Batik Context as PISA-like Problem to Assess Students’ Mathematical Literacy

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Abstract. PISA is an international assessment of mathematics and science achievement that concern for the mathematical literacy. Students’ mathematical literacy, however, was still low in Indonesia. This study aims to develop PISA-like problem that valid, practical and has potential effect to assess mathematical literacy. This study was research and development that consisting of preliminary, development, and assessment stages. The subject of this research was students on grade 7\textsuperscript{th}. The data was collected by observation, questionnaire, and test. This research result PISA-like problem involves three questions with Batik theme in quantity content. This PISA-like problem was declared valid, practical, and had a potential effect to assess mathematical literacy. This problem is valid based on judgment from experts concerning on the content, construct, and language aspects. This problem is practical based on the results of the test to small groups of students. Besides, this problem has potential effect on assessing students’ mathematical literacy.

Keywords: batik context, mathematical literacy, PISA-like problem.

1. Introduction
Programme for International Student Assessment (PISA) is an ongoing program that monitors trends in the knowledge and skills that students around the world, and in demographic subgroups within each country [1]. The focus of PISA is the emphasis on the skills and competencies of students acquired from school and used in daily life with a variety of situations [2]. Good mathematical skills are one of the basics skill on the latest and sophisticated technology development [3]. Therefore, having good mathematical literacy is essential for today’s life.

Based on survey conducted by Trends in International Mathematics and Science Study (TIMSS) 2015, rank of students’ achievement in Indonesia was on 46\textsuperscript{th} of 51\textsuperscript{st} countries with the average score 397 [4]. Moreover, based on result of PISA 2018, Indonesian students’ achievement was on 74\textsuperscript{th} of 79\textsuperscript{th} countries [5]. In Particular, the average students’ achievement on mathematics was 379 lower than overall average 489 [6]. Based on two major international assessments of mathematics and science achievement, PISA and TIMSS, mathematical ability of Indonesian student was very low. TIMSS aims to make an assessment of the (common aspects of the) mathematics curriculum as taught in participating countries, whereas PISA starts from concern for the mathematical literacy that is judged to be valuable to 15-year-olds for their lives [7]. Therefore, using PISA problems on mathematics learning is great idea to improve students’ mathematical literacy. However, the result of questionnaire toward 51 mathematics
teachers showed that none of them using PISA problems on mathematics learning. It is essential to develop PISA-like problems to assess mathematical literacy of students.

Mathematical literacy is defined as an individual’s capacity to formulate, employ and interpret mathematics in a variety of contexts including reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena [1]. There are seven fundamental mathematical capabilities to assess mathematical literacy used in this framework, namely communication; mathematising; representation; reasoning and argument; devising strategies for solving problems; using symbolic, formal and technical language and operations; and using mathematical tools. Mathematical literacy is related to daily life problems [8]. Using local wisdom context could improve students’ literacy and problem solving [9]–[11]. Therefore, developing PISA-like problem in context of local wisdom is needed.

There have been some research conducted toward students’ problem solving on PISA problem [12]–[16]. The studies found that most of Indonesian students’ ability to solving mathematics PISA problems was low and the difficulties on solving it were formulating situation mathematically and evaluating the solution toward real-world problems. To make students familiar with PISA problems, there have been some studied that develop PISA-like problems [17]–[21]. Based on that research, most of them were developing PISA-like in sport theme and it still limited PISA-like problem using local wisdom theme to assess mathematical literacy. Thus, this research aims to develop PISA-like problem that valid, practical and has potential effect to assess mathematical literacy.

2. Research Method

This research was conducted by research and development design which aimed to develop mathematics assessment based on PISA criteria in Junior High School to assess the mathematical literacy of students. Besides, the research was conducted based on Plomp design consisting of preliminary phase, development phase and assessment phase [22]. At the preliminary phase, the researcher analyzed the curriculum including PISA characteristics that would be developed to PISA-like problems. Then, the PISA-like problems were designed and developed on development phase. The draft was validated by expertise and revised by their suggestions. After that, the PISA-like problem was tested toward students to do assessment in small scale. The data was collected by test and analyzed based on mathematical literacy characteristics, the data validation used was researcher validation.

