Mathematical literacy in pre-service elementary school teacher: A case study

V Yustinia\textsuperscript{1,2}, S M Amin\textsuperscript{1} and Abadi\textsuperscript{1}

\textsuperscript{1}Department of Mathematics Education, Postgraduate Program of Universitas Negeri Surabaya, Indonesia
\textsuperscript{2}Universitas PGRI Adi Buana, Surabaya, Indonesia

E-mail: via.yustinia@unipasby.ac.id

Abstract. A prospective teacher to possess the ability of mathematical literacy in order to formulate, to apply, and to interpret mathematics in various contexts, including abilities to do mathematical reasoning and use mathematical concepts. The purpose of this research is to describe the mathematical abilities of the prospective elementary school teachers to solve mathematical literacy problems. We involved prospective teachers in the Elementary School Teacher Education Department as the research participants. This research is a qualitative research. Data collected by interview and test. The result of this study suggested that the ability of prospective teachers to solve basic mathematical literacy problems for levels 1 and level 2 were good, level 3 was enough, but for level 4 or above were still low. This was caused by the low ability of mathematical literacy. Pre-service teachers were rarely accustomed to solving literacy questions and they were less used to deal with the connection process in solving mathematical problems.

1. Introduction

Education is currently in a period of knowledge with acceleration. Global developments and changes in various aspects of people’s lives are making rapid challenges to prepare for a superior future generation. This causes all fields must be ready to change the times, and except fields education. National reports from several countries have also highlighted the importance of joining the global movement to define 21st century literacy and skills for future generations of students who will grow up in the digital world [1]. The theme of 21st century learning is about global awareness, finance, economics, business and entrepreneurs, literacy in citizenship, health literacy, and environmental literacy. Information, media and technology skills about literacy.

The Program for International Student Assessment (PISA) is an international survey conducted by the OECD with 15-year-old students who measure academic performance and store various personal and demographic background information. PISA provides information to the government or other parties about the effectiveness of the special education system in preparing students’ future. Mathematics is one of the domains which is the subject of PISA studies. The object studied by PISA in mathematics is not limited to learning achievement, but studies in mathematics include the ability of mathematical literacy [2].
Mathematical literacy is an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded mathematical judgments and to engage in mathematics, in ways that meet the needs of that individual's current and future life as a constructive, concerned, and reflective citizen [3]. Mathematical literacy is defined as the ability of a person to formulate, apply and interpret mathematics in a variety of contexts, including the ability to carry out punishment using mathematical means and using concepts, procedures, and facts to analyze, to explain, or to predict events. The process of thinking in mathematical literacy involves the ability to think at a higher level. This thought process can be categorized into three main processes namely formulating, using and interpreting [4].

Based on research conducted by PISA, the literacy ability of Indonesian students is still low, it can be seen that Indonesia can rank in the 10 lowest countries. PISA's mathematical literacy assessment consists of 6 levels or levels. Every level it shows the level of competence achieved mathematics. level 6 as highest level of achievement and lowest level 1. In the results of the PISA study, the average international score on mathematics literacy ability was 500 (level 3), while the average score of Indonesian students' mathematics literacy score was 375 (level 1), level 1 was the lowest level of the six levels of mathematical literacy ability in determined by PISA and the highest level that Indonesian students are able to achieve is level 3.

The results of this PISA research show there are differences in the achievement of Indonesian students' literacy abilities, mathematical ability makes it one of the distinguishing factors. Mathematical literacy that is approved is good at being able to analyze, to reason, and to communicate knowledge and mathematical skills effectively, and be able to solve and interpret mathematical solutions [5]. De Lange also stated the importance of learning mathematics, namely managing students' thinking abilities, reasoning, solving problems, communicating, linking mathematical material to the real situation, and being able to use and utilize technology [6].

A prospective teacher must have the ability of mathematical literacy in order to formulate, apply and interpret mathematics in various contexts, including abilities do mathematical reasoning and use concepts [7]. Based on the findings of this study, the investigations mathematics curriculum has potential to promote students' development of quantitative literacy in elementary school [8]. The students found difficulties in the formulation, especially in the work and scientific context [9]. The purpose of this research is to test the mathematical abilities of prospective elementary school teachers to solve mathematical literacy problems.

