The Construction of Mathematical Literacy Problems for Geometry

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Abstract. The students of junior high school should have mathematical literacy ability to formulate, apply, and interpret mathematics in problem solving of daily life. Teaching these students are not enough by giving them ordinary mathematics problems. Teaching activities for these students brings consequence for teacher to construct mathematical literacy problems. Therefore, the aim of this study is to construct mathematical literacy problems to assess mathematical literacy ability. The steps of this study that consists of analysing, designing, theoretical validation, revising, limited testing to students, and evaluating. The data was collected with written test to 38 students of grade IX at one of state junior high school. Mathematical literacy problems consist of three essays with three indicators and three levels at polyhedron subject. The Indicators are formulating and employing mathematics. The results show that: (1) mathematical literacy problems which are constructed have been valid and practical, (2) mathematical literacy problems have good distinguishing characteristics and adequate distinguishing characteristics, (3) difficulty levels of problems are easy and moderate. The final conclusion is mathematical literacy problems which are constructed can be used to assess mathematical literacy ability.

1. Introduction
Mathematics is the important and the basic foundation knowledge to solve the problems of daily life [1] [9]. Given the role of mathematics is important, so the mathematical ability always gets attention for further improved. Geometry is one of the oldest and the most fundamental branches of mathematics [2]. Geometry much involved in various real live situations, one example is polyhedron subject. Polyhedron subject is referred to in this study are cubes and cuboids

Mathematical literacy is one of mathematics ability. Mathematical literacy is an individual’s ability to formulate, employ, and interpret mathematics in a variety of context [3]. Mathematical literacy includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. National Council of Teacher of Mathematics [4] has revealed the importance of having mathematical literacy ability. There are five basic ability in learning mathematics namely mathematical problems solving ability, mathematical reasoning ability, mathematical connection ability, mathematical communication ability, and mathematical representation [4]. The fifth basic capability is actually a competency in mathematical literacy [6]. This means that mathematical literacy is the complex ability as necessary to students.

There are six levels of mathematical literacy in PISA framework [5]. In this research, we construct three levels of mathematical literacy. Because, we conform to Indonesian student ability. In level 1,
students should be able to answer general context question that relevant information is available; level 2, students should be able to interpret and recognize situations in contexts that require direct inference; level 3, students should be able to choose and apply simple problem-solving strategies [5]. Mathematical literacy consists of space and shape content, quantity content, change and relationship content, and uncertainty content [10]. Preceding study shows mathematical literacy problems have developed in PISA framework at quantity content for students of grade IX [7]. Other study reveals mathematical literacy problems have developed at ratio subject for students of grade VII [8]. The difference of this study with preceding study are we construct mathematical literacy problems at polyhedron subject with shape and space content and problems construct with three levels of mathematical literacy for students of grade VIII. The aim of this study is to construct mathematical literacy problems to measure mathematical literacy ability at polyhedron subject.

2. Method
This study constructed mathematical literacy problems to assess the mathematical literacy ability. Research method included several stages that: (1) analysing; (2) designing; (3) theoretical validation; (4) revising; (5) limited testing to students; and (6) evaluating [11]. We constructed three mathematical literacy problems at polyhedron subjects. Next, the mathematical literacy problems were theoretically validated to three experts, including two mathematics lecturers having mathematics education background, a mathematics teacher having mathematics education background, and 38 students of grade IX at one of state junior high school.

3. Result and Discussion

3.1. Analyzing
We analysis journals and books about mathematical literacy to construct mathematical literacy problems. The result of analysis step is generated about indicator and operational definition of mathematical literacy. According to journal, junior high school students still experience various obstacles in solving the problem of mathematical literacy [12]. Constraints faced by students among them have not been able to identify the data on the problem, have not been able to reflect on the meaning of the statement given and mistaken in making conclusions from two facts that are not interrelated, and have not been able to interpret the three-dimensional objects related [12]. This is in contrast to the importance of mathematical literacy ability for students. Therefore, it is important for teachers to construct the problems of mathematical literacy to assess students' mathematical literacy ability at polyhedron subject.