3. Result and Discussion

This result of this research was a PISA-like problem that consisting of three question integrating Batik as local wisdom. There were three stages on this research and development design consisting of preliminary, development, and assessment. The preliminary was the initial identification related curriculum and PISA framework. Then, the development phase was done by designing, developing, and revising the prototype of PISA-like problem. The last, assessment phase consisted of validation, practical viewed, and identification of the potential effect to assess mathematical literacy.

3.1. Preliminary Stages

At the preliminary, the researcher identified and analyzed the curriculum, mathematics problem that used in school, and PISA framework. The majority junior high school in Indonesia use Curriculum 2013. In this curriculum, the material could be classified as the PISA content, namely change and relationships, space and shape, quantity, and uncertainty and data. Most of mathematics teacher used textbooks and electronic books providing by government. This kind of books involves variety type of mathematics problems such as routine-problems, conceptual understanding, problem solving, and higher order thinking skill. A research related mathematics textbook for 8th grade, however, showed that only 33.40% of the problems were in accordance with PISA component [23]. It showed that the PISA-like problems were still low. In addition, based on the questionnaire about mathematics problems that used by teacher, there were 43.1% teacher concern on conceptual understanding problems, 23.5% teacher used higher
order thinking skills problems, and the rest was routine-problem and problem solving. Nonetheless using PISA-like problems on mathematics learning.

The analysis of PISA problems focused on component consisting of content, context, and mathematical process, and also characteristic of PISA framework to assess mathematical literacy. This development product concern on quantity content and societal context. The problems involved formulating, employing, and interpreting as mathematical process. Moreover, the characteristic that used to assess mathematical literacy were focusing on analyze, reasoning, and communicating. The PISA-like problem was developed based on local wisdom from Java, namely Batik. This theme was chosen as using local wisdom could improve literacy ability of students, make the learning effective and reach good achievement, and also promote students’ character education [9], [11], [24]–[28].

3.2. Development Stages
Based on the analyses, the PISA-like problems were developed Indonesian curriculum for students on junior high school. The problem started by explanation of Batik cloth, a traditional fabric from Indonesia. Two of the Batik cities in Indonesia are Yogyakarta and Surakarta, or commonly known as Solo City. Besides, it was designed on three kinds of Batik theme, namely Batik Kawung, Batik Sidoluhur, and Batik Ceplok Kembang Kates. These three motifs were chosen because they contain patterns that can be used in learning sequences. This problem consists of three questions about sequences. Each question was designed in line with PISA components, namely content, context, and process. The draft of product was established by the researcher and produce first prototype. The prototype was validated by expertise in terms of content, construct, and language. Based on the suggestions of the validator, the prototype was revised until got the final prototype. The development stage will be described in detail based on each question on these following paragraphs.

3.2.1. Batik Kawung Context
The first question is using Batik Kawung pattern as one of traditional fabric pattern from Solo, Indonesia. The illustration of Kawung pattern was presented in Figure 1. The stimulation of this question is related on the time used by a craftsman to design one pattern of Kawung with canting technique. Then, students are asked to estimate whether a craftsman could finish a piece of fabric with certain size and time. At the problem solving, students need to formulate the given problem with mathematics model by identifying the pattern. Then, students need to use mathematical concept to calculate the number of pattern and the time needed. After that, students should represent the calculation to analyse the answer.

Figure 1. Batik Kawung Pattern
3.2.2. Batik Sidoluhur Context
The second question is using Batik Sidoluhur pattern as one of fabric pattern from Surakarta and Yogyakarta Palace, Indonesia. The illustration of Sidoluhur pattern was presented in Figure 2. The pattern involves throne ornament, butterfly ornament, garuda ornament, and aquatic ornament. At this question, students were asked to determine the certain pattern. They need to identify the given pattern and used mathematical concept to find the right pattern. Recognition number pattern is one of the quantity content [29].

![Figure 2. Batik Sidoluhur Pattern](image)

3.2.3. Batik Ceplok Kembang Kates Context
The third question is using patter of Batik Ceplok Kembang Kates. The pattern that inspired from papaya plant is special fabric pattern from Bantul, Yogyakarta, Indonesia. The stimulation of this question is given three different kinds of fabrics’ pieces. Students were asked to fulfil the pattern and determine the number of each ornament of the fabric in certain size. For solving this problem, students need to analyze the pattern first, then use it in mathematical concept to calculate the numbers of pattern.

