PISA-like mathematics problem with karate context in Asian Games

H Nizar, R I I Putri and Zulkardi
Universitas Sriwijaya, Jl. Srijaya Negara, Bukit Besar, Palembang, Indonesia

E-mail: ratu.ilma@yahoo.com

Abstract. The background of this research was based on the low achievement of Indonesian students in working on the PISA problems. The research objective produced valid and practical PISA-like mathematics problem with karate context in Asian Games. The subject of this research was tenth-grade students of Senior High School. The research method used is design research with the type of development studies. This research had two stages that were the preliminary and formative evaluation. In this research, only presented the result on self-evaluation, expert reviews and one-to-one, and small group phase. Data collection techniques used were walkthrough, documentation, observation, and interview. The research had produced valid and practical PISA-like mathematics problem with karate context in Asian Games. Valid could be seen from the assessment of validator (expert) regarding content, construct, and language used and artistry of students in the phase one-to-one. Practical could be seen from the skill of students in small group phase where the student could understand the intent or language of the problem. Also, karate context used could make students actively engaged in the discussion, and it could help students to solve the problem and give the argument.

1. Introduction
Programme for International Student Assessment (PISA) was an international study to measure skills and capabilities of students aged 15 years and was held every three years [1]. The skills and capabilities which were assessed in PISA include four types of literacy those were scientific literacy, reading literacy, mathematical literacy, and financial literacy [1]. The PISA problem on the mathematical literacy was developed based on four contents: change and relationship, space and shape, quantity, and uncertainty and data [1]. PISA results were one of the external factors which revised KTSP (Kurikulum Tingkat Satuan Pendidikan) to the 2013 curriculum in Indonesia [2]. So it could be said that PISA was very important, because it became a reference of curriculum development in Indonesia. Indonesia was one of the countries that had been participating in PISA since 2000 and was expected to get achievements in PISA. However result of PISA study on mathematical literacy, Indonesia from 2000 until 2015 was always in lower rank. The result of PISA study on mathematical literacy in 2012, Indonesia was ranked 64 out of 65 countries [3, 4]. Then the result of PISA study on mathematical literacy in 2015, Indonesia was ranked 62 out of 70 countries [5]. The low achievement of Indonesian students in working on PISA problems were caused by the students were not familiar to do the problems that contain context, high level difficulty, and just doing the usual problems. As the result, many students made mistakes when working on PISA problems. This was the same as with the low PISA result of Indonesian students due to the lack of problem-solving capabilities of high level or non-routine, the
evaluation system in Indonesia was still using low-level problems, and students were accustomed to acquiring and using formal mathematics knowledge in the classroom [6-8]. Zulkardi [9] suggested to design the PISA-like mathematics problems and use it in the learning of mathematics in the class.

Context was a situation or phenomenon/natural occurrence associated with the concept of mathematics that was being studied [10]. The use of context in mathematics had several benefits, such as: useful for the formation of concepts, access and motivation to mathematics, model formation, providing tools for thinking using procedures, notations, drawings and rules, reality as the source and application domain, and specific practical skills in specific situations. Pendidikan Matematika Realistik Indonesia (PMRI) was a learning innovation that adapts from a similar learning approach as RME (Realistic Mathematics Education) [11, 12]. In PMRI, learning was begun by presenting a contextual/realistic problem [13]. Using of context was important because it could motivate students in learning mathematics and help students to understand the topics [14-17].

Asian Games is a sporting event of Asian countries which is held every four years [18]. Indonesia is hosting the Asian Games in 2018. Asian Games in 2018 will be consisted by 40 sports and followed by 45 countries in Asia. The kind of the sport at the Asian Games are the games that most students do or watch like karate, so it’s familiar to them and a real context for them. Also, previous researchers that used the context of sports branch at the Asian Games 2018 such as using sprint context [19], dayung context [20], shot-put context [21], swimming context [22], and hurdles context [23]. The results showed that the learning of mathematics with the context of the sports branch could help students in understanding mathematics material.

Several kinds of research already documented their research on the development of PISA-like problems [24-26]. Mardhiyanti et al. [24] developed the PISA-like problem to measure students’ mathematical communication skills. Next, Silva et al. [25] already developed PISA-like problems on uncertainty content to measure students’ mathematical problem-solving abilities. Lastly, Kamaliyah et al. [26] also developed PISA-like problems level 6 for junior high school students.

Based on the background, the researchers were interested to develop PISA-like mathematics problem using one of the sport at the Asian Games in 2018 that was karate. The objective of this research was to produce valid and practical PISA-like mathematics problem with karate context in Asian Games.

