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Developing mathematical literacy problems using Jogja tourism context

Vita Istihapsari, Afit Istiandaru
Universitas Ahmad Dahlan, Jl. Ahmad Yani, Tamanan, Banguntapan, Bantul 55191 Indonesia
*Corresponding e-mail: vita.istihapsari@pmat.uad.ac.id

Abstract
The Indonesian performance in PISA mathematics consistently low in the last decade, despite the increasing awareness among mathematics educators regarding the importance of mathematical literacy. One of the core problems is the lack of mathematical literacy problems while the resources of contexts are available and rich. This research aims to develop a set of mathematical literacy problems using Jogja tourism context. It is an ADDIE research which includes the analysis, design, develop, implementation, and evaluation stage. We involved two mathematics educators as the experts to validate the problems and 441 junior high school students in Yogyakarta to try-out the problems. Finally, we successfully developed 35 valid items of mathematical literacy problems with Jogja tourism context in terms of content and construct. The availability of these word problems would be useful for mathematics educators to foster the students' mathematical literacy at school.

Keywords: ADDIE, Jogja tourism context, mathematical literacy, PISA-like problem

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INTRODUCTION

Mathematical literacy is an individual's ability to reason mathematically, formulate, apply, and interpret mathematics, as well as to solve problems in various real-world contexts (OECD, 2021). This ability is essential for students in order to address 21st-century problems (OECD, 2021). However, Indonesian students' mathematical literacy tends to be low. The 2018 PISA results showed that only 28% of students were able to demonstrate proficiency at Level 2 or above (Avvisati et al., 2019), while 72% reached at most Level 1, meaning they could only answer questions in which all necessary information is directly provided (Puspendik, 2019).

Mathematical literacy is an individual's ability to reason mathematically, formulate, apply, and interpret mathematics, as well as solve problems in various real-world contexts (OECD, 2021). This ability enables individuals to understand the role of mathematics in everyday life and to address a wide range of 21st-century challenges (OECD, 2021. In the PISA 2021 framework, mathematical literacy consists of two key aspects: the reasoning aspect and the problem-solving (modelling) aspect, as illustrated in Figure 1.

Factors contributing to low mathematical literacy include personal factors (Masjaya & Wardono, 2018), instructional factors (Mahdiansyah & Rahmawati, 2014; Hidayati et al., 2020), and environmental factors (Mahdiansyah & Rahmawati, 2014). Instructional factors are particularly important because teacher quality influences student learning outcomes (Puspendik, 2019).

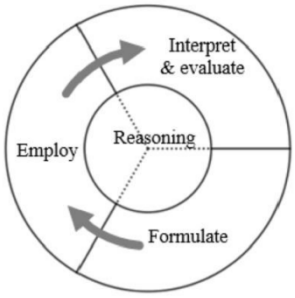

Figure 1. The connection between reasoning and modeling in mathematical literacy

The aspects assessed in PISA consist of three dimensions: content, process, and context (OECD, 2021; Fajrina et al., 2017). The content dimension of PISA mathematics items includes space and shape, change and relationships, quantity, and uncertainty and data. The PISA process dimension comprises three components: formulating situations mathematically; employing mathematical concepts, facts, procedures, and reasoning; and interpreting mathematical results. In addition, PISA items are categorized into several levels based on the degree of difficulty or complexity of the skills assessed, namely: Level 1 (answering questions in which the required information is directly available in the problem), Level 2 (using direct inference and selecting relevant information), Level 3 (carrying out procedures in the correct sequence), Level 4 (working with concrete models in complex situations), Level 5 (working with models in complex situations and being able to make conjectures), and Level 6 (conceptualizing and generalizing using available contexts).

To effectively facilitate students in developing strong mathematical literacy, pre-service teachers must themselves possess good mathematical literacy skills (Hidayati et al., 2020; Hendroanto et al., 2018) and be able to accustom students to engaging with PISA-like tasks (Charmila et al., 2016; Sabrina et al., (2019). Interviews with Grade VII junior high school teachers and Grade X senior high school teachers indicated that their students' mathematical literacy is relatively low due to the lack of routine exposure to mathematical-literacy tasks.

In reality, teachers do not have an adequate bank of mathematical-literacy tasks that align with contexts familiar to students' daily lives. In fact, many contexts surrounding students can be developed into mathematical-literacy problems. The Jogja Tourism context is one such context with rich potential to be integrated into tasks across all content domains. For example, the architectural structures of the Yogyakarta Palace (Keraton) are closely related to the content domain of space and shape (Qomaria & Wulandari, 2022). Another example is the batik motifs found along Malioboro, which are connected to fundamental mathematical-literacy skills (Habibi & Prahmana, 2022).

