PISA-like mathematics problem: The context of basketball in Asian Games

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Abstract. The research background is based on the low achievement of Indonesian students on PISA mathematics literacy. The research aims to produce the valid and practical PISA-like mathematics problem that included uncertainty and data content by using basketball sports conducted in the Asian Games. The research subject was tenth-grade students of Senior High School. The researchers developed a problem based on two stages in the design research with development studies consisting of preliminary and formative evaluation stage. The data collection techniques used were a walkthrough, documentation, an observation, and an interview. The results showed that the developed problem met the valid and practical criteria. Valid criteria came from validator’s assessment of two PISA expert teams from Australia, one expert from Indonesia regarding content, constructs, and language and the students’ comments on the clarity (readability) of the phase one-to-one. Practical criteria obtained in the small group phase. It finds out that students had been able to comprehend the purpose of the problem. Besides, the basketball context used could make students actively in the discussion and help students to solve the problem and provide arguments from the given issues.

1. Introduction
Having good mathematical literacy skills is one of the most important things for everyone in this globalization era to face and solve real-life problems. Mathematical literacy is interpreted as the ability to use knowledge and mathematical understanding effectively in facing challenges in daily life [1]. Also in line with Stacey and Turner [2] opinion, that the main idea in mathematical literacy is the use of mathematics in daily life. In the PISA mathematical literacy is explained about four contents in which one of them is uncertainty and data content. Uncertainty and data is the heart of mathematical analysis of many problem situations, and the theory of probability and statistics as a technique of data representation and description [3]. However, in the results of the PISA survey in 2012, Indonesian students got a score of 384, which is still below the average score of other countries for uncertainty and data content [4].

Moreover, the result from the survey of the Programme for International Student Assessment (PISA) on mathematical literacy in the last two periods showed that in 2012, Indonesia is ranked 64 out of 65 countries with the score 375 from the OECD countries’ average score is 494 [5,6]. Meanwhile, in 2015, Indonesia is ranked 62 out of 70 countries with the score 386 from the OECD countries’ average score is 490 [7]. Based on these results, the importance of mathematical literacy is not in line with the results and achievements obtained by Indonesian students in the International PISA survey. The facts showed that Indonesia is still ranked below with the average score below the OECD’s average score.
Indonesian students have difficulty in solving PISA-like mathematics problems using the context and in turning them into mathematical problems [8]. The effort which can be done is to design problem by the characteristics of PISA to familiarize students practicing to solve the problems of PISA-like and teachers are also required to be able to design problems by using context which closes to the students’ lives [9]. The use of context in the learning of mathematics can make the concept of mathematics more meaningful because its context can present an abstract mathematical concept in the form of representation that is easy to understand by students [10-14]. The learning which is emphasizing on the context or situation is PMRI Approach PMRI approach is one of the learning approaches that will lead students to understand the concept of mathematics by constructing by them through the previous knowledge related to their daily lives, by finding their concept, it is hoped that students’ learning will be more meaningful [15]. In addition, *Pendidikan Matematika Realistik Indonesia* (PMRI) is a learning innovation that adapts from a similar learning approach as RME (Realistic Mathematics Education) [15, 16].

One of the interesting contexts to be implemented is the sports in Asian Games which will be held in Indonesia in 2018, among which is basketball. It is such a common sport played and watched by students, so they are familiar with this context. The previous research by using the context of sports at the Asian Games can help students in understanding mathematics learning such as using sprint context [17], dayung context [18], swimming context [19], and hurdles context [20]. They showed that the context of the Asian Games sports could be used to attract students’ learning interests.

The research about the development of mathematics problems of PISA-like has been done. However, no one has used basketball context in the Asian Games. The previous research developed the PISA-like problems level 6 for Junior High students [21] and the context of Indonesia's natural and cultural heritage to measure students’ mathematical literacy [22]. Therefore, the researchers are interested to develop mathematics problem of PISA-like mathematics by using basketball context in Asian Games on uncertainty and data content.

2. Method

The method in this research was design research with the type of development studies with two stages, preliminary and formative evaluation that includes self-evaluation, expert reviews, one-to-one, small group, and field tests [23, 24]. The subject of this research was tenth-grade students of Senior High School.

In the preliminary stage, the researchers determined the place and subject of the research. Researchers not only conducted a curriculum analysis, analysis of mathematical problems based on PISA framework but also recognized PISA-like mathematics problems that had been developed previously as a reference material in developing the problem. Then, the researchers designed the problem's device that contained the problem grid, problem card, and scoring rubric so that it produced the initial prototype. In self-evaluation phase, the researchers evaluated and reviewed the initial prototype and to form prototype I. The prototype I was then examined and judged by the validator at the expert reviews phase and tested to the students in the one-to-one phase. Expert reviews phase are the steps undertaken to evaluate the problems conducted by experienced experts. The experts assessed prototype I by evaluating it based on the content, constructs, and language. In expert reviews, the panel discussion was also employed. According to Turner [25], panel discussion or item panelling was one of some essential steps in the development of high-quality test items.

Along with the expert reviews phase, prototype I was tested to three students with different abilities (high, medium, and low ability) at one-to-one phase. The focus of this phase was to get students' comments on the clarity and readability of the problem, suggest improvements, and investigate the reasons for the difficulty found in solving the created problem. From the expert reviews and one-to-one phase would produce a valid prototype II.

The next phase was small group. In the small group phase, prototype II was tested to six students with high, medium, and low abilities that were involved to solve the problem and provide suggestions and comments to know the practicality of the developed problems. In the small group phase, the
problem was used in the learning process. The comments and findings at this small group phase were taken into consideration for revising the prototype II. From the small group phase, would produce a valid and practical prototype III. The data collection techniques used were walk-through, document, observation, and an interview. Then the data were analyzed by the qualitative descriptive to describe the result of each step of development.