2. Method

The method in this research is design research with the type of development studies. This research consisted of two stages, which were preliminary and formative evaluation that includes self-evaluation, expert reviews and one-to-one, small group, and field test [27, 28]. The subject of this research was tenth-grade students of Senior High School. Data collection techniques used were walk through, document, observation, and interview.

In the preliminary stage, the researchers analyzed of research subject, curriculum, 2015 PISA framework, and make the instrument of the problem which included problem grid, problem card, and the scoring rubric. In self-evaluation phase, the researchers evaluated and reviewed the initial prototype and to form prototype 1.

In expert reviews phase prototype 1 was validated by the experts in a way observed, assessed and evaluated. Expert validation used analysis regarding content, construct, and language. In expert reviews, researchers also did the panel discussion (item panelling) of the problem. Item panelling or panel discussion was one of some essential steps in the development of high-quality test items [29]. It was a means of subjecting draft test material to the scrutiny of experts who could provide a rigorous evaluation of the quality of the material, and where appropriate could propose ways in which the material may be improved. It was an essential quality assurance process before any use of the material with students or other test candidates.

Along with the expert reviews, researchers did the test to students in individual (one-to-one). In one-to-one phase, the test was done to 3 students with high, medium and low ability. The one-to-one
phase was used to view the readability of the problem. From the expert reviews and one-to-one phase would produce a valid prototype 2.

The next phase was small group. In the small group phase, prototype 2 was tested to 6 students with high, medium, and low ability. In this phase, the problem was used in the learning process. This small group phase was used to see the practicality of the problem. From the small group phase would produce a valid and practical prototype 3.

3. Result and discussion
This research was conducted in Senior High School which involving three students in one-to-one phase and six students in small group phase consisting students who have high ability, medium ability, and low ability. This research had done through 3 phases of 4 phases of design research development studies type, namely: expert reviews, one-to-one, and small group.

3.1. Preliminary
In the preliminary stage, the researchers analyzed research subjects, curriculum, 2015 PISA framework, and design an instrument that included the grid of problem, problem card, and scoring rubric. The researchers developed PISA-like mathematics problem from the original PISA mathematics problem.

On the problem the researchers developed PISA-like mathematics problem from PISA mathematics problem in 2006 that was "Spring Fair". Content of the problem was uncertainty and data. This Spring Fair problem asked how the possibility of Sue will win the prize. Solve the problem with the concept of probability with regard condition that the spinner stops on an even number. PISA-like that was developed was “Karate Kick Training”. The problem asked player most probability to win the match in the other match. Resolve the problem by using the concept of probability by calculating the score obtained and compared with the maximum score. The context of the problem used was occupational, the content used was uncertainty and data, then prediction level was level 4. From the preliminary stage was obtained initial prototype.

3.2. Formative Evaluation
In self-evaluation phase, the researchers evaluated and reviewed the initial prototype based on the three characteristics that became the focus of the prototype regarding content, constructs, and language. Three characteristics were validated by researchers, supervisors, and peers. The results obtained at this phase was prototype 1 which would be tested at expert reviews and one-to-one phase.

The experts reviewed the PISA-like mathematics problem regarding content, construct, and language. In the expert reviews phase, panel discussion was also conducted by researchers with 9 masters of mathematics education of Sriwijaya University and 3 students of mathematics education of Sriwijaya University who also did a research on PISA-like mathematics problems, and also 3 lecturers of mathematics education of Sriwijaya University.

Along with the expert reviews phase, the problems were tested in one-to-one phase. In this phase, the PISA-like problem was tested to 3 students of tenth-grade class with different abilities. The three students were AR, AL, and FA. They were asked to work on the problem and then each student asked for opinions, comments and suggestions on the problem. This aimed to observe the responses and constraints of students when working on the problems and focus on the readability and clarity of the problems. The followings were the comments/suggestions from Experts and Students as well as the revision decision on problem in Table 1.
Table 1. Comments/suggestions from experts and students