![Potongan 1, Potongan 2, Potongan 3](image)

![Figure 3. Batik Ceplok Kembang Kates Pattern](image)

After the problem developed, it validated by three experts. They were two lecturers of Mathematics Education Departement and a mathematics teacher. The problem was validated from three aspects, namely material, construction and language. On the material aspect, it contains the suitability of the questions with the PISA indicators. Based on these reviews, the problem was improved to Prototype 2. The comments and suggestions from the experts are summarized as follows.
Table 1. The validators’ reviews

| Comments and suggestions                                                                 | Follow up                                    |
|------------------------------------------------------------------------------------------|----------------------------------------------|
| Over all, the problem meet with PISA indicators                                           |                                              |
| It is better to use more valid reference about the explanation of Batik context. It's    | Change the reference into KBBI               |
| better to avoid sources from Wikipedia                                                   | (Indonesian dictionary)                      |
| The problem contains ancestral heritage, so that it is not only assess mathematical      |                                              |
| reasoning, but also to preserve cultural heritage. The details about the Batik patterns  |                                              |
| and their meanings are explained as well.                                                |                                              |
| Do not write the content and context of the questions. This can lead to ambiguity in     | Delete the content and context writing       |
| students perceptions                                                                     |                                              |
| The sentence in Question 1: One sheet of Batik cloth has a size $2m \times 1.5m$, it     | Change the sentence into “Pengrajin membuat |
| is better to be improved by give a connection to blend with the previous sentence.       | kain Batik dari bahan dasar berukuran $2m \times |
| For example, provide information that usually the Batik fabric are made in a cloth with  | 1.5m”                                        |
| a size $2m \times 1.5m$.                                                                |                                              |
| In Question 3, the information of Ceplok Kembang Kates pattern contains “only use      | Change the sentence into “Complete the flower |
| seeds and flowers of papaya tree”, but the pattern also use leafs. It is better to       | and seed patterns, and the leaves on the     |
| change the sentence in Question 3 so that it is suitable with the Ceplok Kembang         | motif”                                       |
| Kates pattern.                                                                           |                                              |

After the Prototype 2 was designed, the problem was given to three students to evaluate the practicality of the PISA-like problem. The students were selected from three mathematical abilities, student with low ability, student with moderate ability, and student with high ability. In this phase, the problem was evaluated from some aspects, namely the instruction, the readability of the problem by students, and students’ understanding on the problem. In problem solving, understanding the problem is a crucial point before students go to next steps [30]. The data validation of this practicality aspects were evaluated by two researchers. Based on the triangulation, it concluded that the problem instructions were clear. Students wrote answers on the right place and complies with the presented problems. A students understood the problems because he was able to write down what is known. Though the two students did not write down what is known from the problem, their answer leads to the correct completion of the problem. In case of continuing the pattern, all of the students could draw in correct way based on the instruction.. Therefore, the problem met with practicality indicators.

3.3. Assessment Stages
As the framework of mathematical literacy on PISA refers to seven fundamental mathematical capabilities, [1], these seven aspects are used to assess individuals’ mathematical literacy. The seven fundamental mathematical capabilities to assess mathematical literacy used in this framework, are communication; mathematising; representation; reasoning and argument; devising strategies for solving problems; using symbolic, formal and technical language and operations; and using mathematical tools. Mathematical literacy is related to daily and work life problems. This helps students face with social life [31].

The figure 4 shows students’ answer on questions 1. From the figure, it can be seen that students could solve the problem correctly. Based on seven fundamentals mathematical capabilities, student fulfilled all aspect of mathematical literacy, except using mathematical tools. (1) Student could construct the explanation and argument to solve the problem by presenting the data how large the size of fabric...
that could be done by the craftsman, so that it involves communication abilities. (2) Student could transform the problem in the real world to mathematical form by calculating the size in question, hence it fulfilled mathematising aspect. One of the mathematical literacy skills is that students can formulate real problems into mathematical terms [7]. (3) Students fulfill representation aspect as she can compare the result toward the given information, so that she made conclusion that a craftsman could not done drawing batik yet in 8 hours. (4) Student did right calculation on how large the fabric could be drawn with batik pattern, hence she had argumentation on her conclusion. It fulfilled reasoning and argument. (5) Student devised strategies for solving the problem by calculating the size in question, the time provided, then she can determine whether the given time are enough or not to finish it. Hence, it involves devising strategies for solving problems. (6) Student did not use any symbol on transforming and solving the problem, but she used mathematics operation. (7) student did not use mathematical tools as the calculation is easy. 

