An Identification of Problem Solving Ability as a Component of Mathematical Literacy

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Abstract. Mathematical literacy is an ability that is expected to be obtained by students in learning mathematics. One of the components of mathematical literacy is problem solving ability which should be supported by an ability of logical reasoning and mathematical communication. Its is essential to identify the problem solving ability as the basis of understanding one of the components of learners'mathematical literacy. The identification is done by considering learners' basic ability that has been achieved in the previous stage of the learning process. The result of the identification can be utilized to improve students' basic mathematic ability. In this descriptive qualitative study, nine students were involved as the research subject. They were divided into three groups that represented different mathematic abilities: high, moderate, and low. Test and interview were employed to collect the data. The data were analyzed through triangulation process based on the indicators that were determined. The result of the study shows that the students with high mathematic ability were able to utilize the problem solving components including: (1) understand the problem, (2) make a plan, (3) carry out the plan, and (4) look back at the completed solution. In the opposite, students with moderate and low abilities could not meet the problem solving components optimally due to their insufficients mathematic ability in the previous educational level.

1. Introduction

Mathematics, in Indonesian education system, is one of compulsory subjects to be taught at schools starting from elementary, junior high, and senior high schools. As a discipline that influences various aspects of human life, mathematics plays an important role in the development of modern technology and the development of other disciplines. This is due to the fact that mathematics consists of fruitful concepts.

The concepts in mathematics are interrelated not only within the discipline itself, but to other fields of study and many aspects of life as well. Therefore, the teaching and learning process is expected to be done optimally by considering the correlations between the concepts as well as any aspects related to students' ability. This is in line with the core competence which is mandated in *Permendikbud No. 68, 2013* about the Content Standard. In general, the core competence of every subject in the cognitive domain is formulated to provide students with factual, conceptual, and procedural knowledge which should be based on students' interests in science, technology, and arts which are related to real life phenomena. While the core competence is the one in psychomotor domain which is intended to enable students to analyze, present, and formulate in the concrete fields (to use, elaborate, compose, modify, and create) and the abstract ones (to write, read, calculate, and draw). The core competence is related to the topics discussed at school as well as other related theoretical sources.

Nowadays, in learning mathematics the students are expected to not only be able to calculate and memorize concepts. The reasoning and problem solving abilities are essential to obtain. According to OECD [1],

"Mathematical literacy is an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens."

The concept of mathematical literacy is closely related to several other concepts discussed in mathematics education [2]. According to Stacey and Tuner [3], mathematical literacy means having the power to employ mathematical reasoning in solving various problems in the daily life in order to face the future challenges. The mathematical reasoning covers problem solving paradigm, logical thinking, communicating and explaining. The paradigm is developed based on mathematical concepts, procedures, and facts which are relevant to the problems being faced.

Problem solving can be defined as a systematic process done by an individual to decide what to do to solve a problem [4]. According to Hayes [5] a problem is "whenever there is a gap between where you are now and where you want to be, and you don't know how to find a way to cross that gap." Therefore, finding this 'way' is an important part of problem solving In learning mathematics, students with problem solving ability are the ones who are able to do more than answering and completing mathematics tasks. John and Rising [6] state that there are five reasons why problem solving ability is important in learning mathematics: 1) problem solving is a way to learn new concepts, 2) problem solving is the best way to demonstrate computational ability, 3) through problem solving, students are able to learn how to implement the concepts and skills into new situations, 4) problem solving stimulates intellectual curiosity, and 5) problem solving ability enables students to acquire new knowledge. Those reasons show the importance of the problem solving ability especially in learning mathematics.

Problem solving is the process of moving from the given information (inside the container) through the problem (the container) to the solution (outside the container). There presentations are the means of moving from inside to outside of the container [7]. There are four phases or steps involved in problem solving i.e. 1) understanding the problem, 2) see how the various items are connected, how the unknown is linked to the data in order to obtain the idea of the solution, to make a plan, 3) carry out the plan, and 4) look back at the completed solution we review and discuss it [8]. The four phases must be fulfilled as the indicators of problem solving ability.

The problems which are discussed here are the non-routine ones that require quite complicated algorithm. As a result, it is difficult enough for some students to perform the problem solving process. In general, not all of the steps in problem solving process employed by the students in written tasks. The common step which is skipped is the second step: formulating a plan to solve the problem. In this case, certain procedures are needed in order to find out whether or not the students employ the steps needed.