2. Method
This research is a qualitative that aims to describe to the mathematical abilities of prospective elementary school teachers to solve mathematical literacy problems to department of Elementary School Teacher Education Study. Case study was used to elementary school teachers. The research was carried out at Universitas PGRI Adi Buana Surabaya. Research carried out in the third semester Elementary School Education in the 2018/2019 year.

The data were collected through test and structural interview about mathematical literacy. Analysis of the data used in this study is analysis descriptive qualitative using the Milles and Hubberman models which consists of data reduction, data presentation, verification, and retrieval decision. Researchers provide tests of mathematical ability to 180 students to determine the research subject. The subjects of this study were 3 students selected from 120 students of classes E, F, and G.

The subject chosen to be used as a test of mathematical literacy skills. Test contained 6 item which were adopted from Indonesian Mathematical Literacy Contest of Universitas Sriwijaya. These six problems were chosen such that all of PISA contents include in the test. These are 2 quantity problems (in three different level those are level 1, 2, and 4), 2 uncertainty problems (level 4 and level 5), and 2 space and shape problems (in three different level those are level 1, 3, and 4). We provided around 10 minutes for each problem, so the teachers were asked to solve the problems in 60 minutes. The literacy level criteria used are adjusted to the level developed by PISA, as presented in Table 1.
Table 1. The literacy level criteria

| Level | What Students Can Do |
|-------|----------------------|
| 6     | Conduct conceptualization, generalization, and use information based on analysis and modelling in a complex situation and can use above average knowledge.  
       | Apply knowledge, mastery, and relationships of mathematical symbols and operations, develop new strategies and approaches for dealing with new situations.  
| 5     | Select, compare and evaluate precisely the problem solving strategies associated with complex problems relates to the model.  
       | Reflect on their work and can formulate and communicate their interpretations and reasons.  
| 4     | Choosing and combining different representations, including symbols, link them to real situations.  
       | Provide explanations and communicate them with arguments based on their interpretations and actions.  
| 3     | Carry out procedures clearly, including those that require sequential decisions.  
       | Interpret and use representations based on different sources of information and state the reasons directly.  
| 2     | Interpreting and recognizing situations with contexts that require direct conclusions.  
       | Work on basic algorithms, use formulas, carry out procedures or agreements.  
| 1     | Answering questions with known contexts and all relevant information are provided with clear questions.  
       | Identify information, and use general methods based on clear instructions.  

The answers of the three research subjects each with key answers to mathematical literacy questions henceforth are explained qualitatively. The final step is to draw conclusions from the results of the verification and description of the answers to the mathematics literacy tests of the research subjects.

3. Results and discussion
Based on the results of student analysis highly capable (M1) capable doing 4 of the 5 test questions literacy ability provided. M1 able to answer questions that can measure mathematical literacy abilities level 1 correctly and already meet all indicators at level 1. M1 can answer questions that are the context is general and known as well all relevant information is available with clear questions. They can identify information and complete routine procedures according to explicit instructions. They got it take action in accordance with given stimulus. M1 is able to answer questions that can measure literacy skills math level 2 correctly.

M1 determines the aquarium volume that is understood to be its size. In the matter provided images of food in the form of blocks. This means it is not a problem faced by the subject. Next is the answer to question, which is done by M1, as presented in Figure 1.
Coral reefs
The relationship between the length and the height of the coral is:

\[ y = 0.75x - 0.5 \]

Note:
The height of coral is \( x \) mm.
The length is \( y \) mm.

Problem 1
The length of the coral with the height of 40 mm is … .

A. 26.63 mm
B. 29.50 mm
C. 29.95 mm
D. 30.50 mm

Solution
\[ y = 0.75x - 0.5 \]
\[ = 0.75(40) - 0.5 \]
\[ = 30 - 0.5 \]
\[ = 29.5 \]

Figure 1. Answer from Subject M1

Based on Figure 1, M1 has been able to carry out the procedure clearly. M1 substitutes \( x \) and \( y \) values for known functions. M1 has been able to carry out problem solving procedures clearly and in sequence and formulate a simple settlement plan. Based on the results of interviews, M1 was able to interpret and put forward arguments directly about solving problems. However, M1 does not communicate the results of its interpretation in answering questions.

