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ANALYSIS OF TEACHER UNDERSTANDING OF MATHEMATICAL LITERACY PROBLEMS

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ABSTRACT

The Indonesian government has been promoting the National Literacy Movement since 2016. However, teachers' readiness to promote mathematical literacy skills in the classroom are deficient. This research aims to analyze secondary school mathematics teachers' understanding of mathematical literacy problems. We carried out a survey study involving 32 mathematics teachers in Bandung-West Java. In this survey, each teacher was requested to send two mathematics problems considered as mathematical literacy problems via Google Form. The result of the analysis showed that only one-fourth of the teachers are familiar with mathematical literacy problems. Implications for mathematics educations is discussed.

ABSTRAK

Pemerintah Indonesia telah menggalakkan Gerakan Literasi Nasional sejak 2016. Namun, kesiapan guru untuk mempromosikan keterampilan literasi matematika di kelas masih kurang. Penelitian ini bertujuan untuk menganalisis pemahaman guru matematika sekolah menengah tentang masalah literasi matematika. Kami melakukan studi survei yang melibatkan 32 guru matematika di Bandung-Jawa Barat. Dalam survei ini, setiap guru diminta untuk mengirimkan dua soal matematika yang dianggap sebagai soal literasi matematika melalui Google Form. Hasil analisis menunjukkan bahwa hanya seperempat jumlah guru yang paham dengan masalah literasi matematika. Implikasi untuk pendidikan matematika kemudian dibahas.

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INTRODUCTION

The results of the Program for International Student Assessment (PISA) in this decade showed that Indonesian students' mathematical literacy scores are far below international averages: the average scores were about 360 to 386, which are below the international averages of 489-500 (OECD, 2019; 2016; 2014). These disappointing results have led the Indonesian government to do a similar study using Indonesian contexts: the result showed that Indonesian students' mathematical literacy is truly low and varied between cities (Mahdiansyah and Rahmawati, 2014). A qualitative study conducted by Setiawati, Herman, and Jupri (2017) for investigating students' mathematical literacy skills also showed a disappointing result; students generally can only solve mathematics problems using simple and routine procedures. Sari and Wijaya (2017) study involving 813 students in Yogyakarta-Indonesia found that 94.17% students were categorized as somewhat mathematically illiterate (low to very low mathematics literacy score).

Reflecting on the aforementioned international study results, the Indonesian government has been promoting the National Literacy Movement since 2016, including the importance of quantitative and mathematical literacy (Indonesian Ministry of Education and Culture, 2017). This movement should be encouraged by all stakeholders, including teachers and academicians. The 'infrastructure' for succeeding this movement, however, seems lacking. Suharyono and Rosnawati (2020) study, for example, found that 50.74% of the questions in junior high school mathematics textbooks used in Indonesia did not accommodate mathematical literacy skills development, and the questions mostly targeted competency level up to level 2. As important as books, teachers are the factors for success in any educational program but Siebert and Draper (2012) study found that teachers were reluctant to integrate mathematical literacy into their classroom. Recent studies also found perturbing results, Ozgen (2019) found that mathematics teachers' ability to pose mathematics literacy problems was not significantly different

from preservice teachers, particularly for employing and interpreting. Genc and Erbas (2019) study in the same year suggested that secondary mathematics teachers may have a confusing and ambiguous understanding of mathematics literacy. Studies exploring teachers' readiness in promoting mathematical literacy skills in the learning and teaching process in Indonesia are still limited, and therefore, this present study investigated teachers' readiness to support the national and mathematical literacy movements by probing their understanding of mathematical literacy problems. A framework for investigating mathematical literacy understanding includes their skills to formulate, employ, and interpret mathematics in a variety of contexts, which is stated in the OECD's definition of mathematical literacy:

Mathematical literacy is an individual's capacity to formulate, employ, and interpret mathematics in various 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 make the well-founded judgments and decisions needed by constructive, engaged, and reflective citizens. (OECD, 2013, p. 25)

According to De Lange (2006), the term 'literacy' in mathematical literacy is not confined to indicating a basic, minimum level of functionality only, but it is a continuous, multidimensional spectrum ranging from aspects of basic functionality to high-level mastery. This means, for analyzing teachers' understanding of this kind of literacy, we can investigate to the greatest extent of the teacher's capability to formulate, employ, and interpret mathematics in various contexts.

METHOD

We conducted a survey to investigate teachers' understanding of mathematical literacy problems. The survey—an online survey via Google Form—was conducted as part of the registration form for attending a workshop on the development of mathematical literacy problems. Each teacher participant candidate was requested to fill the Google Form (http://bit.ly/untukgurumatematika) for information such as identity and educational background as well as send two mathematics problems and solutions that they considered to be mathematical literacy problems. The registration period lasted for one month.