Any mathematical concepts have the potentials to be developed and presented as the questions which can be solved through problem solving process. One of the concepts is social arithmetic. This is one of the concepts is mathematics teaching and learning given to seventh grade students. This concept contains of various topics including purchase price, sales price, profit and loss, profit/loss percentage towards purchase price, discount, gross, net, tare, and loan interest.

Understanding on the concepts of social arithmetic is influenced by students' basic mathematical ability that is related to numerical operation. The basic mathematical ability is expected to be the foundation in understanding the concepts of social arithmetic. In general, basic mathematical ability can be divided into three levels: low, moderate, and high. The classification is based on some considerations such as students' ability, level of difficulty of the materials, and so on.

Based on the background above, the researcher formulates a research problem to answer: How is the problem solving ability performed by students with low, moderate, and high basic mathematical ability?

2. Research Method

The identification process of problem solving ability was done descriptive qualitatively. The research subjects were seventh grade students at SMP 1 Tegalsari, Banyuwangi, selected through purposive and snowball sampling techniques. By considering the basic mathematical ability, the subjects were divided into three groups representing different basic mathematical abilities: low, moderate, and high.

The data collection was done by conducting tests and interview. There were two tests given to the students including a test to decide the research subjects and a problem solving test. To test the basic ability, the researcher used the materials of the National Examination 2017 for elementary school due to the validity and reliability. The analysis of the results of the test was done to determine the total scores achieved by the students by using the following formula [9] :

$$S = \frac{B}{N} \times 100$$

Note: S: total score

B: correct answers

N: number of test items

Based on the results of the test, the subjects were divided into three criteria: 1) high, when the students achieved 76-100; 2) moderate, when the students got 65-75; and 3) low, when the students got <60.

After conducting the test, the results of the test and the interview were analyzed through data triangulation process. The data analysis was done qualitatively by considering the indicators that had been determined, including (1) understand the problem, (2) make a plan, (3) carry out the plan, and (4) look back at the completed solution.

In general, the study employs the following steps:
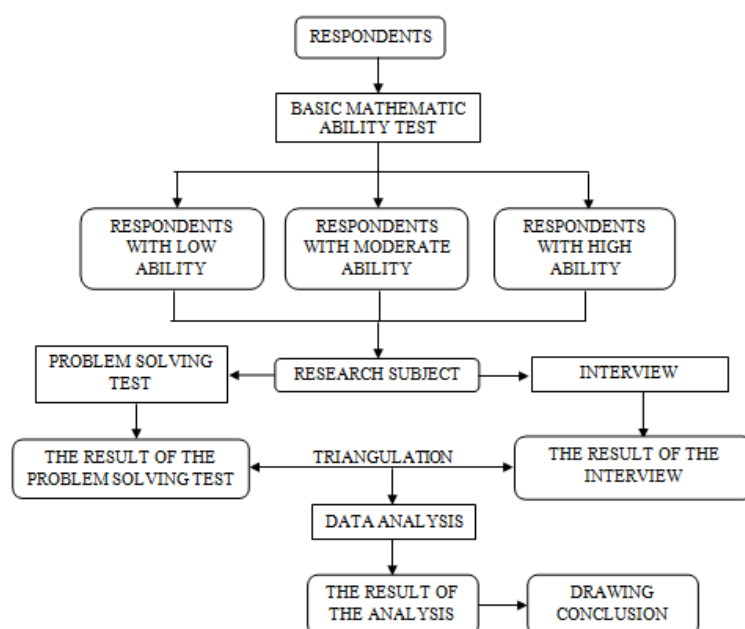
Figure 1. The Diagram of Research Procedure

3. Result and Discussion

The results of the basic ability test show that from the total of 27 students, 10 students were classified into low category, 7 students were classified into moderate category, and 10 students were

classified into high category. From every level, 3 students with good communication skill were chosen as the research subjects.

Next, the research subjects were given problem solving test as well as interview, the results of which were analyzed through triangulation. Regarding the test, the first problem was given to discover the problem solving ability related to unit price, wholesale price, and discount.

Pak Rama membeli 2 lusin kemeja batik dengan harga Rp. 75.000,00/potong. Pembelian tersebut mendapatkan diskon sebesar 5% dari keseluruhan pembayaran. Jika pak Rama ingin menjual kembali kemeja batik tersebut dengan harga Rp. 87.500,00/potong, berapa keuntungan yang diperoleh pak Rama ?