Yogyakarta is a highly popular tourist destination visited by many travelers, featuring attractions such as Prambanan Temple, the Yogyakarta Palace (Keraton), the Southern Square (Alun-alun Selatan), Taman Sari, Malioboro Street, and the Southern Beach area. In addition to its tourist destinations, Yogyakarta's variety of local souvenirs is also widely sought after by tourists and residents alike, such as gudeg, Dagadu merchandise, pottery, and batik, which can easily be found along Malioboro Street or at Beringharjo Market.

The Jogja Tourism context is one of the richest contexts with great potential to be developed into mathematical-literacy tasks across all content domains. For example, the architectural structures of the Yogyakarta Palace are closely related to the content domain of space and shape (Qomaria & Wulandari, 2022). Another example is the batik motifs found along Malioboro, which are connected to fundamental mathematical-literacy skills (Habibi & Prahmana, 2022).

Although several researchers have developed mathematical-literacy tasks using specific contexts (Oktiningrum, 2016; Putri, 2020; Nizar & Putri, 2018), the tasks produced are generally limited to only one content domain or have not yet been aligned with the school mathematics curriculum, such as considering whether the mathematical content in a task has been taught at a particular grade level. The urgency of this study lies in the fact that the lack of mathematical-literacy tasks in schools, especially those grounded in contexts relevant to students' daily lives, has contributed to students' low performance in mathematical literacy. Therefore, this research is important to support teachers by providing accessible mathematical-literacy tasks and to help improve students' mathematical literacy skills.

It is necessary to develop mathematical-literacy tasks for junior high school students with more diverse contexts, more comprehensive content domains, and alignment with the mapping of mathematics basic competencies at that educational level. This research aims to develop a set of mathematical literacy problems using Jogja tourism context.

RESEARCH METHOD

This study is a development research adopting the Analysis–Design–Develop–Implementation–Evaluation (ADDIE) framework, with junior and senior high school students as the subjects. The research design is as follows.

In the analysis stage, we involved junior and senior high school teachers and students in the Yogyakarta area to conduct brainstorming sessions regarding potential contexts and content specifications to be developed. In the design stage, we designed test blueprints based on the needs identified during the analysis stage. In the develop stage, we constructed items based on the blueprints and validated them through expert review. In the implementation stage, we piloted the items with 441 students from several junior high schools in Yogyakarta. The evaluation stage occurred throughout all phases of ADDIE, in which revisions were made based on findings from each stage.

Data collection methods included Focus Group Discussions (FGDs) during the analysis stage, walk-through validation by experts during the product validation stage, and test during the pilot testing. Data analysis in this study employed descriptive qualitative methods. The first was validity analysis, in which expert validation scores and feedback were analyzed qualitatively, presented, reduced, and concluded. The second was practicality analysis, in which student responses obtained from the test.

RESULTS AND DISCUSSION

Need analysis

In the needs-analysis stage, the researchers obtained information from a brainstorming session involving junior and senior high school mathematics teachers (n = 16) in Yogyakarta. In general, the teachers stated that word problems are highly needed in mathematics instruction. As many as 43.8% of

the teachers reported that they often give word problems to their students, and 18.8% reported that they always use word problems in their teaching. The remaining teachers stated that they rarely (12.5%) or occasionally (25%) use word problems (Figure 2).

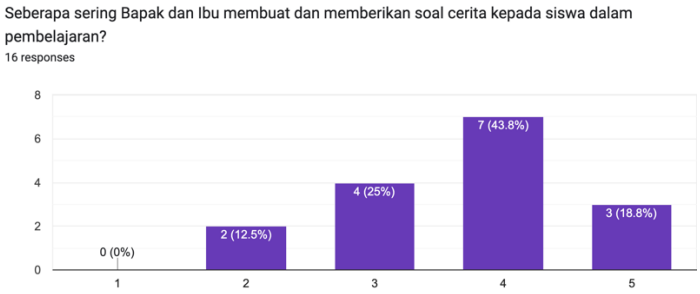

Figure 2. The use of word problems in mathematics classrooms.

The teachers proposed various ideas related to contexts that could be developed into word problems based on their relevance to the mathematics topics being taught. Several examples are summarized in Table 1.

