Uncertainty and data content in bowling: Task design

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Abstract. The students still difficulties in solving the PISA-like mathematics problem on uncertainty and data content. It is because the students were never solving context-based problems such as PISA. This research aimed to produce the valid and practical of PISA-like problems using bowling context. The research involved tenth-grade students of the senior high school in Palembang. The research method used is design research with development studies type through two phases: the preliminary and formative evaluation. In the preliminary phase have been reviewed some of literature and design. Meanwhile, the formative evaluation phase only consists of self-evaluation, expert reviews, one-to-one, and small group. The data collection techniques used were walkthrough, document, observation, and interview. This research produced two valid and practical problems using bowling context. From the expert reviews and one-to-one, the problems using bowling context have been well based on content, constructs, and language. From the small group, the problems could be understood and easy to be used by students. In addition, the bowling context that used could involve students’ mathematics literacy ability such as communication, representation, reasoning and argument abilities to find the concept, give perception, and can interpret the problems.

1. Introduction
Uncertainty and data are part of the content of the Program for International Student Assessment (PISA) that very important and useful to solve the problems which are closely related to daily life [1, 2]. However, many students in Indonesia are still difficulties in solving PISA problems. It’s because students never solving context-based problems such as PISA which is seen in the evaluation system in Indonesia is still using routine-problems [3-6]. Accordance with PISA’s result, Indonesia is ranked 63 out of 65 countries with a score of 384 on uncertainty and data content [7].

Therefore, the low result of PISA’s Indonesia students is the basis for the development of the 2013 Curriculum. Also, the teachers required to forming the students to be creative in thinking, solving problems, making decisions, reasoning, and conveying ideas in activities through PISA problems [8]. In PISA, the problems were presented mostly in real-world situations, so students can feel the benefits of mathematics in solving the problems of daily life [1, 9].

Furthermore, the use of real-world situations or context in learning mathematics can present an abstract mathematical concept in the form of representation that is easy to understand by students, so the mathematical concept becomes more meaningful [10]. One of the contexts that can be used is sports because it’s one of the fields that use probability or in the PISA framework called uncertainty and data content [2]. Besides that, on August 8, 2018, Indonesia is a host of the 18th Asian Games precisely in Jakarta and Palembang. Also, one of the sports in this competition is bowling.
In addition, several previous studies have shown good results in learning mathematics by using a context, namely the research by [11] which used Jambi context in developing PISA-like mathematics problem. A study conducted by [12] using swimming context in mathematics learning. Then, [13] shown that the use of sports rowing context can enlarge the students’ thought and can make the students understand the mathematical concept. In this case, the use of bowling context is a new experience for students in solving PISA-like mathematics problems and one of the efforts to enliven the 18th Asian Games among the students. Therefore, researchers are interested in using bowling as a context for solving the PISA-like mathematics problems on uncertainty and data content with the aim to produce the valid and practical problems.

2. Method
This research was conducted tenth-grade students of the senior high school in Palembang by using design research method with development studies type through two phases: preliminary and formative evaluation [14]. In the preliminary that includes the preparation and design, the researchers reviewed some of the literature related to this research, then designed instruments such as lattices, question cards, and rubric assessment by the 2015 PISA framework.

The next phase is a formative evaluation that includes the phase of self-evaluation, expert reviews, one-to-one, small group, and field test. But in this research, the researchers only discussed until small group by the problem statements of this research.

In self-evaluation, the researchers have analyzed the designed problems by ourselves and produce prototype I. After that it used in the expert reviews phase. The prototype I was validated by experts, in this phase the researchers using three methods of validation process: mails review with PISA expert from Brunei Darussalam University; panel review with lecturers of mathematics education in Sriwijaya University and some of the peers that had experience in developing of PISA-like problems; face-to-face with mathematics teacher. Along with validations with experts, a one-to-one phase performed. It’s done to know the validity of PISA-like mathematics problems. This phase involving three students of senior high school with various abilities (high, medium, low). The validation result was produced prototype II and used in the next phase.