Based on test results and interviews shows that M1 meets all indicators at level 2. M1 is able interpreting and recognizing situations with contexts that require direct conclusions and work on basic algorithms, use formulas, carry out procedures or agreements. Based on the results of the interview M1 is able to sort information relevant from a single source, and using a single presentation method. M1 able to give a reason go straight and do that interpretation in fact, it looks at interview results, able to answer questions which can measure literacy math level 3 correctly and able to meet all the indicators on level 3. M1 is able to implement procedures clearly, including procedures which requires a decision sequentially, it appears in the results interview with M1. M1 is able solve problems, and apply simple strategy, capable interpret and use source based representation different information and put forward their reasons directly, it is based on Interview result.

Based on the results M1 interview is able communicating the results of interpretations and their reasons. But for the answers given to the problems which can measure literacy mathematics level 5 and 6 M1 gives wrong answer, as well as with result of the interview they conducted haven't been able to work with models for complex situation, not yet able to know the obstacles encountered, and have not been able to make guesses faced. Students have difficulty in solve all the material questions tested and it appears that the score achieved by students in each item is very diverse. There are some capable students answering questions and getting the maximum score, but there are also students who don't can answer the question of the problem being tested.
Based on the results of student analysis Medium capable (M2) able work through to the problems that can be measured the ability of mathematical literacy level 3. M2 is able to answer questions that are can measure literacy skills mathematically at level 1 correctly. Based on the results M2 interviews are able to show an action in accordance with the stimulus which is given. So M2 fulfills all indicators at level 1. M2 is capable correctly answer the question about the question can measure literacy skills math level 2. Based on results answers and interviews, M2 already meet all indicators at level 2. M2 is able to interpret and recognize a situation with a context that requires direct conclusion. This is caused by the ability of mathematical literacy is still small. Pre-service teacher are rarely accustomed to solving literacy questions and they are less used to do the connection process in solving mathematical problems [10]. The low results of PISA studies among Indonesian students so far have been caused by a number factors, including Indonesian students not familiar with modeling problems and the lack of mathematical textbooks that emphasize solving everyday problems as tested by PISA [11].

M2 is unable to answer questions that can measure mathematical literacy skills at the level 4, 5 and 6, besides that M2 is incapable meet the indicators on each level. This is seen in the results the interview, that M2 really doesn't know how to solve these problems. Based on the results of answers and interviews, M2 is only able to meet indicators up to level 3. This also in accordance with the analysis conducted by the investigator. Based on that M2 is in literacy ability mathematics at level 3.

In the problem provided information presented in the table, the information is a bit complex. M2 is able to represent mathematical models in real situations. M2 is able to make the assumption that the concept to be used is the concept of opportunity. Therefore, it determines a lot of sample space and a lot of events. Next is the answer to question, which is done by M2.

| Player | Number of penalty kick | Number of successful penalty kick |
|--------|------------------------|----------------------------------|
| Arif   | 12                     | 10                               |
| Bambang| 10                     | 8                                |
| Candra | 20                     | 15                               |
| Dedi   | 15                     | 12                               |

**Problem 3**
Which player has the highest probability to make a success penalty kick?
A. Arif  B. Bambang  C. Candra  D. Dedi

**Solution**
Suppose that A is the number of successful kick and S is the number of penalty kick, then
\[
\begin{align*}
P(A) &= \frac{n(A)}{n(S)} = \frac{10}{12} = 0.83 \\
P(B) &= \frac{n(B)}{n(S)} = \frac{8}{10} = 0.8 \\
P(C) &= \frac{n(C)}{n(S)} = \frac{15}{20} = 0.75 \\
P(D) &= \frac{n(D)}{n(S)} = \frac{12}{15} = 0.8
\end{align*}
\]

**Figure 2. Answer from Subject M2**
M2 is able to combine different representations, for example mathematical models with real situations. The number of penalty kicks is assumed to be a lot of sample space, while the number of successful penalty kicks is assumed to be the number of events. Each player's name is assumed to be A, B, C, and D. M2 is able to put forward his argument with some clear context views. M2 is able to communicate arguments based on their interpretation.