Table 1. Teachers' ideas for contexts to be used for word problems

No.	School mathematics topics	Relevant contexts
1	Arithmetics sequence	Determining the height of staircase
2	Linear equation system in two variables	Determining the unit price of an item
3	Linear equation system in three variables	Case of buying three kinds of product
4	Linear programming	Optomation of parking area
5	Social arithmetics	Profit, loss, nett, gross
6	Exponent and logarithm	Compound interest, growth
7	Probability	Probability of an event
8	Similarity	Determining the height of a flag pole
9	Quadratic function	Determining the height of a ball throwing

There are many reasons why teachers use word problems in mathematics instruction. These reasons were confirmed during discussions with teachers who often or always use word problems in their teaching. Among them are: (1) word problems help students understand real situations; (2) word problems bridge the transition from informal to formal mathematics; (3) word problems provide practice for students in solving complex problems; and (4) word problems train students to construct representations (Verschaffel et al., 2020). Thus, the word problems referred to in this study are those that incorporate meaningful contexts and aim to develop mathematical literacy skills, rather than merely transforming abstract mathematical exercises into sentences.

However, not all school mathematics topics are easy for teachers to transform into contextual word problems or mathematical-literacy tasks. Based on the preliminary survey, several topics were identified by teachers as unsuitable for contextualization, including limits of trigonometric functions, surds, geometric transformations, and calculus (limits and integrals). Teachers'

difficulties in developing word problems are generally caused by limited knowledge regarding mathematical content and its connection to appropriate contexts (Luo, 2009). Therefore, teachers need broader insights by exploring various contexts that are often linked to the mathematics topics they teach.

Furthermore, when teachers were asked about their views on mathematical-literacy tasks that use the Jogja tourism context, all respondents agreed that the Jogja tourism context is highly potential for developing mathematical-literacy problems (See Figure 3).

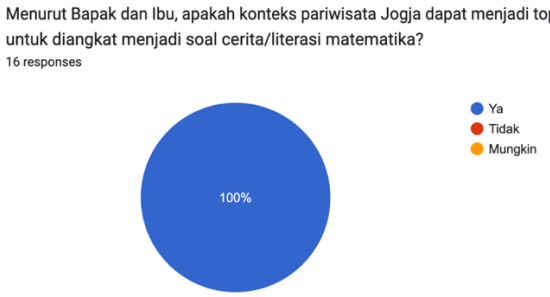

Figure 3. The potential of Jogja tourism contexts to be developed into mathematical-literacy tasks.

Furthermore, the teachers provided additional notes regarding the use of word problems (contextual problems, mathematical-literacy tasks) in mathematics instruction. They stated that word problems are generally perceived as more difficult than abstract mathematics exercises. Nevertheless, such problems are important because they stimulate students' critical and creative thinking. In terms of context, mathematical-literacy tasks may incorporate elements such as trending issues, local cultural characteristics, or integration with contexts drawn from other school subjects (beyond mathematics) to provide engaging stimuli for students.

Table 2. Sample blueprint of mathematical-literacy tasks using the Jogja tourism context

No.	Context	Content	Reasoning activities	Problem-solving activities	21 century skills	Level	Connection to school mathematics
1	Statistics of the visits to Parangtritis beach and surrounding	Uncertainty and data (drawing conclusion based on data)	Comparing visitors data of several beaches in Parangtritis, then evaluating the trip plan	Choosing the best day and the best route to have a beach trip	Critical thinking, creative	3	Mean and mode of single data, data trend
2	Statistics of review and distance (Google maps) to several options of restaurants in Yogyakarta	Uncertainty and data (drawing conclusion based on data)	Comparing the distance and rating for some restaurants.	Choosing the best option for restaurant based on its distance and rating	Critical thinking, creative	3	Mean of single data

Design and develop

At this stage, we developed the test blueprint for mathematical-literacy tasks using the Jogja tourism context, as presented in Table 2. There are 35 items successfully develop in this stage.

Furthermore, we develop the word problems based on the blueprint of the 35 items (See the sample in Figure 4).

Figure 4. Sample of the task with the context of Tamansari water palace.

The test was then validated by two experts, one from the mathematics education department (a lecturer) and one from the school partner (a mathematics teacher). The validation resulted that the test scored 4.73 (of maximum 5). The validators also suggested some revisions such as to provide a more clear context and visualization, to avoid ambiguation, and to revise the sample of solution.

Implementation and evaluation

At this stage, we tried out the test to 441 students from 11 private junior high schools in Yogyakarta. The test results are presented in Table 3.

Table 3. The test results

Statistics	Data
Minimum	4/100
Maximum	82/100
Average (mean)	36.7/100
Median	40/100

From Table 3, we admitted that the students' performance in the test was considered low. Though the there was a student got 82 score which was categorized high, the mean, however, was still 36.7, which indicates there are so many data are under average. Furthermore, the median was only 40, which means that half of the students' population scored under 40. The data indicated two things, either the test was too difficult or the students' capacity in mathematics literacy was too low.

CONCLUSION

Finally, we successfully developed 35 valid items of mathematical literacy problems with Jogja tourism context in terms of content and construct. The availability of these word problems would be useful for mathematics educators to foster the students' mathematical literacy at school.

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