Mathematical problems of PISA-like with the 200m swimming contexts in Asian Games

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

E-mail: ratu.ilma@yahoo.com

Abstract. This study aimed to develop valid and practical mathematical problems of PISA-like with 200m swimming contexts at the Asian Games. The subjects were tenth-grade students of senior high school, the research methodology used was designed research with the type of development study divided into 2 stages, namely preliminary and formative evaluation. The preliminary stage included the student analysis, curriculum analysis, and analysis of PISA problems. Formative evaluation stage included one-to-one that all together with the expert reviews than the small group. Data collection techniques used were documentation, walk through, interview, and observation. This study aimed to produce a valid and practical mathematical problem of PISA-like with 200m swimming contexts at the Asian Games. Valid based on the results of the validator assessment at the expert reviews phase and panel discussion which states that the matter had been well viewed in terms of content, constructs and language and workmanship of students at the one-to-one phase. Practical could be seen from small group phase that students could use the problem device well.

1. Introduction
The curriculum currently applied in Indonesia is the curriculum of 2013. Implementation of the 2013 curriculum [1] requires that competency-based assessments include assessment of attitudes, knowledge, skills that are integrated with the learning process and make the portfolio the main instrument. One that can support the 2013 curriculum is given PISA questions to students.

Programme for International Student Assessment (PISA) is an international study to measure the skills and abilities of students aged 15 years and are held every three years [2]. Indonesia for the first time had become one of the participating countries that participated in PISA since 2003. On PISA 2012 Indonesia ranked 64th out of 65 countries that follow PISA [3, 4], while at PISA 2015 Indonesia was ranked 62nd out of 70 countries [5].

The problem of PISA 2015 was developed based on four content, including change and relationship, Space and shape, Quantity, and Uncertainty and data [2]. One of the PISA content was related to the subject matter of statistics and opportunities of Uncertainty and data. Uncertainty was, therefore, a phenomenon at the heart of the mathematical analysis of many problem situations, and the theory of probability and statistic as well as techniques of data Representation and description had been established to deal with it [2].

The results of the PISA study in 2012 on uncertainty and data content, students were only able to be level 2 to 6 PISA levels [6]. The low PISA result of Indonesian students was caused by the lack of problem-solving abilities of the non-routine or high level, the evaluation system in Indonesia was still
using low-level problem, and students were accustomed to acquiring and using formal mathematics knowledge in the classroom [7-9]. Also, the low PISA results were due to students in Indonesia having difficulty in solving PISA-based math problems that were context-based and turn them into math problems [10].

The success of Indonesian students in solving the problems of PISA was determined by the evaluation system and the ability of teachers in developing students' mathematical literacy [11, 12]. One approach that suits the 2013 curriculum is the Indonesia Realistic Mathematics Education Approach, where math should be close to the student and relevant to the daily life situation of the students [13]. The Indonesia Realistic Mathematics Education was a learning innovation that adapt from a similar learning approach as RME (Realistic Mathematics Education) [14, 15]. In the Indonesia Realistic Mathematics Education, learning began by presenting a contextual/realistic problem [16]. Using of context was important because it could motivate students in learning mathematics and help students to understand the topics [17-19]. Context was a situation or phenomenon/natural occurrence associated with the concept of mathematics being studied [20]. The PISA problem was designed to assess, define areas of interest, and use three main characteristics: content, context, and mathematical processes. Indonesia Realistic Mathematics Education and PISA had similarities that both use contextual problems. One context that can be used is the sport at the Asian Games. It is by the proposed by Putri et al. [21] who states that the sport at the 2018 Asian Games can be an activity in mathematics. One of the sports that competed in the Asian Games is swimming. Swimming is very well known even by most students so it can be a real context for them in learning mathematics. This is in accordance with the statement Putri [22] who says that learning mathematics through sports could make students like mathematics, this was because students will quickly adapted because it related to everyday life. Some research that use the context of the Asian Games 2018 sports in designing mathematics learning, such as learning fractions through swimming context for elementary school students [23]. dayung context in fraction [24], fraction in shot-put: a learning trajectory [25], multiplication of fraction with natural number by using hurdles [26], and sprint context of Asian Games in the division of fractions [27].

From the description above, the formulation of the problem in this study is how the mathematics of PISA-Like uncertainty and data content with the context of a valid and practical 200m swimming. This study aimed to produce a valid and practical mathematical problem of PISA-like with 200m swimming contexts in the Asian Games.

2. Method

The method used in this research is design research method with the type of development studies. This study aimed to generate the mathematics problems of PISA-like as a valid and practical of tenth-grade enrichment program. Validity was shown from the results of the validator assessment at the expert reviews phase and panel discussion which states that the matter had been well viewed in terms of content, constructs and language and also from student comments on the one-to-one phase. The practicality could be seen from small group phase that students could use the problem device well [28, 29].