Student analysis results low math ability (M3) able to do 2 problems. M3 is able answer correctly the questions that can be measure the ability of mathematical literacy level 1, apart from that M3 is able to fulfill all indicators of literacy ability math level 1. M3 is able to answer questions with known contexts as well as all relevant information available with clear questions, it is based on the results of the answers M3. M3 is able to identify information, and do the way it is general based on clear instructions.

Based on the results of the answers and interviews, M3 already meet all indicators at level 2. On questions that can measure literacy skills math level 3, M3 only writes what is known in the problem. At the time the researchers provoked answers from M3, M3 said that he did not know. M3 is still confused to answer questions that can measure level 3 mathematical literacy skills, it can be seen in the results of M3's answers and the results of interviews with M3.

Based on things the M3 does not meet all indicator in level 3. M3 does not answer questions that can measure ability level 4 math literacy, level 5 and level 6. At the time researchers do an interview M3 said that he did not know. M3 also not Meet the indicators at level 5 and level 6. Based on the matter M3 only meets the indicator up to level 2. Mathematical literacy helps fostering mathematical reasoning and rational thinking skills and allows people to establish causal relationships between events in order to cope with the difficulties they encounter in their personal, vocational, and social life [12].

4. Conclusion
The ability of prospective teachers to solve basic mathematical literacy problems for levels 1 to 2 it's good, level 3 is enough, but for level 4 or above it's still low. This is caused by the ability of mathematical literacy is still small. Pre-service teachers are rarely accustomed to solving literacy problems and they are less used to it do the connection process in solving mathematical problems.

Acknowledgement
The researcher would like to thank Universitas PGRI Adi Buana Surabaya for the research grant of doctoral dissertation for fiscal year 2019 granted to the researcher. Thanks to all of our students that has help us in collected the data.

References
[1] K Y Wong, M Koyama and K Lee 2014 Mathematics curriculum policies: A framework with case studies from Japan, Korea, and Singapore Mathematics curriculum in school education (Dordrecht: Springer) pp 79-91
[2] K Stacey and R Turner 2015 Assessing mathematical literacy: The PISA experience (Dordrecht: Springer International Publishing AG)
[3] M Neubrand 2004 Mathematical literacy und mathematische grundbildung: Der mathematikdidaktische diskurs und die strukturierung des PISA-tests Math. Kompetenzen von Schülerinnen und Schülern Deutschl. (Wiesbaden: VS Verlag für Sozialwissenschaften) pp 15–29
[4] A Aningsih 2018 Kemampuan berpikir tingkat tinggi Journal Reseapedia 1 5–24
[5] S Murphy 2019 School location and socioeconomic status and patterns of participation and achievement in senior secondary mathematics Math. Educ. Res. J. 31 219–35
[6] Salim and R Prajono 2018 Profil kemampuan literasi matematis siswa kelas VIII SMP Negeri 9
Kendari *Indones. Digit. J. Math. Educ.* **5** 594–602

[7] C Sawatzki and P Sullivan 2018 Shopping for shoes: Teaching students to apply and interpret mathematics in the real world *Int. J. Sci. Math. Educ.* **16** 1355–73

[8] J L M Wilkins 2015 Standards-based mathematics curricula and the promotion of quantitative literacy in elementary school *Int. J. STEM Educ.* **2** 19

[9] A Hendroanto, A Istriandaru, N Syakrina, F Setyawan, R C I Prahmana and A S E Hidayat 2018 How students solves PISA tasks: An overview of students’ mathematical literacy *Int. J. Emerg. Math. Educ.* **2** 129

[10] A S Argaw, B B Haile, B T Ayalew and S G Kuma 2017 The effect of problem based learning (PBL) instruction on students’ motivation and problem solving skills of physics *Eurasia J. Math. Sci. Technol. Educ.* **13** 857–71

[11] M Nurkamilah, M F Nugraha and A Sunendar 2018 Mengembangkan literasi matematika siswa sekolah dasar melalui pembelajaran matematika realistik Indonesia *Theorems* **2** 70–9

[12] M Genc and A K Erbas 2019 Secondary mathematics teachers’ conceptions of mathematical literacy *Int. J. Educ. Math. Sci. Technol.* **7** 222–37