Designing PISA-like mathematics problems using the context of Karawang

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Abstract. The improvement of students' mathematics ability has been the major attention of educators in many countries, including Indonesia. The purpose of this research was to generate PISA-like mathematics problems using the context of Karawang. This research was a development research, and the evaluation flow was conducted by using a formative study including self-evaluation, expert review and field test. The discussion of this article was on the expert review phase and one-to-one. The participants were three students of a junior high school in Karawang. The data collection techniques were walk through and interview. The walk through technique was based on expert reviews to obtain valid PISA-like problems in content, construction, and language aspects. The interview was one-to-one interview. Once collected, the data were analyzed by using descriptive analysis method. Based on expert reviews as well as students' responses, valid PISA-like mathematics problems using the context of Karawang were obtained. The results of this study provide implications for the development of PISA-like mathematics problems using the context of Karawang.

1. Introduction
Program for International Student Assessment (PISA) is an international survey that assesses the skills and abilities of 15-year-old students [1]. PISA focuses on assessing students' skills and abilities in mathematics, reading, and science [1,2]. As a large-scale assessment forum, PISA examines students’ mathematical literacy. According to PISA, mathematical literacy is “an individual’s capacity to identify, and understand the role that mathematics play in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual’s life as a constructive, concerned, and reflective citizen” [3]. Mathematical literacy is the ability of a student to identify and understand mathematical rules and their application in everyday life.

The question of how to improve students' mathematics ability has been a significant concern of educators worldwide, including Indonesia. PISA results since 2000 to 2015 show that Indonesian students were at the 10th lowest rank of all participating countries in PISA [4].

Students’ low achievement in PISA cannot be separated from the teaching and learning process in schools. Students are not accustomed to solving contextual problems, and only do problems exemplified by teachers without truly understand the meaning of mathematics in everyday life. In fact, Indonesian students are particularly not accustomed to solving high-level contextual problems because
mathematics learning in Indonesian schools do not use high-level problems [5]. Therefore, students need a better learning activity that promotes their higher order thinking skill.

One of the efforts to familiarize students with PISA-based mathematical problems is by introducing the problems as early as possible or at the beginning of students' middle school experience. Hence many studies have attempted to develop PISA model in junior high schools with various focuses.

Formal mathematics problems cause students to consider that mathematics is not easy and fun. Some students even think that mathematics does not have implementation in their everyday life [6]. Therefore, putting mathematics problems in context is very important [7]. It is also necessary to use local contexts in order to help students to understand mathematical phenomena from their daily-life experiences. One context that can be applied is the context of Karawang.

Karawang is one of the districts in West Java province, Indonesia. There are many local contexts of Karawang district including the aspect of heritage buildings such as Kebulatan Tekad monument, Soekarno's Exile House, Walahar Dam and many more. Previous research has developed many PISA-like problems [8]. However, the context of Karawang has never been used. This study aimed to produce valid PISA-like mathematics problems using the context of Karawang. The main reason for selecting the context of Karawang for the PISA-like problems was to enable the students who participated in the study to understand the problems more easily since the context was familiar to them. The PISA-like problems developed in this research were at levels three and four considering that students in Karawang were not yet familiar or never heard of PISA problems. The problems that their teacher usually presented in the classroom or available in the text books and student worksheet are of level one or level two [9].

According to the Organisation for Economic Co-operation and Development (OECD), level three mathematical competence on PISA problems requires students to be able to perform procedures well, including procedures that require consecutive decisions [2]. Students can choose and apply simple problem-solving strategies. Students at this level can interpret and use representations based on different sources of information and rationalize the reasons. The competence of mathematics at level four is that students can work effectively with concrete models in complex situations. In this level, students can choose and integrate different representations and relate them to real situations. Furthermore, they can use their skills well and present reasons as well as views that are flexible according to the context. Students can explain their interpretations and actions.

The question addressed in this study was formulated as follows: How is the designing of valid PISA-like mathematics problems using the context of Karawang. The purpose of this research was to develop valid PISA-like mathematics problems utilizing the context of Karawang.

2. Method

This research applied research development or development studies research design [10]. This study was conducted in three steps: preliminary or preparatory step, the prototyping step, and assessment step [11]. In the prototyping step, the evaluation used formative evaluation which included self-evaluation, expert review and one-to-one, small group, and field tests. The assessment step was conducted to analyze the preliminary and the prototyping steps [12,13].

