An analysis of mathematical literacy of state junior high school students in Kupang

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Abstract. This survey was conducted to describe the mathematical literacy of state junior high school students in Kupang, East Nusa Tenggara province. Not only was it done due to the low performances of Indonesian 15-year-old students in PISA but also since there was not any research studies that had been done before to map the mathematical literacy of 15-year-old students in Kupang. This study used two-stage cluster randomized sampling to choose six-state junior high schools representing six sub-districts around Kupang. A total of 377 ninth-grade students were selected to become the respondents in this survey. They were tested using fifteen mathematical literacy problems directly adopted from PISA 2012 and some development researches items. The results showed that the mathematical literacy of state junior high school students in Kupang generally was in a low category. When we looked into three process domains as well as four content domains, the math literacy of students was also classified as either a low or a very-low-category. The results of this study can provide valid and actual data for society and the government regarding the math literacy of students in Kupang.

1. Introduction
Educational evaluation is often done to measure the quality and equity of the educational system in a country. It is a combination of measurement and assessment activities [1]. At the national level, the educational evaluation frequently held by the Indonesian government through the ministry of education and culture (Kemdikbud) is the national exam (UN).

Meanwhile, one of the international educational evaluations held every three years by the Organization for Economic Co-operation and Development (OECD) is Programme for International Student Assessment (PISA). It intends to measure some essential skills of students all around the world [2-5]. The main intention of PISA is to provide indicators of students learning outcomes for all participating countries which may be compared internationally [6]. Indeed, PISA results also contribute to the evaluation of educational policies regarding the school curriculum and educational system in most of the countries engaging the PISA survey, including Indonesia [3, 7-8].

One of the skills assessed in PISA is mathematical literacy. It is not limited to applying the aspect of calculation in mathematics, yet it takes a broader approach in assessing the mathematical ability of students [9-10]. It includes reasoning mathematically and making use of mathematical concepts, procedures, facts, and tools to explain and portend phenomena [2-5]. In addition, the mathematical literacy of students covers the content and process domain [3-4, 11-12] in line with what had been recommended by NCTM [13].
However, in reality, the performance of Indonesian 15-year-old students in PISA was still at a low level. According to the results of PISA survey, Indonesian students still occupied 61st out of 65 countries in 2009, 64th out of 65 countries in 2012, and 61st out of 70 countries in PISA 2015 [14-16]. This occurred because they did not accustom to such contextual problems [17]. As a result, they felt difficult to solve the items and often made errors when solving context-based mathematical literacy problems [18-20]. Nevertheless, there was still an assuredness that 15-year-old students will perform well like adults in executing the problems [21].

Considering the research results recommended that mathematical literacy problems should be socialized to students through competitions, researches, and the UN [22], the Indonesian government has been engaging some PISA-like problems in the UN since 2014. Even so, the mathematics achievement of junior high school students in the UN was in a low category. In Kupang city itself, the average score was only 34.98 in UN 2018 [23]. It was statistically below the average score at the provincial and national levels [23]. It would not adequate for students if they were only accustomed to solving low-level problems in the UN, not a higher level of PISA-like mathematics problems. Moreover, there were no investigations that had been done before to describe students' math literacy in Kupang. Retrospective research only documented the math literacy of students in Bantul regency, Yogyakarta [24]. Furthermore, Nizar et al., Jannah et al., and Yansen et al. had produced PISA-like mathematics problems using various contexts in Asian Games [25-27]. Thus, since it was a necessity to analyze the mathematical literacy of students in Kupang city, this study would have been focusing on describing math literacy of state junior high school students in Kupang and adopting PISA-like problems produced by some developmental researches.

In accordance with the explanations above, this research intended to generally describe the mathematical literacy of state junior high school students in Kupang city. In particular, it would be also discussing the mathematical literacy of students while reviewing two major domains of mathematical literacy, namely the content and process domain. This study discovered that the mathematical literacy of state junior high school students in Kupang generally was in a low category. When we looked into three process domains as well as four content domains, the math literacy of students was also classified as either a low or a very-low-category. The results of this study can provide valid and actual data for society and the government regarding the math literacy of students in Kupang city.

2. Method

This research used a survey method with a descriptive-quantitative characteristic. It was done within three weeks from the 21st of March until the 16th of April 2019. In order to measure the mathematical literacy of students, PISA assessment uses respondents between the age range of fifteen years two months old until sixteen years three months old [28]. In almost all countries, most of the students in the age range are ninth-grade students. Hence, this research demands ninth-grade students as respondents.