This research consists of two stages namely preliminary stage which included student analysis, curriculum analysis, and analysis of PISA problems and formative evaluation stage which included self-evaluation, expert reviews, and one-to-one, small group and field test [30, 31]. In this study, researchers only discuss the prototyping stage (formative evaluation) which included self-evaluation, expert reviews and one-to-one and small group.

The subject of this research was the tenth-grade students of Senior High School. Data collection techniques used in the study were documentation, walk through, interview, and observation. The document used was the Curriculum 2013 for high school, PISA framework and the problems of PISA. The walk through was done with experts at the expert reviews phase. Experts provided feedback, comments or suggestions regarding content, constructs, and languages. From the walk through, results were used to revise the prototype 1 to be combined with the one-to-one test to get the prototype 2. Interviews were conducted with students when students worked on the mathematics of PISA-Like at
one-to-one and small group phases. Interview results at the one-to-one and small group phases were used as materials to revise the prototype. Observations were made to students when students worked on the problems of mathematics PISA like at one-to-one and small group phases. In this research, the observation was done to find out students' difficulties in doing the mathematics of PISA like at the one-to-one phase and to know the practicality of the problem when small group phase.

3. Result and discussion

3.1. Preliminary Stage
In the preliminary stage, the researcher conducted student analysis, curriculum analysis, and analysis of PISA questions. Analysis of students was done to know the students who had high ability, moderate, and low and to know student which age 15 years. Curriculum analysis was conducted to determine the Standard Kompetensi (SK) and Kompetensi Dasar (KD) of statistical materials and opportunities in the curriculum of 2013. Analysis of PISA questions was done to develop the mathematics of PISA like on uncertainty and data content based on the PISA 2015 framework.

3.2. Formative Evaluation Stage
The formative evaluation stage in this research includes self-evaluation, expert reviews, and one-to-one. At the self-evaluation phase, the researchers conducted an evaluation and reviewed their design results about the type of PISA that had been made. The result was called prototype 1. Next, at the Expert reviews phase, the validation of prototype one was checked by an expert regarding content, constructs, and language. The validation process was done by sending the PISA type problem via email to the validator. The validators validating prototype 1 were KS (from Australia), and SA (from Indonesia). In addition to the expert reviews phase, the researchers also conducted a panel discussion at Sriwijaya University and attended by nine peers (Magister Mathematics Education) and three lecturers. Comments and suggestions from expert reviews and discussion panel were used to revise prototype 1.

At one-to-one, prototype one was tested to 3 students who have low, medium, and high ability. The three students were EM, EN, and NA. The result of student's observation and the interview was used to revise prototype 1. The analysis results obtained from expert reviews, one-to-one and panel discussion could be seen on Table 1.

| Validation          | Comment                                                                 | Revision                                         |
|---------------------|-------------------------------------------------------------------------|--------------------------------------------------|
| Panel discussion    | 1. Fix the way of writing.                                               | 1. Fixed the recommended way of writing          |
|                     | 2. Change the question to make it more meaningful by comparing the fastest time record in Asian games 2014. | 2. Change the question to have meaning           |
| Expert Reviews      | 1. Compare with the average time data on Asian games 2014                | 3. Added the fastest time record in Asian Games 2014 |
|                     | 2. Fix the way of writing to make it easier for students to understand   |                                                  |
|                     | 3. One of the athletes who were attended or all athletes followed the training |                                                  |
| One-to-one          | 1. The problem was difficult and must repeatedly read it to understand the meaning of the problem |                                                  |
|                     | 2. Need accuracy and reasoning in answering questions                     |                                                  |
3. Based on the answer, student 1 could answer the problem according to the instructions about; student 2 had answered the question but was wrong in the settlement; student 3 had answered the question but not finished.

Based on the comments/suggestions of expert reviews, panel discussion, and one-to-one conducted in parallel, then the problem on prototype one was improved and revised again. The revised question was called prototype 2 can be seen in Figure 1.

![Figure 1. Prototype 2](image)

In the small group phase, prototype two was tested to 6 students who have different ability. Two students low ability, two students medium ability, and two students high ability. The six students were RG, ES, CA, FA, ML, and LA. The small group phase was done to see the practicality of the developed problem. The practical meaning of the problem that was easy to use could be administrated and could be interpreted well by students.

In the small group phase, the results achieved by the students do not very much with the results achieved by students at the phase of one-to-one. This could be seen from the results and the systematic answers of students about looking for average travel time of 200m individual men’s swimming. The Figure 2 shows the result of answers from some students.

