a distance 4 m between the lamps. How much the lamps required to be installed around the park?

Step 1. Understand the problem

Known : A park shape is rectangular
 length (l) = 32 m
 width (w) = 24 m
 Distance between lamps = 4 m
 Unknown : The number of lamps required

Step 2. Devise a plan

The circumference of rectangular = $2 \times (l + w)$
 The number of lamps required = circumference of rectangular : distance between lamps

Step 3. Carry out the plan

The circumference of rectangular = $2 \times (32 \text{ m} + 24 \text{ m})$
 $= 2 \times 56 \text{ m}$
 $= 112 \text{ m}$
 The number of lamps required = circumference of rectangular : distance between lamps
 $= \frac{112 \text{ m}}{4 \text{ m}}$
 $= 24$

Step 4. Look back

The circumference of rectangular = $2 \times (32 \text{ m} + 24 \text{ m})$
 $112 \text{ m} = 2 \times 56 \text{ m}$
 $112 \text{ m} = 112 \text{ m} \quad (\text{true})$

The last step of Polya’s step only requires the student to check back the steps which they have done and the answer the received. The step is intended to look back at the step’s compatibility which has done and to recheck whether there are any mistakes in the calculation process. Meanwhile, the last step of steps in solving math story problem is to decide the conclusion of the answer, where the answer conclusion of math story problem must be related to the problem which is asked in the question. Therefore, there need to be a little modification and adjustment on Polya’s steps with the steps in solving math story problem so that the Polya’s step could become clearer for solving math story problem. The Polya’s step could be modified by adding one additional step which is deciding the conclusion. A step can be added in Polya’s step is as follows:

Step 5. Decide a conclusion

So, the number of lamps needed to be required around the park with a distance 4 m between lamps is 24 lamps.

This last step is the important step and frequently forgotten by the students when they solving math story problem. Often when solving math story problem, the students' answer is only concluded at the final answer of the calculation without writing the conclusion of the answer and connecting the answer with the question. So, decide a conclusion step can be added in Polya's step to fit math story problem steps.

CONCLUSION

Polya's steps and math story problem are two interconnected matter. The Polya's steps are steps to solve a problem, while math story problem is one of the problems which must be solved. Polya's steps have similarities with steps in solving math story problem. This is because the basis for the two steps is a mean to solve a problem. Even though Polya's steps and steps in solving math story problem have an almost similar syntax, there is a little difference on each final step. The last step in Polya's steps is look back and the last step of steps in solving math story problem is deciding a conclusion of the answer. If the Polya's steps are implemented to solve a math story problem, then the final answer would not be appropriate with the desired answer of the math story problem. This is because the final answer of math story problem should be a conclusion which can answer the question in the math story problem.

Based on the description above, it can be concluded that to make the final answer of math story problem be appropriate with the desired answer, then the implemented Polya's steps must be adjusted with the steps in solving math story problem. Polya's step can be modified by adding one additional step which helps the students in solving math story problem. So, the modification on Polya's step which can be used to solve math story problem are (1) understand the problem, (2) create a math model, (3) do the calculation or computation, (4) make a conclusion, and (5) decide a conclusion.

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