3. Result and discussion
This research generated PISA-like mathematics problem that included the context of basketball in Asian Games that included uncertainty and data which are valid and practical. The PISA-like mathematics problem had been through some development studies stages including preliminary stage and formative evaluation stage consisting of self-evaluation, expert reviews, one-to-one, and small group.

3.1. Preliminary
In the preliminary stage, the researchers conducted student analysis, curriculum analysis, PISA framework, and design an instrument that included the problem grid, problem card, and scoring rubric. Next, researchers designed the PISA-like mathematics problem. The researchers developed the PISA-like mathematics problem from an original PISA mathematics problem. In designing the problem using the context of the basketball, the researchers were inspired by the problem of PISA in 2006 which included uncertainty and data content that is "test scores". This problem asked students to use their reasoning to provide a reason or argument in proving and solving the problem. Indonesian students are weak in solving problems that require giving arguments or sense-making [26-30]. It is, therefore, necessary to develop students' reasoning in expressing their opinions and arguments by showing appropriate evidence and steps [28-30]. Thus, the researchers developed the problem using this basketball context by asking students' arguments that could be given to support the Lebanese basketball team as the winners in the game to able to assist educators in the learning process for the students in the school. Then, the next stage was the formative evaluation.

3.2. Formative Evaluation
In the formative evaluation stage, the first phase was self-evaluation. The researchers evaluated and re-examined the PISA-like mathematics set prepared previously. Researchers found out errors or shortcomings that had been designed with attention to the characteristics that became the focus of the prototype (i.e. content, constructs, and language). The results obtained at this stage were called prototype I. Next, the prototype I was assessed or validated by the validator at the expert content stage regarding terms of content, constructs, and language. The validators involved are experts; KS and RT from Australia, including HJ from Indonesia. The researchers also conducted panel discussion to get suggestions and comments on the developed problems. Panel discussion was done with nine colleagues who were students of Masters of mathematics Education of Sriwijaya University who also in the meantime conducted research on the development of PISA-like mathematics problems and the three lecturers of Sriwijaya University as well. In conjunction with expert reviews phase, the prototype I was tested to three tenth-grade students of Senior High School with different abilities (high, medium, and low). During the process, the researchers observed and found out how each student answered and understood the problem. The researchers asked the students if there are words, instructions, and information that was not clear on the matter. The following shows some suggestions/comments on the prototype I in expert reviews and one-to-one phase in Table 1.
### Table 1. Comments/suggestions from experts and students

| Validation | Comments/Suggestions | Revision |
|------------|----------------------|----------|
| KS         | Basically good problems but there is a miscalculation in the answer contained in the answer key. | 1. Revise some words or sentences in the problem - "Winning score is 2" becomes "The team gets two points for every winning game." - "Winning score is 1" becomes "The team gets one point for every losing game." - "Score results" becomes "Score of the Match Results" |
| RT         | 1. This is a nice problem, reasoning testing, and strategy devising. 2. There are some sentences on the instructions that should be fixed, they are; - The winning score is 2 should be changed to the team gets two points for each winning match. - The value of defeat is 1 should be changed to the team gets one point for every lost match. | 2. Revise the data of the competition scores by using the original data obtained from the real match |
| HJ         | Problem received and no comments | |
| Panel discussion | Data presented should be the actual data | |
| Students   | Tables and instructions or rules contained in the problems are clear enough. | |

The prototype I was then revised based on the validator suggestions from expert review phase and one-to-one phase. The result of this revision was called prototype II that had been valid. The validity of the problem from the validator’s assessment of the content, construct, and language and from suggestions and comments one-to-one phase to the clarity/readability of the problem [23]. The following was prototype II in Figure 1.

**Figure 1. Prototype II**

The valid prototype II was then tested to six students at the small group phase. The six students were two students with high abilities, two students with medium abilities, and two students with low abilities. Based on the results of the work, most students had been able to answer the problem with the right steps to completion. Moreover, in the learning process, it found that students were very enthusiastic in solving the problem and active during the discussion it also in line with the result of previous research [17-19] in...
which found that the Asian Games context could help students in understanding mathematics and improve their motivation throughout the learning process. The following is an example of student answers that researchers found in the small group phase in Figure 2.

Figure 2 indicates that it can be seen that the student was able to understand the problem well. Student wrote complete and appropriate completion steps that were to calculate the score of each country based on the number of victories and defeats. Therefore, the student was able to draw conclusions and provide the correct argument to the given problem that was the Lebanese basketball team and the South Korean team has the same highest score compared with the other teams. However, based on the game rules stated on the problem, if both teams get the same score then the winner is determined by the result of the match when the two teams compete. When the Lebanese and South Korean teams competed, Lebanese team became the winner.

There was no revision that the researchers did from prototype II to prototype III. Based on the small group phase, it obtained valid and practical prototype III. Practicality was seen from the ease of students in understanding the problem [23, 24, 31, 32].

4. Conclusion
The developed PISA-like mathematics problem that included uncertainty and data content using the basketball context in Asian Games had fulfilled the valid and practical criteria and had been in accordance with the PISA framework. The validity of the problem was obtained through the validation of validators who validated in terms of content, constructs, and language as well as comments and suggestions from students about the clarity/readability of the matter at the one-to-one phase. Then, the practicality of the problem was evidenced in the small group phase; students could understand and use PISA-like mathematics problem well. In addition, the basketball context that was used could make students actively in the discussion and help students to solve the problem and provide arguments from the problems given.

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