3.2. Designing
The next step is designing mathematical literacy problems. We construct mathematical literacy problems at polyhedron subject (cubes and cuboids). There are three essays about mathematical literacy problems that we have constructed. Mathematical literacy problems have been constructed based on the purposes of learning polyhedron subject at new curriculum in Indonesia. The purposes of the learning at polyhedron subject are identifying the characteristics of cubes and cuboids; making nets cubes and cuboids; and calculating surface area and volume cubes and cuboids. The indicators of mathematical literacy problems based on two mathematical literacy processes. They are formulating situation mathematically and employing mathematical concepts, fact, procedures and reasoning [3]. This study uses scoring guideline that adhere to the QUASAR general rubric [13]. Problems in level 2 and level 3 are constructed by modifying [17]. Mathematical literacy problems content outline can be seen at Table 1.
Table 1. Mathematical Literacy Problems Content Outline.

| Item | Indicator | Learning Objectives                                      | Level | Score |
|------|-----------|----------------------------------------------------------|-------|-------|
| 1    | Formulating situation mathematically | Identify the characteristics of polyhedron | 1     | 3     |
| 2    | Employing mathematical concepts, fact, procedure, and reasoning | Making polyhedron nets | 2     | 4     |
| 3    | Employing mathematical concepts, fact, procedure, and reasoning | Calculate the volume of polyhedron | 3     | 4     |

Table 1 shows that mathematical literacy problems are constructed not only from indicators, but also from learning objectives at new curriculum in Indonesia. Every score of problems is developed by problems complexity and levels of mathematical literacy ability.

3.3. Theoretical Validation
This activity is done after mathematical literacy problems are compiled and ready to be validated by three experts. Two experts are mathematics education lecturers with mathematics and mathematics education background. While another expert is a mathematics teacher with mathematics education background. The experts validate from several aspects as content, language, and appearance. Suggestions of experts as follows.

Validator 1 gives suggestions for (1) mathematical literacy problems must be appropriated to the learning objectives; (2) difficulty levels of problems are adapted by mathematical literacy levels; and (3) additional words “explain the reason” at problem 2. Advice from validator 2 are (1) for problem 1, change the word “cuboids” with one example of a cuboids-shaped object in daily life; (2) add an image to illustrate container and add the words “give the reason” at problem 3; (3) the final recommendation from validator 3 is to simplify the image of cube nets at problem 2.

3.4. Revising
Grounded on expert validator advice in theoretical validation step, we improve mathematical literacy problems. Mathematical literacy problems are corrected by changing the wording, adding picture, and replacing question. The revision of mathematical literacy problems is executed in order to students comprehend the purpose of the problems well. This is the result of revision.

**Level 1**
A brick has a size of 24 cm long, 12 cm wide, and 6 cm thick. a) make a sketch of the brick and add the sizes; b) how many side; c) how many sides are 24 cm × 12 cm in size; d) write down the length and width of the other sides.

**Level 2**
Notice the four cube nets below!

There will be searched cube nets that by the rule that the total number of points on the two opposite sides of the dice is always seven. For each of the above nets, circle “yes” or “no” in the table below.
| nets | by the rules | explain the reason |
|------|-------------|--------------------|
| I    | yes or no   |                    |
| II   | yes or no   |                    |
| III  | yes or no   |                    |
| IV   | yes or no   |                    |

**Level 3**
Consider the picture of the container below!

(image source: http://icon-container.de/en/)

The container will be filled with a cube shape box. The size of the crate and the number of boxes that are already inside the container can be seen as shown below.

How many boxes are still needed to fill the container? Give the reason!