Small group phase was conducted to find out the practicality of the problems developed by involving six students with high-ability, medium-ability, and low-ability. The results of this phase produce prototype III that valid and practical.

Data collection techniques used was the walkthrough, document, observation, and an interview. Then the data were analyzed by the qualitative descriptive method to describe the result of each step of development.

3. Result and discussion
This research produced two items of PISA-like mathematics problems on uncertainty and data content using bowling context in Asian Games which was valid and practical. However, in this paper, the researchers only covered one problem using bowling context at sixth level.

3.1. Preliminary
In preliminary, the researchers analyzed the students with a mathematics teacher by determining the level of mathematical ability of the students in choosing the research subject. Therefore, the researchers got three tenth-grade students (low, medium, high-ability) for one-to-one phase and six tenth-grade students with the different ability for the small group phase. Next, curriculum analysis by determining indicators of problem achievement, and the strategies students use in mathematical literacy ability. After that, the results of this phase were designed lattices, some of the PISA-like mathematics problems using bowling context on uncertainty and data content, and rubric assessment.
3.2. Formative evaluation

3.2.1. Self-evaluations

In self-evaluation, the PISA-like problems that designed, the evaluated and examined are owned by the researchers. The revision results in this phase called prototype I. Then, it used in the next step. One of the PISA-like mathematics problems using bowling context in Asian Games can be seen in Figure 1.

![Figure 1. The PISA-like problem before revision](image)

3.2.2. Expert reviews and one-to-one

Expert reviews and one-to-one phase were conducted in parallel to see the validity of problems. The prototype I was validated by experts based on existing criteria both regarding content, construct, and language. While the process of one-to-one involved three tenth-grade students of the senior high school, namely BHIP (high-ability), RR (medium-ability), and CAP (low-ability).

The students are asked to read and examine the problem so that the researchers can find out the responses, constraints faced, and understanding of students in solving the problem using bowling context. The responses and obstacles that observed focus on legibility and clarity of problems. Table 1 shows the validation result from expert reviews and one-to-one phases.

| Validation      | Comments/Response                                      | Revise                                      |
|-----------------|--------------------------------------------------------|---------------------------------------------|
| Expert reviews  | • The question is not clear, so change it to “What position should the ball be shot by the player in order to strike all the pin?”<br>• Change figure of pin formation that seen from in front of to figure that seen from the top | • Change the question according to the suggestion from the expert<br>• Change the figure |
| Students        | • How many are the strategy of ball positions asked this question?<br>• I don’t understand what the meaning of this problem | • Make the problem clearly |

Based on the results of expert validation and one-to-one, the researchers revised it. Furthermore, it can be concluded that the problems have designed are categorized as valid problems. It’s reflected in the comment provided by expert validation, then responses, constraints, and understanding of the students when solving the problem [14].

The validity of the problems in terms of content (according to the domain of mathematics literacy in PISA, also according to probability learning in tenth-grade); in terms of construct, the problems have been in accord with the characteristics of PISA problems level and abilities of the tenth-grade students; and in terms of language, the problems use of enhancing spelling, could be understood, and didn’t have variety of
meanings [15]. Then, the revised result called prototype II and used in the next phase. The problem in prototype II can be seen in Figure 2.

![Figure 1. Pin formation when viewed from above](source: google.com)

**Figure 2.** PISA-like problem after revision

3.2.3. Small group

Small group phase was conducted to see the practicality of problems for students in the implementation. This phase involved six tenth-grade students of the senior high school, namely DBA (high-ability), MA (high-ability), TCBS (medium-ability), AFP (medium-ability), DG (low-ability), PUR (low-ability).

The students were first asked to solve the problem individually. After that, students were asked to discuss in their group. Almost all of the students were able to understand and solve the problem well in the learning process. From the analysis result, the students use different strategies to solve the problem (see Figure 3 and Figure 4).

