The analysis of mathematic problem solving ability by polya steps on material trigonometric reviewed from self-regulated learning

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Abstract. The problem solving ability is a personal capability to identify the existing condition and relate it to knowledge owned by students. The steps in problem solving according to Polya are problem understanding, planning, implementing and evaluating of problem solving. This is a descriptive qualitative research which aims to describe and analyze students’ ability in problem solving based on Polya’s steps reviewed from self-regulated learning. The subject of the research is two students in each SRL (high, middle, low). The method of collecting data is test and interview. The result of the research comes to the students with high SRL can apply the Polya steps. The students with middle SRL can apply the problem understanding step. In the step of planning, students write the strategy leading to the correct answer but it has not completed yet. In the implementation step, students do the planned strategy but less complete in doing the calculation and they give improper conclusion at the evaluation step. Meanwhile, the students with low SRL can understand the problem by writing down what they know and what is asked. At the planning step, students write the relevant strategy but improper as heading to incorrect answer. At the step of implementation, they do not do the strategy appropriately as well at the stage of evaluation.

1. Introduction
According to the National Council of Teachers of Mathematics (NCTM) one of the goals of learning mathematics is problems solving [1]. Therefore a good problem solving ability is needed so that students can be said that they have understood a mathematical concept. In mathematics, problem solving is the most effective activity for contextualizing and re-contextualizing concepts, doing operational transfer of mathematical knowledge, and ensuring continuous and meaningful learning [2]. Basically the ultimate goal of learning is to produce students who have the knowledge and skills in solving problems encountered later in society [3].

Problem solving is seen as a process of finding a combination of a number of rules that can be applied in an effort to cope with new situations [3]. In line with Ozcan that problem solving is considered as an act of transferring existing knowledge to a new situation [4]. In solving the problem not only using the formulas that have been obtained, but also using reasoning activities, analysis, critical thinking in processing and combining the formulas that have been obtained to get a way out in solving the problem. It becomes an idea Polya to propose problem-solving steps. The first step is to
understand the problem. The second step is to make a problem solving plan. The third step is to implement a problem-solving plan. The fourth step is evaluation [5].

Question are considered as problems in mathematics according to Suradji if they can’t be solved or resolved with patterns of behavior or patterns of behavior possessed (by someone) [6]. In addition Sujono reveals a mathematical problem can be described as a "challenge" if the solution requires creativity, understanding, original thought or implication [7]. This indicates that in solving the problem the students must be able to identify the existing condition and relate it to the knowledge they possesses. Therefore, students are required to think independently in solving problems. As the research on students' strategic in problem solving done Pimpaka Intaros considered that solving math problems starts from open ended problems, students will solve their own problems, then it encourages students to make problem-solving strategies [8]. So the problem is as a practical or theoretical difficulty that a student must solve independently [9]. In learning the students not only control cognitive activity (metacognition), but also develop skills related to the will which enables to regulate attitudes, environment, and behavior to improve positive learning outcomes [10]. An important factor of students influencing learning is Self Regulated Learning. In addition there is also a relationship between students' self regulated learning with problem-solving abilities [11]. It shows how important students' self regulated learning is related to student problem solving abilities.

According to Zimmerman students who have high SRL will be active to seek information when they need it and they will take the necessary steps to master information [12]. Boekaerts defines self regulated learning as follows: "Self regulated learning (SRL) has been defined as a complex interactive process involving not only cognitive self regulation but also motivational self regulation" [13]. That means SRL is a process that requires cognitive independence and motivation. Independence also contains three characteristics: designing goals, choosing strategies, and monitoring the cognitive and affective processes that take place when a person completes an academic task [14]. Giving academic assignment is one of the opportunities to the student where the student can be responsible for his learning [4]. Zimmerman defines SRL into three dimensions of motivation, attitude (behavior) and metacognitive [15]. These three dimensions are variables that correlate significantly with the values of math, science and reading activities [16]. Motivated, individual-oriented differences affect cognitive settings [17]. Related with metacognitive is the ability to realize what they know and when and how to do it in applying that knowledge [4]. Thus metacognitive also becomes important in solving a mathematical problem. Cognitive, motivation, metacognitive, attitudes are parts of success in solving problems. So that problem solving ability owned by student influenced by students' SRL.