| Validation | Comments/Suggestions | Revision |
|------------|----------------------|----------|
| RT         | 1. Not a probability, but a relative frequency for the key answer  
2. Added a formula to calculate the relative frequency of the number of kicks which had been done and associated it with a score on the answer key | 1. Adding words to the question became: "From the data above which players are most likely to win match at the upcoming 2018 Asian Games?"  
2. Adding words in the problem "every karate player is given different kicking opportunities"  
3. The answer key used the concept of relative frequency  
4. Exclamation mark (!) In the sentence "give your explanation!" on the problem was replaced with full stop (.) |
| KS         | 1. Not a probability, but a proportion for the answer key  
2. For the answer in terms of the number of kicks, there was a possibility that also Chamil may be better. | |
| HJ         | 1. Ask the criteria for winning the game  
2. The answer key was not to use probability, but relative frequency | 3. The answer key used the concept of relative frequency |
| Panel Discussion | 1. Add “match at the upcoming Asian Games 2018” to the problem  
2. After the words “give your explanation” use full stop (.) , not an exclamation mark (!) | 4. Exclamation mark (!) In the sentence “give your explanation!” on the problem was replaced with full stop (.) |
| Students   | 1. Students could read the table of karate kick training result clearly  
2. Students assumed the words "win the game" was an ongoing trainings | |

After the problem was revised then the problem became prototype 2 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 [30]. The following was prototype 2 in Figure 1.

![Karate Kick Training](http://asset.indosport.com)

5 Indonesian karate players are doing joint kick training to prepare for the upcoming 2018 Asian Games. They practice against coach one by one. They practice kicks against coach one by one with every karate player is given a chance kick different. The system of karate matches that kicks on the head gets score of 3, while the kick on the body get score of 2. In the karate training, the data obtained as follows:

| Number | Players Name   | Number of Kicks | Head kick | Body kick |
|--------|----------------|-----------------|-----------|-----------|
| 1      | Iwan Bidu Sirait | 13              | 3         | 3         |
| 2      | Muh. Riski      | 11              | 3         | 2         |
| 3      | Chamil Nazbudin Irfandi | 15  | 4         | 4         |
| 4      | Diki Hermawan  | 14              | 4         | 3         |
| 5      | Rakha Agung Suryandaru | 12  | 2         | 4         |

**Question:** From which data are the most likely player to win the match at upcoming 2018 Asian Games? Give your reasoning.

**Figure 1. Prototype 2**

In small group phase, the researchers tested PISA-like mathematics problem that had been developed to 6 students of tenth-grade class with different abilities in the learning process. The six
students were AN, TM, AM, MF, MHD, MRF. The following was an example of student answers in small group phase in Figure 2.

In Figure 2, it could be seen that the student could understand the problem well, the student could write down the steps to solve the problem which was calculating the relative frequency of each karate player with calculating the total score and compared with the maximum score, and the student could give an argument of their answer correctly, which was determining Iwan Bidu Sirait as a player who most likely to win the match at upcoming 2018 Asian Games. It was based on the relative frequency value, which was the highest among the other karate players that was 0.46.

Based on the results of student work from small group phase, it could be concluded that the problem was easy to understand, explanation or clue on the problem was clear, students were able to answer the problem correctly. Also, in the learning process, the students were actively engaged in discussion with karate context that familiar with them, and also it could help students to solve the problem and give the argument.

4. Conclusion
The research had produced valid and practical PISA-like mathematics problem with karate context in Asian Games. Validity was shown from the validator assessment results at the expert reviews phase regarding of content, construct, and language problem and also from students’ suggestions/comments of one-to-one phase to the clarity/readability of the problem. For practicality in the small group phase, that students had been able to understand the problem well. Also, karate context that was used could make students actively engaged in the discussion and it could help students to solve the problem and give the argument.

Acknowledgements
The researchers would like to express gratitude to the Directorate General of Higher Education Indonesia who has funded Postgraduate Grant research in 2017-2018, and to Ms. Eriga 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.