(image source: https://intitute.blogspot.co.id)

**3.5. Limited Testing to Students**
In this step, mathematical literacy problems are tested to 38 junior high students. There are 20 female students and 18 male students as sample. We select students in IX grade as sample, because they have learned about polyhedron subject. Before being tested to students on a limited scale, the problems of mathematical literacy are corrected first on the advice of expert validators. The students do problems for 80 minutes. Mathematical literacy problems are done individually by the student. The example of student’s solution can be seen at Figure 1.
Figure 1. Representative Example of Student’s Solution on Problems 1 until 3

Figure 1 indicates that in problem 1, student has drawn the brick properly and answered question about cuboids elements correctly. In second problem, student has chosen the right nets but for the reason, student doesn’t explain the point of dice clearly. Next for problem 3, student has answered the question correctly. Student has written many boxes that can stow container with volume.

3.6. Evaluating

Next, we evaluate the student’s answer on limited testing. There are four tests to evaluate mathematical literacy problems. The first is validity test. The validity of mathematical literacy problems is determined by bivariate correlation. The second is reliability test. The reliability of mathematical literacy problems is decided by Cronbach’s Alpha. Interpretations of correlation coefficient and reliability coefficient are very high, high, moderate, low, and slight [14]. The third is distinguishing test. The distinguishing of mathematical literacy problems is determined by the formula of distinguishing [15].

\[ DP = \frac{S_A - S_B}{J_A} \]

Annotation:
- \( DP \): distinguishing
- \( S_A \): the sum of top group score item
- \( S_B \): the sum of bottom group score item
- \( J_A \): the sum of ideal score item

Interpretations of distinguishing mathematical literacy problems are very good, good, adequate, poor, and very poor [16]. The last is difficulty levels test. Difficulty of mathematical literacy problems is calculated by the formula of difficulty level [15].

\[ IK = \frac{S_A + S_B}{2J_A} \]

Annotation:
- \( IK \): difficulty level
- \( S_A \): the sum of top group score item
- \( S_B \): the sum of bottom group score item
\( J_A \) : the sum of ideal score item

The interpretations of difficulty levels mathematical literacy problems are very difficult, difficult, moderate, easy, and very easy [16].

The recapitulation of validity test, reliability test, distinguishing test, and difficulty levels test about mathematical literacy problems is presented in Table 2.

**Table 2. The Recapitulation of Experiment Result.**

| Level | Validity Criteria | Reliability Criteria | Distinguishing Criteria | Difficulty Levels Criteria | Decision |
|-------|------------------|----------------------|------------------------|---------------------------|----------|
| 1     | 0.62 Moderate     | 0.87                 | 0.33 Adequate           | 0.77 Easy                  | Used     |
| 2     | 0.80 High         | High criteria        | 0.41 Good              | 0.75 Easy                  | Used     |
| 3     | 0.60 Moderate     |                      | 0.43 Good              | 0.60 Moderate              | Used     |

Table 2 reveals that, all of mathematical literacy problems can be used to assess mathematical literacy ability according to the result of fourth test. First, validity test shows that problem 1 and 3 can assess passably. Meanwhile, problem 2 can measure appropriately. Second, reliability test indicates that problems have good consistency to assess mathematical literacy ability. Third, distinguishing test construes problems can differentiate students with high ability and moderate ability well. The last, difficulty test declares problems have not too difficult and not too easy. This finding indicates, the problems have a good difficulty levels to assess mathematical literacy ability.

**4. Conclusion**

According to analysis and results described in the previous section, we draw the following three conclusions. First, mathematical literacy problems are considered by expert as appropriate for assessing mathematical literacy ability. In other word, the mathematical literacy problems are theoretically valid for assessing mathematical literacy ability at polyhedron subject. Seconds, mathematical literacy problems have been good distinguishing characteristics and adequate distinguishing characteristics. This finding indicates that mathematical literacy problems can distinguish the quality answers between students who understand and students who do not understand about the polyhedron subject. Third, the levels of difficulty of mathematical literacy problems are easy and moderate. This means, mathematical literacy problems have various levels of difficulty.

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