2. Method
This research is a qualitative descriptive study. The purpose of this study is to describe the students' steps of solving problems based on Polya steps reviewed from SRL. Data collection techniques are test, interviews and documentation. Research in SMA Batik 1 Surakarta in the academic year 2017/2018. Selection of research subjects based on the technique of taking purposive sampling. SRL instruments are modified from Lopez, Yot, Tuovila, & Rodriguez, there are 35 items in the form of a Likert questionnaire to categorize high, medium and low SRL [18]. The test instrument in the form of problem solving abilities consists of two items. From each category of learning independence, two subjects were taken to analyze the results of the problem-solving test. Data analysis techniques are data reduction, data presentation, drawing conclusions and verification. Data validity is done by triangulation method. Triangulation method that is comparing data from writing (test) to orally (interview). If the data of the triangulation is the same, then the subject data is valid.

3. Result and Discussion
Instruments of SRL consist of several indicators, they are know the purpose of learning mathematics, the desire to succeed, confidence in learning mathematics, seriousness in learning mathematics, self-discipline in learning mathematics, setting the time to learn mathematics, responsibility in doing tasks, completeness of learning facilities, self-assessment, and positive attitude during math lessons. From 90 students of class X MIPA, 20 students obtained of high SRL, 43 students of middle SRL and 27
students of low SRL. From each category of learning independence, two students were selected for interviewing about their problem-solving abilities.

The instruments ability problem solving:

- Si A looks at a spire with an elevation angle $30^\circ$. The height of Si A is 180 cm. The position of Si A with the base of the tower is 20 m. Then si B also looks at a spire in the same position as the A with an elevation angle $60^\circ$. Determine the height of Si B!

- ABC is a right triangle in B is inside the circle. The line AC on the circle as diameter. $AC = 20$ cm, $\angle ACB = 30^\circ$ and $AB = 10$ cm. Determine the area of the non-shaded area!

Analysis of students' problem solving skills was done based on Polya steps. Polya stages are understanding problem, planning, implementation, and revaluation.

3.1. High Self-Regulated Learning

Figure 1. Test Result of Number 1 of Students with High SRL.

Figure 2. Test Result of Number 2 of Students with High SRL.

Figure 1 is a test result of number 1 of subject 1 and Figure 2 is a test result of number 2 of subject 2 which has a high SRL. Phase of understanding problem had been done by students. Students could write down what is known and what is asked. Students illustrate the illustration of the item with wrote additional information that is not in the test item. Students know about the unknown in the problem, meaning students understand about the purpose of solving the problem [19]. So it can be said that those students could understand the problem. The problem-solving planning stage, students could write down the sequential steps and led to the correct answers. Students can choose the right strategy to use based on their previous knowledge. In question number 1 students look for the length of the front side of elevation angles A and B. Students can think in looking for the height of the B by "subtracting the height A with the reduction of front side of angle A and front side of angle B". On the question number 2 students look for an area that is not shaded with a "area circle less the area of a
In implementing stage, students wrote the formula in accordance with the planning and calculated based on the formula correctly. In question number 1 students work on a trigonometric ratio formula. and do the calculations correctly. In question number 2 students work with phytagoras theorem and area of triangle. In the evaluation stage, the students wrote the conclusion of the problem. The results of the student interviews, students checked the calculation from beginning to the end, as well as on question number 2 the student used another way to evaluate the answer. Students work again using the triangle area wide rule and trigonometric ratio, showing the same result. Based on the results of the analysis and interviews obtained that students with high SRL can implement all Polya steps well namely understanding the problem, problem solving planning, implementation of completion plan and evaluation.

3.2. Middle Self Regulated Learning

![Figure 3](image1.png) **Figure 3.** Test Result of Number 1 of Students with Middle SRL.