We collected 32 teachers' identities from the registration list, and 64 mathematics problems considered mathematical literacy problems by the teachers. Of the 32 mathematics teachers, 13 are junior high school teachers, and 19 are senior high school teachers from the Bandung area. We then analysed the collected mathematics problems and solutions using the mathematical literacy framework (OECD, 2013). This analysis first observed the problems and their possible sources globally. Next, we classified whether the problems are indeed literacy problems or not. Finally, we concluded whether the teacher sent appropriate literacy problems and solutions correctly understands mathematical literacy problems.

RESULTS AND DISCUSSION

Teachers' problems mostly fall into common mathematics problems because only sixteen (25%) problems can be classified into mathematical literacy problems, while 48 (75%) problems can only be regarded as common school mathematics problems. This means that from 32 teachers, only 8 (25%) teachers understand what can be considered as mathematical literacy problems. Considering the number of senior and junior high school teachers who understand mathematical literacy problems, Table 1 shows that only less than one-third of each group understands mathematical literacy problems.

Table 1. Types of mathematics problems

	#Math literacy problems (%)	#School math problems (%)
SHS teachers	8 (21)	30 (79)
JHS teachers	8 (31)	18 (69)
Total	16 (25)	48 (75)

JHS: Junior High School; SHS: Senior High School

To show further how we decided whether the mathematics problems sent by the teachers are appropriate mathematical literacy problems, we address three questions examples. The first and the second examples exemplify a mathematical literacy problem and a school mathematics problem, respectively. The third example illustrates a more complex and challenging problem to determine between the two classifications. As OECD frameworks (OECD, 2013) implied, mathematical literacy problems should evaluate students' ability to

reason mathematically and use mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena. In line with other studies (e.g., Malasari, Herman, and Jupri, 2017; Oktiningrum, Zulkardi, and Hartono, 2016; Sari, 2015), the first problem example (Figure 1) was considered as mathematical literacy problem for the following reasons: 1) the problem contains a daily life context that is meaningful for students, in this case, the context indirectly supports students using their mathematical repertoire of knowledge (Ku and Sullivan, 2000), and (2) it requires students to decide with mathematical reasoning as stated in the framework of mathematical literacy (OECD, 2013). The solution to the problem in Figure 1, which needs to use mathematical reasoning in decision making, might be like the following. As the mileage must be less than 120,000 km, Naufal has three options, namely cars A, B, and D. Next, as the price is not more than 240 million, cars C and D must be one of the candidates. As the car must first appear in 2010 or earlier, cars B and D are reasonable options. Based on these three subconclusions, we conclude that Naufal should buy the car D.

Naufal has already had driving license, and he wants to buy a car. Table below presents information of four different cars in a car dealer.

	A	B	C	D
Year	2013	2010	2011	2009
Price (million rupiah)	280	245	225	199
Mileage (thousands km)	105	115	128	109

Naufal wants to buy a car with the following criteria:
- Mileage is less than 120,000 km;
- The price is not more than 240 million
- The car was firstly appeared in 2010 or earlier.

Which car can Naufal buy?

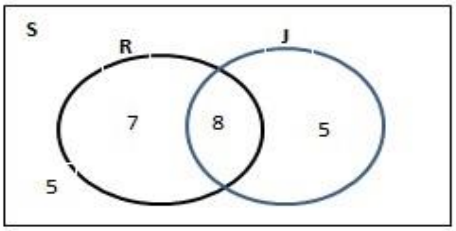
Figure 1. A mathematical literacy problem

Compared to the first problem, which probes students' ability to use mathematical reasoning in decision making, the second problem (see Figure 2) is a school mathematics problem commonly found in school mathematics textbooks for the topic of application of a set concept.

Of the 25 female students, 8 students like roses and jasmine, 15 students like roses, 5 students dislike both.
How many students like jasmine?

Figure 2. A school mathematics problem

As the problem solution indicates (Figure 3), solving the problem can be easily done using a standard routine procedure. Even if standard routine procedures are not prohibited in mathematical literacy assessment in PISA and PISA items can also be influenced by school mathematics curriculum (Stacey, 2011), the emergence of problems requiring standard routine procedures is rare. We consider that even if the second problem is a word problem—a problem presented in the form of words of natural language (see Jupri and Drijvers, 2016)— with a relevant context, it is not a mathematical literacy problem. The context itself does not help students in the solution process, and to a certain extent, it does not provide sufficient reasons on *why* we should solve the problem (Van den Heuvel-Panhuizen, 2005). Also, the procedure for solving such a problem is already standard and popular within school mathematics textbooks and is usually trained for preparing examinations.



Let R be the set of students who like roses. Let J be the set of students who like jasmine. From the task we know:

$n(S) = 25; n(R \cap J) = 8; n(R) = 15;$
$n(R \cup J)' = 5.$

Let $n(J) = x$.