![Figure 3. DG’s answer to the problem using bowling context.](source: google.com)

**Figure 3.** DG’s answer to the problem using bowling context.

![Figure 4. DBA’s answer to the problem using bowling context.](source: google.com)

**Figure 4.** DBA’s answer to the problem using bowling context.

Figure 3 shows the students explain the ball should be shot between the 1st and 3rd pin because it will hit the pin of the behind and the pin will fall each other. The student also said that if the ball shot in the middle, so pin on the end namely the 7th or 10th pin will not fall. Then, they can draw the process of pinfall by the picture. It means that the student can use their representation ability. While from the figure 4, it appears that students can explain in detail of the probabilities that will happen. Based on their analysis,
there are two ways to get the strike: between the 1st and 2nd pin or between the 1st and 3rd pin. Students are also able to communicate the process of pinfall by their self-sentences.

Figure 4 also shows the analysis of student from various sides and the reasons that support their arguments such as they explain if the players use the left hand so that the ball will shot between the 1st and 2nd pins. It will hit the 1st, 2nd, 5th, 8th, and 9th pins. Also, the 1st pin will hit another pin on end. Then the 2nd pin will hit the 6th and 7th pins. Not only that but also the students explain the process of pinfall if the players use right hand and shot between the 1st and 3rd pins. Furthermore, they clarify if the players shoot between the 3rd and 4th pins or between the 4th and 10th pins, the pins on the left will not fall. Besides, if the ball shot between the 2nd and 6th pins or between the 6th and 10th pins, also the pins on the right will not fall.

The analysis result of students’ worksheet shows that most students can solve the problems well that using bowling context. Students also involving the communication, representation, reasoning and argument abilities to compare the probabilities of each other in solving the problems. Accordance with the results of research by [16] which states that students with good reasoning ability can understand, formulate, and solve problems correctly and adequately.

Based on the result of expert reviews, one-to-one, and small group, it can be concluded that the problems using bowling context that has designed are categorized valid and practical. It’s not only reflected from the result of expert reviews, but also from student’s response and understanding in solving the problem [17, 18]. In this case, almost students can solve the problems well that using bowling context. Students also involving the communication, representation, reasoning and argument abilities to compare the probabilities of each other in deciding the position should the ball shot. The practicality illustrated by the result of small group phase which is the problems could be understood for learning probability, easy to be used because they can solve the problems well by imagining the situations and probabilities that can happen [15, 19, 20].

In addition, the interview result of students’ answer sheet, it can be concluded that the PISA-like mathematics problems using bowling context on uncertainty and data can improve students’ mathematics literacy ability such as communication, representation, reasoning and argument abilities. Also, students said that they felt happy to do such problems because it is interesting to them. The implemented context in problems can help students to find the concept, help students to give the perception and can interpret information of problems easily, also can stimulate informal knowledge to formal knowledge [21-24].

4. Conclusion
This research produced two valid and practical of PISA-like mathematics problems using bowling context on uncertainty and data content. Valid theoretically can be seen from the validation results where all validators state that the items have been well based on content, constructs, and language. In terms of content, the problems that have been designed according to the domain of mathematics literacy in PISA, also according to probability learning in tenth-grade; in terms of construct, the problems have been in accord with the characteristics of PISA problems level and abilities of the tenth-grade students; and in terms of language, the problems use of enhancing spelling, could be understood, and didn’t have variety of meanings. Practically illustrated by the results of small group phase where the problems could be understood as learning probability, easy to use because students can solve the problems well by imagining the situations and probabilities that can happen. In addition, the bowling context could help students involving their communication, representation, reasoning and argument abilities to find the concept, give perception, and interpret the problems.

Acknowledgments
The researchers would like to express gratitude to the Directorate General of Higher Education Indonesia who has funded Pasca-grant research in 2018, and to Ms. Dian Fitriana and her students for participating in this research. As well as those who have helped the researchers in developing the research and writing this article.
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