![Figure 4](image2.png) **Figure 4.** Test Result of Number 2 of Students with Middle SRL.

Figure 3 is a test result of number 1 of subject 3 and In Figure 4 is a test result of number 2 of subject 4 which have middle SRL. Phase understanding of problem had been done by students. Students could write down what is known and asked, they also could illustrate the problem of the test item. During planning stage, they could write down the completion steps leading to correct but incomplete and less detailed answers. In test item 1, the error occurred in step 4, the student looked for the height of the B by simply reducing the result of the front side at the elevation angle 30° and 60°. The result of the interview, the students do not understand in looking for high Si B, then the existing number is deducted. In test item number 2, there was no explanation to find the length of BC, he or she directly looked for immensity of the triangle and circle. The results of the student interviews considered useless looking for the length of BC. In the implementation stage, students could
implement with the appropriate formula, but there was an imprecise calculation, so the final result was wrong. In question number 2 there is a step that is not right on the side of the picture. The results of the student interviews, students will look for the length of BC (front side), but obtained the wrong calculation. In the evaluation stage, the students wrote the conclusion of the problem even though the final result was wrong. The results of the student interviews, students didn't check the recalculation from beginning to end. Students have no other strategy to check their answers. Based on the results of the analysis and interviews obtained that students with middle SRL are able to undertake a problem understanding stage. In the problem-solving planning stage, students wrote strategies that lead to correct but incomplete answers to solve the problems. The implementation stage executes the planned strategy, but with incomplete calculation. In evaluation stage, they gave an incorrect conclusion.

3.3. Low Self Redulated Learning

![Figure 5](image1.png)  ![Figure 6](image2.png)

**Figure 5.** Test Result of Number 1 of Students with Low SRL.  
**Figure 6.** Test Result of Number 2 of Students with Low SRL.

Figure 5 is a test result of number 1 of subject 5 and In Figure 6 is a test result of number 2 of subject 6 which have low SRL. In stage of understanding the problem, students could write down what is known and what is asked. Students who were interviewed could only provide information from test item. In problem-solving planning stage, the students could write down the completion steps, but it didn't lead to the correct answer. When they were interviewed, they confessed that they were still confused with the purpose of the test item. The difficulties that often occur at the stage of understanding the problem are not being able to identify what is the problem and not being able to interpret the situation [20]. Students simply wrote down the plan of completion of materials that they remembered. The implementation stage of the completion plan and the evaluation stages were not performed by the students. Students who are lack in understanding questions can’t actualize the thought process needed to reach the solution [21]. Students said that the test items were very difficult and the time provided was limit. Students which have low SRL dependence on what teachers have to say in the classroom without studying individually or in groups with personal initiative to have further understanding the material. Based on the results of the analysis and interviews obtained that students with low SRL could take the stage of understanding the problem by writing down what is known and
what is asked. In the problem-solving planning stage, they wrote down relevant but inappropriate strategies so they didn't lead to the right answers. In implementation stage, they didn't carry out a proper planned strategy. As a result, they did nothing in evaluation stage.

4. Conclusion
The results of the discussion above can be concluded that students with high SRL can implement all Polya steps well namely understanding the problem, problem solving planning, implementation of completion plan and evaluation. Students with middle SRL are able to undertake a problem understanding stage. In the problem-solving planning stage, students wrote strategies that lead to correct but incomplete answers to solve the problems. The implementation stage executes the planned strategy, but with incomplete calculation. In evaluation stage, they gave an incorrect conclusion. Students with low SRL could take the stage of understanding the problem by writing down what is known and what is asked. In the problem-solving planning stage, they wrote down relevant but inappropriate strategies so they didn't lead to the right answers. In implementation stage, they didn't carry out a proper planned strategy. As a result, they did nothing in evaluation stage.

The impact of this study is that teachers can know the weaknesses and advantages of students in solving problems in each category of student self regulated learning. Increasing students' SRL requires a long process. So the teachers can provide a certain way in improving students' problem-solving skills based on their level of SRL.

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