In the self-evaluation step, the researchers evaluated the PISA-like mathematic problems using the context of Karawang. The design process was based on three characteristics: content, construct, and language as shown in table 1. These three characteristics were validated by the researchers. The results were analyzed to form the first prototype.
Table 1. Examination of the characteristics of the prototype.

| No. | Characteristics | Aspects Examined |
|-----|----------------|------------------|
| 1.  | Content        | The problems are following the characteristics of PISA |
| 2.  | Construct      | The problems are suitable for junior high school level  |
|     |                | The problems can be developed                          |
|     |                | In accordance with the PISA framework                  |
| 3.  | Language       | The problems are in line with the general guidelines of |
|     |                | Indonesian spelling                                    |
|     |                | Unambiguous Questions                                  |
|     |                | The language of the questions and the questions are clear |

The researchers developed three PISA-like problems using the context of Karawang. The success criteria of this research was when the problems were declared valid. The validity was obtained from mathematics-expert validators. The validation process of the first prototype required the experts to review the steps that were executed in three ways including face-to-face review, mail/review (mails review), and panel review [12]. In conjunction with that, the researchers tested students individually (one-to-one). The results of the expert reviews and one-to-one were used to revise the product.

3. Result and discussion

Expert reviews and one-to-one steps were implemented to produce a product which was then tested on three students. The one-to-one step was in line with the formative evaluation guidelines to produce substantial changes to PISA-like mathematic problems using the context of Karawang [11,13]. The three students were referred to as MS, NA, and AC respectively. The purpose of this trial was to find out the responses and difficulties that the students encountered when reading or answering the questions. The observation focused on the legibility and clarity of the matter. The problems covered the topics of quadrilateral, circle, and Pythagoras. The students were asked to read and answer the problems. Interview was conducted to see the students’ responses and understanding [14,15]. Table 2 shows the questions for the interview.

Table 2. Interview questions.

| Number | Question                                         |
|--------|-------------------------------------------------|
| 1      | Do you know the meaning of the question?        |
| 2      | Using your own words, can you tell me what the problem is in the question? |
| 3      | Do you think the information in the question can be used to solve the problem? |
| 4      | Have you ever encountered a problem like this before? |

The result of one-to-one showed students’ opinions that the PISA-like Karawang's context were good and could encourage the students’ reasoning skills. All the three students were able to answer the questions correctly and explain their answers. However, there were several words in the problems that were poorly understood by the students. Besides, the students felt unfamiliar with the illustrations in the problems. They confessed that they had to read over and over again to understand them. Thus, the explanation must be more specific. Based on the student's answers, it was concluded that the students could interpret and use representations based on existing sources of information and explain the reasons.

Then, the researcher asked the students to give comments or suggestions on the PISA-like mathematic problems in the context of Karawang. Table 3 shows the comments and suggestions provided by the students.
Table 3. Students’ comments.

| No | Name | Comments |
|----|------|----------|
| 1. | MS   | “I do not understand, and I am not accustomed to working with problems like this. It takes me a long time to finish it. And there is a word that is not clear in the problem. |
| 2. | NA   | Too many words that I have to read repeatedly in order to understand the question, to see the relation between the problem and the picture provided in the problem. |
| 3. | AC   | I know more about the history of the relics in Karawang. |

It was revealed from the students’ answers and comments that they understood and were able to answer the given problem even though not perfectly. In the one-to-one stage, it was known that the students' ability to read problems and interpret them into mathematical expressions was good enough, but it took a long time. This was an input for the researchers in revising the problems to make the problems clearer so that students could understand the problems more easily. The students attempted to solve the problems by guessing and trying to find the pattern. This indicated that the students generally understood the PISA-like mathematics problems. This meant that PISA-like mathematics problems could serve as an alternative form of assessment to be used by teachers in the classroom.

During the expert review, the researchers requested for the opinions of mathematics education experts including Prof. PY, a lecturer at postgraduate program of Pasundan University, Dr. DL, a lecturer at the University of Singaperbangsa Karawang and MF, a junior high school teacher. The experts’ feedbacks and suggestions are shown in Table 4.

Table 4. Experts’ comments.

| No | Name   | Comments |
|----|--------|----------|
| 1. | Prof. YP | The issues presented should be tailored to the learning indicators in junior high school. The language should follow the general Indonesian spelling guidelines. |
| 2. | Dr. DL  | It is still better to present an interesting question that fits the context you want to research. |
| 3. | MF      | Text writing should follow the general guidelines for Indonesian spelling. The content and construct of the problems are in line with the framework of PISA problems. It all leads to the content of shape and space, and the general context of Karawang. Similarly, the questions are appropriate for junior high school level. Furthermore, the basic competencies presented in this instrument are in line with the materials studied at junior high school level. So, the essence and the content are appropriate. |

The PISA-like mathematics problems were developed by researchers and validated through one-to-one and expert reviews. From both steps mentioned, the researcher revised the problems in accordance with the general guidelines of Indonesian spelling, eliminated irrelevant information and pictures and fixed the layout and display of the questions.

The results from expert reviews and one-to-one showed that the designed problems could be categorized as valid PISA-like mathematics problems.

4. Conclusion

The results of this research were valid PISA-like mathematics problems using the context of Karawang. The first prototype of the development was declared valid based on expert reviews and one-to-one test. The prototype was valid after the content, construction, and language revisions. There were three PISA-like mathematics problems produced.
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