References
[1] OECD 2016 PISA 2015 Assessment and Analytical Framework: Science, Reading, Mathematics, and Financial Literacy (Paris: OECD)
[2] Kemendikbud 2014 Per mendikbud No. 59 Tahun 2014 Tentang Kurikulum 2013 Sekolah Menengah Atas/Madrasah Aliyah (Jakarta: Kemendikbud)
[3] OECD 2014 PISA 2012 Results in Focus: What 15-year-old know and what they can do with what they know (Paris: OECD)
[4] Putri R I I and Zulkardi Z 2018 Higher-order thinking skill problem on data representation in primary school: A case study J. of Physics: Conf. Series 948 012056
[5] OECD 2016 PISA 2015 Result (Volume 1): Excellence and Equity in Education (Paris: OECD)
[6] Stacey K 2010 Mathematical and scientific literacy around the world J. of Science and Mathematics 33 1
[7] Wu M 2012 Using PISA and TIMSS mathematics assessments to identify relative strengths of students in Western and Asian J. of Research in Education Sciences 1 67
[8] Novita R, Zulkardi and Hartono Y 2012 Exploring primary student’s problem-solving ability by doing tasks like PISA’s question J. on Mathematic Education 3 133
[9] Zulkardi 2010 PISA, KTSP and UN Proc. KNM XV (Manado: UNIMA) p 53
[10] Zulkardi and Putri R I I 2006 Mendesain Sendiri Soal Kontekstual Matematika Proc. KNM13 (Semarang: UNNES) p 1
[11] Putri R I I 2011 Pembelajaran materi bangun datar melalui cerita menggunakan pendekatan Pendidikan Matematika Realistik Indonesia (PMRI) di sekolah dasar J. Pendidikan dan Pembelajaran 18 234
[12] Risma D A, Putri R I I, and Hartono Y 2013 On developing students’ spatial visualisation ability J. International Education Studies 6 1
[13] Merpaung Y and Julie H 2011 PMRI dan PISA: Suatu Usaha Peningkatan Mutu Pendidikan Matematika di Indonesia Available from https://www.usd.ac.id/fakultas/pendidikan/pen_matematika/f1l3/PMRI%20dan%20PISA.pdf (Accessed 25th September 2017)
[14] Widjaja W 2013 The used of contextual problems support mathematical learning J. On Mathematics Education 4 151
[15] Fauziah A, Putri R I I, Zulkardi, and Somakim 2017 Primary school student teachers’ perception to Pendidikan Matematika Realistik Indonesia (PMRI) instruction J. of Physics: Conf. Series 943 012044
[16] Arifin S, Zulkardi, Putri R I I, Hartono Y, and Susanti E 2017 Developing Ill-defined problem solving for the context of “South Sumatera” J. of Physics: Conf. Series 943 012038
[17] Rejeki S and Putri R I I 2018 Models to support students’ understanding of measuring area of circles J. of Physics: Conf. Series 948 012058
[18] Wulandari D and Atmojo D 2014 Fresh Update Top No. 1 Soal-Soal CPNS (Jakarta - PT. Wahyumedia)
[19] Roni A, Zulkardi and Putri R I I 2017 Sprint Context of Asian Games in the Division of Fractions Proc. 5th South East Asia Development Research (SEA-DR) International Conference 2017, (Banjarmasin: ULM) p 22
[20] Nasution M F, Putri R I I and Zulkardi 2017 Dayung Context in Fraction Proc. 5th South East Asia Development Research (SEA-DR) International Conference 2017 (Banjarmasin: ULM) p 1
[21] Putri, R I I and Zulkardi 2017 Fraction in shot-put: a learning trajectory AIP Conference Proceedings 1868 050005
[22] Putri R I I , Gunawan M S, and Zulkardi 2017 Addition of fraction in swimming context J. of Physics: Conf. Series 943 012035
[23] Rahayu C, Putri R I I and Zulkardi 2017 Multiplication of Fraction With Natural Number by Using Hurdles Proc. 5th South East Asia Development Research (SEA-DR) International Conference 2017 (Banjarmasin: ULM) p 43
[24] Mardhiyanti D, Putri R I I and Kesumawati N 2013 Pengembangan soal matematika model PISA untuk mengukur kemampuan komunikasi matematis siswa sekolah dasar J. Pendidikan Matematika 5 16
[25] Silva E Y, Zulkardi and Darmawijoyo 2013 Pengembangan soal matematika model PISA pada konten uncertainty untuk mengukur kemampuan pemecahan masalah matematika siswa sekolah menengah pertama J. Pendidikan Matematika 5 48
[26] Kamaliyah, Zulkardi and Darmawijoyo 2013 Developing the sixth level of PISA-like Mathematics problems for secondary school students J. on Mathematic Education 4 9
[27] Tessmer M 1993 Planning and Conducting Formative Evaluations (London: Kogan Page)
[28] Zulkardi 2006 Formative Evaluation : What, why, when, and how Available from http://www.oocities.org/zulkardi/books.html (Accessed 15th September 2017)
[29] Turner R 2000 Item panelling , or cognitive walk-through Available from https://works.bepress.com/ross_turner/21/ (Accessed 11th October 2017)
[30] Zulkardi 2002 Developing A Learning Environment on Realistic Mathematics Education for Indonesian Student Teachers Published Dissertation (Enschede: University Of Twente)
[31] Riyanto B, Zulkardi, and Putri R I I 2017 Mathematical modeling in realistic mathematics education J. of Physics: Conf. Series 943 012049