![Figure 2. Student’s answer](image)

From the student's answer in Figure 2, it appeared that the student had understood the purpose of the problem. In order to surpass the fastest time of athletes in Asian games 2014, students made an
equation for the average time of 12 sessions of 114 seconds. So after the calculated as a whole, the average time was obtained is 114.8 seconds. Based on the results and discussion of students at the small group phase, the problems developed could be understood, explanations and clues on the problem were clear and students could answer the problem correctly.

4. Conclusion
This research had produced a PISA-like math problem with a valid and practical 200m swimming context in Asian Games. Validity was shown from the results of the validator assessment at the expert reviews phase and panel discussion which stated that the matter had been well viewed in terms of content, constructs and language and workmanship of students in the one-to-one phase. Practicality could be seen from small group phase that students could use the problem device well.

Acknowledgements
The authors would like to express his gratitude to the Directorate General of Higher Education Indonesia who has funded a post grant research in 2017-2018. Then the authors would like to express his gratitude to ‘the teacher (Siti Fatimah) and the tenth-grade students of Senior High School number 3 Prabumulih who have helped a lot in this research.

References
[1] Kemendikbud. 2014 Permendikbud No. 59 Tahun 2014 tentang Kurikulum 2013 Sekolah Menengah Atas/Madrasah Aliyah (Jakarta: Kemendikbud)
[2] OECD 2016 PISA 2015 Assessment and Analytical Framework: Science, Reading, Mathematics, and Financial Literacy (Paris: OECD)
[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] Zuhra R 2015 Analisis Strategi Siswa dalam Menyelesaikan Soal PISA (Programme For International Student Assesment) Konten Uncertainty and Data Pada Siswa Kelas VIII Mtsn Model Banda Aceh Unpublished Thesis (Banda Aceh: Universitas Syiah Kuala)
[7] Stacey K 2010 Mathematical and scientific literacy around the world J. of Science and Mathematics 33 1
[8] 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
[9] 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
[10] Wijaya A, Heuvel-Panhuizen M v d, Doorman M and Robitzsch A 2014 Difficulties in solving context-based (PISA) J. The Mathematics Enthusiast 11 155
[11] Johar R 2012 Domain soal PISA untuk literasi matematika J. Peluang 1 30
[12] Hendroanto A, et al 2018 Mathematics education students solving PISA’s mathematics problems: An overview of students’ mathematical literacy International Journal on Emerging Mathematics Education 2 129
[13] Putri R I I 2014 Evaluasi program pelatihan Pendidikan Matematika Realistik Indonesia (PMRI) Bagi Guru Matematika Sumatera Selatan Proc. Seminar Nasional Evaluasi Pendidikan p 522
[14] 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
[15] Risma D A, Putri R I I, and Hartono Y 2013 On developing students’ spatial visualisation ability J. International Education Studies 6 1
[16] Revina S and Leung F K S 2018 Educational borrowing and mathematics curriculum: Realistic mathematics education in Dutch and Indonesian primary curriculum *International Journal on Emerging Mathematics Education* **2** 1

[17] 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

[18] 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

[19] 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

[20] Zulkardi and Putri R I I 2006 *Mendesain Sendiri Soal Kontekstual Matematika Proc. KNM13* (Semarang: UNNES) pp 1

[21] Putri R I I, Zulkardi and Widodo (2015) *Ciptakan Pembelajaran Matematika dengan Asian Games* Available from http://sumselpostonline.com/ciptakan-pembelajaran-matematika dengan-asean-games/ (Accessed 18th September 2017)

[22] Putri R I I 2015 *Penilaian dalam pendidikan matematika di Indonesia: Lokal, Nasional, dan Internasional. Paper presented at the special meeting open of senat Sriwijaya University*, Available from http://fkip.unsri.ac.id/index.php/posting/90 (Accessed 20th April 2015)

[23] Putri R I I, Gunawan M S, and Zulkardi 2017 Addition of fraction in swimming context *J. of Physics: Conf. Series* **943** 012035

[24] 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

[25] Putri, R I I and Zulkardi 2017 Fraction in slot-put: A learning trajectory *AIP Conference Proceedings* **1868** 050005

[26] 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

[27] 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

[28] Zulkardi 2002 *Developing A Learning Environment on Realistic Mathematics Education for Indonesian Student Teachers* Published Dissertation (Enschede: University of Twente)

[29] Riyanto B, Zulkardi, and Putri R I I 2017 Mathematical modeling in realistic mathematics education *J. of Physics: Conf. Series* **943** 012049

[30] Tessmer M 1993 *Planning and Conducting Formative Evaluations* (London: Kogan Page)

[31] Zulkardi 2006 *Formative Evaluation : What, why, when, and how* Available from http://www.oocities.org/zulkardi/books.html (Accessed 14th September 2017)