The sampling technique used in this research was two-stage-cluster randomized sampling to choose a group of students from six state junior high schools. The six selected schools represented six sub-districts in Kupang. The determination of the sample size needed for this research referred to the table of Krejcie and Morgan [29]. The total population of the ninth-grade students of state junior high schools in the 2018/2019 academic year in Kupang was 6049 students. Thus, a minimum sample size that is proportional to that amount is 364 respondents. Though the total sample chosen was 377 the ninth-grade students, it had been greater than the minimum sample size required.

The test instrument utilized in this study consisted of fifteen mathematical literacy items. Twelve of the items were directly adopted from PISA 2012 mathematics items [3]. Meanwhile, the rest three items regarding uncertainty and data content were the products of developmental researches [25-27].

The mathematical literacy test was held for 120 minutes with an approximate time of eight minutes per question. The time allocation would be sufficient for the students when comparing it to the time limitation in PISA 2005 [2]. The researchers themselves were invigilators during the test.
The score obtained from the test would be described statistically to explore the data’s characteristics. In addition, the percentage of achieved scores would also be analyzed using the equation (1) [24].

\[
P = \frac{\sum B}{\sum T} \times 100\% \tag{1}
\]

where \( P \) is the percentage of an achieved score, \( B \) is the total score achieved, and \( T \) is the ideal maximum score.

Table 1. The normative reference of deviation standard.

| Score Range | Criteria         |
|-------------|------------------|
| \( M_i + 1.5Sd_i \) \(<\ X \<\ M_i + 3Sd_i \) | Very High       |
| \( M_i + 0.5Sd_i \) \(<\ X \<\ M_i + 1.5Sd_i \) | High             |
| \( M_i - 0.5Sd_i \) \(<\ X \<\ M_i + 0.5Sd_i \) | Medium           |
| \( M_i - 1.5Sd_i \) \(<\ X \<\ M_i - 0.5Sd_i \) | Low              |
| \( M_i - 3Sd_i \) \(<\ X \<\ M_i - 1.5Sd_i \) | Very Low         |

\( M_i \) is the ideal mean acquired by multiplying the sum of the ideal maximum score and ideal minimum score by one half. \( Sd_i \) is the ideal deviation standard obtained by multiplying the difference of the ideal maximum score and the ideal minimum score by one-sixth. \( X \) is the total score achieved.

Moreover, to generalize the results obtained to whole state junior high school students in Kupang city, the approximation of confidence interval was done for \( \mu \) with the \( \alpha \) value of 5%. The confidence interval used is shown in equation (2) [30].

\[
\bar{X} - t_{\frac{\alpha}{2}} \frac{s}{\sqrt{n}} < \mu < \bar{X} + t_{\frac{\alpha}{2}} \frac{s}{\sqrt{n}} \tag{2}
\]

where \( \bar{X} \) is mean score of the sample, \( t_{\frac{\alpha}{2}} \) is a critical value of \( t \) distribution, \( n \) is the sample size, \( v \) is the degree of freedom that equals \( n \) minus one, and \( s \) is the deviation standard of the sample.

The normality tests used were the skewness test and the kurtosis test. It was done to avoid the unreliability of the Kolmogorov-Smirnov and Shapiro-Wilk test since there was a large amount of sample size used. The data are not from a normally distributed population if and only if the absolute value of skewness is greater than two or the absolute value of kurtosis is greater than seven [31].

3. Result and discussion

Table 2 provides descriptive statistics of students’ mathematical literacy scores.

Table 2. The descriptive statistics of students’ mathematical literacy scores.

| Description            | Mathematical Literacy of Students |
|------------------------|----------------------------------|
| Mean                   | 18.50                            |
| Deviation Standard     | 10.79                            |
| Ideal Maximum          | 73                               |
| Maximum                | 53                               |
| Ideal Minimum          | 0                                |
| Minimum                | 2.69                             |
| Range                  | 50.31                            |
| Sample Size            | 377                              |
The mean score is significantly below the ideal maximum value. Moreover, the deviation standard implies that most of the scores achieved by students were distributed closely around the mean score. Though there were students who got a maximum score, it could not compare to the number of students who got a minimum score. As a result, it indicates that most state junior high school students in Kupang city achieved a low score in mathematical literacy tests.

Figure 1. The distribution of students based on their level of mathematical literacy.