Figure 2. Problem Number 1

The second test was given to the subjects in order to find out the problem solving ability. The test item was related to total and partial weights.

Bu Sinta membeli sekaleng susu di Roxi Banyuwangi.
Di rumah, bu Sinta menimbang kaleng susu tersebut beserta isinya. Ternyata berat keseluruhan dari kaleng dan isinya adalah 0,9 kg. Berapa berat kaleng tersebut (gram) ?

Figure 3. Problem Number 2

The third problem was given to investigate students' ability in solving a problem which is related to loan interest.

Pak Raden meminjam uang di bank sebesar Rp. 30.000.000,00 untuk mengembangkan usahanya dengan bunga 12,5% pertahun. Berapa besar angsuran yang harus dibayar pak Raden tiap bulan jika pinjaman akan dilunasi selama 2,5 tahun ?

Figure 4. Problem Number 3

Research subject coding as H1, H2, and H3 for research subject with high ability; M1, M2, and M3 for research subject with moderate ability; L1, L2, and L3 for research subject with low ability. The results of the problem solving test can be seen in the following table.

Table 1. The Results of the Problem Solving Test

SUBJECT	TEST RESULT
H1	
H2	
H3	
M1	

M2

M3

L1

L2

L3

The results of the analysis of the first problem solving test and the interview achieved by the students can be seen in Table 2.

Table 2. the Results of the Analysis on Problem Solving Test No. 1

PROBLEM SOLVING COMPONENTS	SUBJECTS								
	H1	H2	H3	M1	M2	M3	L1	L2	L3
UNDERSTAND THE PROBLEM	√	√	√	-	√	√	√	√	-
MAKE A PLAN	√	√	√	-	√	√	√	√	-
CARRY OUT THE PLAN	√	√	-	-	-	√	√	√	-
LOOK BACK AT THE COMPLETED SOLUTION	√	√	-	-	-	√	√	√	-

The results of the analysis show that in the first question, the research subjects with high ability were able to identify the problem and formulate the planning for the solution. However, there is a subject who could not use algorithm and do reflection well enough. From the subjects with moderate ability, two students were able to identify the problems and decide the solution plan. However, two students were found unable to use algorithm as well as performed reflection well. The last, from the students with low ability, two of them could meet all problem solving components. The results of the second test as well as the interview as performed by the subjects can be seen as follows.

Table 3. the Results of the Analysis on Problem Solving Test No. 2

PROBLEM SOLVING COMPONENTS	SUBJECTS								
	H1	H2	H3	M1	M2	M3	L1	L2	L3
UNDERSTAND THE PROBLEM	√	√	√	√	√	√	√	√	√
MAKE A PLAN	√	√	√	√	√	√	√	√	√
CARRY OUT THE PLAN	√	√	√	√	√	√	√	√	√
LOOK BACK AT THE COMPLETED SOLUTION	√	√	√	√	√	√	√	√	√

The results of the analysis of the test item number two shows that all students, from the three levels, could meet the problem solving components very well. The results of the analysis on the third problem based on the interview are shown in the following table.

Table 4. the Results of the Analysis on Problem Solving Test No. 3

PROBLEM SOLVING COMPONENTS	SUBJECTS								
	H1	H2	H3	M1	M2	M3	L1	L2	L3
UNDERSTAND THE PROBLEM	√	√	√	√	√	√	-	-	-
MAKE A PLAN	√	√	√	√	√	√	-	-	-
CARRY OUT THE PLAN	√	√	√	√	-	-	-	-	-
LOOK BACK AT THE COMPLETED SOLUTION	√	√	√	√	-	-	-	-	-

As seen above, the students with high ability were able to perform very well by meeting every component of problem solving. The subjects with moderate ability could meet the components of problem identification and planning of the solution, while only one of them who could meet the other two components. In contrast, none of the students with low ability could meet the problem solving components.

4. Conclusions

Based on the obtained data as well as the analysis and discussion, it can be concluded that 1) generally, the students with high ability are able to meet problem solving components including identification of problems, planning of solution, use of algorithm, and reflection, while 2) student with moderate and low ability could not perform the problem solving components well. It is suggested that the conclusion above can be used as the reference in improving students' problem solving ability as the part of mathematical literacy. The improvement of the problem solving ability applies in problem posing as well in order to help students to understand any problems they face.

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