The figure 5 is students’ answer on question 2. It shows that student could solve the problem properly. Based on seven fundamentals mathematical capabilities, student fulfilled student only achieve representation, reasoning, and devising strategy. (1) It does not accomplish communication aspect as student did not explain how she solve the problem in detail. (2) Student did not identify the problem with formal mathematical model because she only explained informal reason, so that it did not fulfill mathematising aspect. (3) Even though student did not answer the problem in mathematical model, but she explained how to solve the problem with mathematical concept clearly. Hence, it fulfilled representation aspect. (4) It achieved reasoning and argument aspect as student could provide a justification related the problem by using multiple patterns based on the question. (5) Student could select a strategy to mathematically reframe contextualized problems by using multiple concepts. Therefore, it completed devising strategies for solving problems aspect. (6) Student did not use any symbol on transforming and solving the problem. (7) student did not use mathematical tools as the calculation is easy.
The figure 6 is one of students’ answer of question 3. Based on seven fundamentals mathematical capabilities, student achieved all aspect of mathematical literacy, except using symbolic and mathematical tools (1) Student present intermediate mathematical results by giving explanation of solution in simple way. Thus, it fulfilled communication aspect. (2) Student used an understanding of the context to guide or expedite the mathematical solving process by providing mathematical calculation so that it involved mathematising (3) It fulfilled representation aspect as student used a variety of representations when interacting with a problem. Student calculated the large of fabric divided by the small area, instead of determine the-n pattern based on the table. (4) Student connected pieces of information to arrive at a mathematical solution by solving the problem based on her logical thinking, instead of use the pattern. Thus, it fulfilled reasoning and argument aspect. (5) Student used an effective strategy to find the right solution, hence it involved devising strategies for solving problems aspect. (6) Student did not use any symbol on transforming and solving the problem. (7) student did not use mathematical tools as the calculation is easy.

![Figure 6. Students’ Answer on Question 3](image)

Based on the result above, students could fulfill six fundamental capabilities of mathematics, namely communication; mathematising; representation; reasoning and argument; devising strategies for solving problems; and using symbolic, formal and technical language and operations. It does not achieve using mathematical tools aspect as the calculation or mathematical concept was easy enough to be solved without mathematical tools. Besides, the communication aspect was low as students did not give in-depth explanation or reasons related to their solution. This result in line with other study result, the communication ability is still low because the students do not give detailed answers [32]. As this PISA-like problem could integrate the fundamental mathematics capabilities which are the mathematical literacy aspect, then this problem had a potential effect to assess students’ mathematical literacy.

The mathematical literacy abilities can be improved by rediscovering the concept of mathematics. The PISA-like problems could improve students' mathematical literacy. One approach of mathematics learning that can have a positive impact on students' literacy skills is the Realistic Mathematics Approach (RME) [33]. PMRI approach with character education and PISA-like assessments is effective in improving students' mathematical literacy skills [34]. Learning with a real-life approach can encourage mathematical literacy mainly on process employing and interpreting [35]. As this PISA-like problem was designed by using contextual problems related to Batik as Indonesian local wisdom, then this problem is potential to assess students’ mathematical literacy.
4. Conclusion

This research result one problem with three questions in Batik theme with PISA characteristics and aims to assess students’ mathematical literacy. The PISA-like problem was concluded to be valid, practical, and had a potential effect to assess students’ mathematical literacy. The validity of the problem was done by reviewing the problems by expertise, which stated that the problem meet the PISA characteristics and it was good in terms of content, constructions, and language. The PISA-like problem was practical viewed from students’ answer and readability. Besides, the developed PISA-like problem was analyzed based on seven fundamental mathematics capabilities whereas it involves to mathematical literacy. The dominant aspects of students on solving the problems are representation, reasoning, and devising strategy. Meanwhile, the communication aspect was low as most of students only solved the problem directly without write the explanation as well the given information, aspect of using symbolic and mathematical tools was very low as the calculation was simple. Therefore, this PISA-like problem had a potential effect to assess students’ mathematical literacy. It was suggested to develop PISA-like problem on the other content with local wisdom theme.

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