$n(S) = n(R \cup J)' + n(R \cup J).$
$25 = 5 + n(R \cup J).$
$n(R \cup J) = 20.$

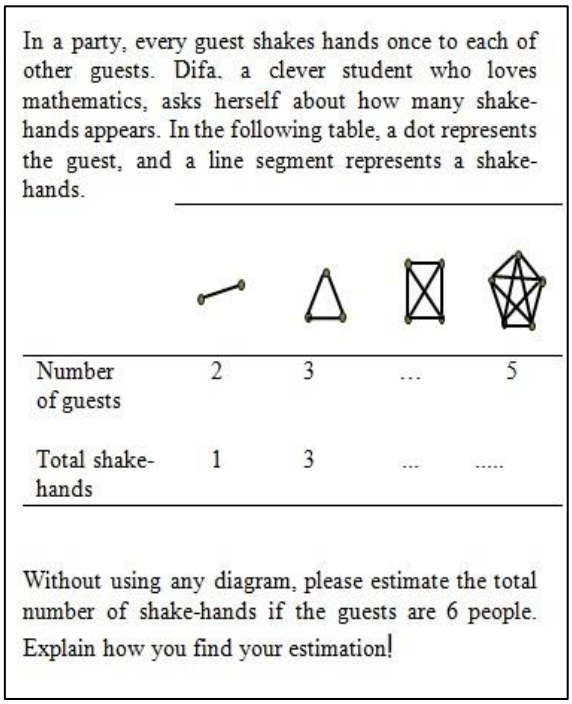
Consider that
$n(R \cup J) = n(R) + n(J) - n(R \cap J).$
$\Leftrightarrow 20 = 15 + x - 8.$
$\Leftrightarrow x = 13.$

Therefore, the number of students who like jasmine is $n(J) = 13$.

Figure 3. A standard solution to a set problem

As suggested previously, the third problem example (Figure 4, shake hands scenario) was a bit difficult to decide whether the problem could be classified into a mathematical literacy problem or

not. The problem was initially classified as a mathematical literacy problem because it contains a meaningful context that supports a solution process. However, the problem proved to be popular (see, for instance, Albrecht, 2016; Budak, 2012; Rowland, 2003; Spresser, 1990) and can easily be solved using a combination formula, and therefore, it is then classified into ordinary school mathematics problem.


In a party, every guest shakes hands once to each of other guests. Difa, a clever student who loves mathematics, asks herself about how many shake-hands appears. In the following table, a dot represents the guest, and a line segment represents a shake-hands.

Number of guests	2	3	…	5
Total shake-hands	1	3	...	.....

Without using any diagram, please estimate the total number of shake-hands if the guests are 6 people. Explain how you find your estimation!

Figure 4. Shake-hands problem

Out of 64 mathematics problems sent by teachers, 58 are word problems. This finding suggested that the teachers consider that the mathematical literacy problems are the same as word problems. This incorrect perception might be because word problems frequently contain daily life contexts (Chapman, 2006) and play a role as application problems (Lantz-Andersson, Linder-oth, and Säljö, 2009; Toom, 1999; Foong and Koay, 1997).

Siebert and Draper (2012) study found that teachers were reluctant to integrate mathematical literacy into their classroom, but to the contrary to Siebert and Draper (2012), findings in this study inclined to corroborated Genc and Erbas (2019) that mathematics teachers have an equivocal understanding of mathematics literacy. Rather than the unwillingness to integrate mathematical literacy, teachers must have difficulty integrating it in their classroom. Ozgen (2019) study found that mathematics teachers' ability to pose mathematics literacy problems was not significantly different from preservice teachers, and therefore, we need to prepare the teachers by exposing them to practices that include literacy-based strategies (Colwell and Enderson, 2016) so that they can improve their ability in teaching mathematical literacy (Arslan and Yavuz, 2012).

CONCLUSION

We draw the following two main conclusions based on the results and discussion. First, as only one-fourth of the teachers involved in the present study is familiar with mathematical literacy problems, this finding indicates that teachers' understanding of mathematical literacy problems needs improvement. This means that generally speaking, teachers involved in this study are not ready yet to support and promote the National Literacy Movement, particularly for the case of mathematical literacy. For further investigation on the teacher understanding, we recommend doing an interview study as an addition to the study of analysis of teachers' written work only. This way, we will get more comprehensive data about teachers' understanding of mathematical literacy.

Second, we observe that teachers seemed to consider mathematical literacy problems as the same as word problems in school mathematics. In the future, this incorrect perception should be minimized by, for instance, conducting in-service training for mathematical literacy; and pre-service teacher training for school mathematics teachers' candidates. If this is done correctly by the government and relevant stakeholders, we are optimistic that the teachers can integrate their proper understanding of mathematical literacy into the learning and teaching process.

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