Figure 1 illustrates that there were not any students classified in a very high category. Most state junior high school students were categorized in a very low level. The number of students increased significantly from the medium level to a very low level. From the bar graph, it also might be seen that the lower the level of students’ mathematical literacy, the greater the number of students. In conclusion, the majority of state junior high school students in Kupang were incapable of carrying out mathematical literacy problems.

Figure 2. The percentage of scores achieved by students reviewing mathematical literacy process domain.

Figure 3. The percentage of scores achieved by students reviewing mathematical literacy content domain.

Furthermore, Figure 2 demonstrates that, in general, the scores achieved by students in each mathematical literacy process were not meaningfully different from one another, so were the content domains in Figure 3. In line with Figure 2, Figure 3 demonstrates that the scores achieved may vary among the content domain. Nonetheless, most of the students obtained low scores either in all processes or contents. It indicates that they were unable to perform well when solving the problems in both domains. Due to a large number of samples, both Figure 2 and Figure 3 also indicate that the process of interpreting mathematical outcomes and the content of geometry was the most difficult out of others. Those results were pretty similar to research that had been done before [24].

The skewness and the kurtosis values were determined as shown in Table 3. It was done to verify whether the data were from a normally distributed population or not.

Table 3. The skewness and the kurtosis values of the data.
Table 3 infers that the absolute skewness value of the data is less than two. Meanwhile, the absolute kurtosis value of the data is also less than seven. In conclusion, the data were from a normally distributed population. The approximation of confidence intervals may be done since the normality of data had been tested. Table 4 displays the categorization of students' abilities according to the approximated confidence interval for $\mu$.

**Table 4.** The categorization of students' mathematical literacy based on the approximation of confidence interval for $\mu$.

| Domain            | Sub-domain | Confidence Interval | Categories          |
|-------------------|------------|---------------------|---------------------|
| Contents          | Quantity   | $1.42 \leq \mu \leq 1.72$ | Low/Very Low        |
|                   | Algebra    | $6.77 \leq \mu \leq 7.68$ | Low/Very Low        |
|                   | Geometry   | $2.74 \leq \mu \leq 3.22$ | Low/Very Low        |
|                   | Uncertainty and Data | $6.27 \leq \mu \leq 7.17$ | Low/Very Low        |
| Formulating       |            | $4.35 \leq \mu \leq 4.85$ | Low/Very Low        |
| Processes         | Employing  | $6.64 \leq \mu \leq 7.70$ | Low/Very Low        |
|                   | Interpreting | $6.27 \leq \mu \leq 7.17$ | Low/Very Low        |
| Generally         |            | $17.40 \leq \mu \leq 19.59$ | Low/Very Low        |

From Table 4, we came up with a result that mathematical literacy of state junior high school students in Kupang was generally in a low category. Though the proportion of low achievers and very low achievers respectively were 61.19% and 38.81%, the highest number of students occupied the low category. Based on direct observation, the researcher, which was also an invigilator, discovered that most of the students suffered difficulties to understand the items' meaning. Indeed, most of the students did not accustom to such problems that demand higher mathematical reasoning. It was also the same as the discoveries from retrospective researches [17, 24].

When reviewing content domain, the proportion of low achievers and very low achievers in quantity were successively 73.33% and 26.67% so that it belonged to the low level. Same as quantity, the proportion of students who categorized low and very low in algebra were serially 74.72% and 25.27%. Consequently, it belonged to the low category. Meantime, the percentage of students who classified low and very low in geometry were severally 45.83% and 54.17%. Therefore, it belonged to a very low level. In line with that, the total of low-level students and very-low-level students in uncertainty and data were apiece 46.67% and 53.33%. As a result, it belonged to a very low category.

In addition, when reviewing the process domain, the proportion of low achievers and very low achievers in formulating situations mathematically domain were apiece 70.22% and 29.78%. Hence, it belonged to the low category. Moreover, the same as that, the number of students who classified low and very low in the employing domain were respectively 66.04% and 33.96%. Thus, it belonged to the low level. However, in the interpreting domain, the proportion of low-level students and very-low-level students were severally 46.67% and 53.33%. Consequently, it belonged to a very low category.

4. Conclusion
The mathematical literacy of state junior high school students in Kupang city generally was in a low category. Reviewing content domain, mathematical literacy of students for quantity and algebra was classified as a low category, while for geometry as well as uncertainty and data was in the very low category. Reviewing process domain, mathematical literacy of students in formulating situations mathematically domain as well as employing mathematical concepts, facts, procedures, and reasoning domain was in a low category, although interpreting, applying, and evaluating mathematical outcomes domain was classified as a very low category.

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