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PISA-LIKE MATHEMATICS PROBLEMS: USING TAEKWONDO CONTEXT OF ASIAN GAMES

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Abstract

This research aims to produce a valid, practical, and having potential effects PISA-like mathematics problems using taekwondo context in Asian Games. The subjects were MIA 3 student of SMA 10 Palembang. This study was design research of development study in which had two stages: the preliminary and formative evaluation. The formative evaluation includes self-evaluation, one-to-one and expert review, small group, and field test. The context is used to have the students estimate maximum numbers of exercising athletes in a hall with a specific size. The result of the analysis shows that the problems which were reviewed by three expert reviews are valid qualitatively based on the PISA framework; it is also practical and easy to understand the problem. Based on the analysis of students' answer, the developed problems display potential effects on student's diverse basic mathematical abilities on the various process of answering the problems. The basic mathematics abilities emerging among which are reasoning and argument ability. It appears that students can develop and solve the problem by modeling using their assumptions. Also, the other ability is designing strategies to solve problems in which students use various procedures in solving problems leading the conclusion.

Keywords: Asian Games, Design Research, PISA, Taekwondo

Abstrak

Tujuan dari penelitian ini adalah menghasilkan soal matematika tipe PISA menggunakan konteks olahraga taekwondo pada Asian Games yang valid, praktis serta mengetahui efek potensial. Subjek penelitian ini adalah siswa kelas MIA 3 SMA 10 Palembang. Penelitian ini merupakan *design research* tipe *development study* yang terdiri dari dua tahap: *preliminary* dan *formative evaluation*. *Formative evaluation* meliputi: *self-evaluation*, *one-to-one* dan *expert review*, *small group*, dan *field test*. Penggunaan konteks ini untuk meminta siswa mengestimasi jumlah maksimal atlet yang dapat latihan dalam aula dengan ukuran yang ditentukan. Hasil penelitian ini menghasilkan soal yang telah dinyatakan valid, sesuai berdasarkan *framework* PISA yang divalidasi 3 *expert review* secara kualitatif; praktis juga dan mudah dalam memahami soal. Berdasarkan analisis hasil jawaban siswa, soal yang dikembangkan ini memiliki efek potensial terhadap kemampuan dasar matematis siswa yang beragam pada proses penyelesainnya. Kemampuan dasar matematis yang muncul pada permasalahan ini diantaranya kemampuan penalaran dan argumen. Terlihat siswa dapat mengembangkan dan menyelesaikan masalah dengan *modelling* menggunakan asumsi sendiri. Selain itu, kemampuan lainnya adalah merancang strategi untuk memecahkan masalah, terlihat siswa menggunakan berbagai prosedur dalam memecahkan masalah dengan menggiring pada satu penarikan kesimpulan.

Kata Kunci: Asian Games, *Design Research*, PISA, Taekwondo

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PISA (Programme for International Student Assesment) is an international study organized by OECD (Organization for Economic Cooperation and Development) which assessment students' literacy skills (Edo, *et al*. 2013). PISA held every three years to see academic ability both in literacy reading, mathematics literacy, science literacy, and financial literacy (OECD, 2016). Based on Indonesia's participation in PISA 2015, as shown that the average for Indonesia students was 386 and ranked 63 out of the 70 participating countries (OECD, 2016). The involvement of Indonesia in PISA is an effort to see the position of literacy ability of students in Indonesia compared to the student in other countries and the problem affecting it (Khairuddin, 2017).

The low result of Indonesian students was caused by students' failure to work on the PISA problem which lay on their difficulty in formulating everyday problems into formal mathematical forms, understanding mathematical structures and evaluating mathematical results to real-world contexts (Edo, *et al.* 2013; Jupri & Drijvers, 2016). Moreover, when they have found the mathematical solution of the problem, then it was not followed by interpreting the solution back to the given context/situation of the problem (Jupri, *et al*. 2014; Lutfianto, *et al*. 2013; Hendroanto, *et al*. 2018). Putri (2012) states in using a context, students would not learn directly using the formula, such as culture (Risdiyanti & Prahmana, 2018; Maryati & Prahmana, 2019), games (Prahmana, *et al*. 2012; Kaune, *et al*. 2013), or several sports in Asian Games (Nasution, *et al*. 2018; Gunawan, *et al*. 2017; Rahayu, *et al*. 2017; Roni, *et al*. 2017). Classroom activities designed by the teachers also have engaged students in group and classroom discussions. One effort to familiarize students with the PISA model problem is to provide the problem as early as possible or at an early phase of middle school (Barczi, 2008). PISA results show that students who were able to answer the problem correctly on geometry were 47.5%, on statistics were 61.96%, and on number were 53.7% (Wardani, 2011). The result is one of the reasons for the revision of the 2006 curriculum, which results in the development and implementation of the 2013 curriculum (MOEC, 2014). Putri (2013) reveals that one approach in line with the 2013 curriculum is PMRI. PMRI is one approach using context (Zulkardi & Putri, 2006; Prahmana, *et al*. 2012; Ginting, *et al*. 2018). Aminuddin (2012) on his study which developed a mathematical problem of PISA model on space and shape content aiming at finding out the ability of mathematical connection of junior high school students stated that less than 50% of students could solve math problems of PISA model level 4,5 and 6. Furthermore, Purnomo, *et al*. (2015) indicates a poor ability of students in solving PISA problem on space and shape content based on Rasch model analysis is still lacking.

Moreover, Charmila, *et al*. (2016) concludes that it is important to integrate the context in the surrounding environment. Mathematics learning will be more meaningful, interesting, and fun by using the context of sports in the process of learning (Yansen, *et al*. 2019). Various researches on the development of mathematical PISA-like problems for High School students with various focus both on content and ability have been conducted (Jannah, *et al*. 2019). In 2018, Indonesia hosted the XVIII Asian Games. It is a sporting competition conducted every four years with participating countries of members of the Olympic Council of Asia. A lot of applicable contexts related to space and shape are available in the event either from the equipment used, the situation of events, and place of sport. Several studies developed PISA-like problem in Asian Games, such as Rahayu, *et al*. (2017) states context of athletics hurdles which is an Asian Games sport is used as the starting point used as a helpful media to solve the problems associated with fractional multiplication operations with natural numbers. Roni, *et al*. (2017) states used the context of sprint sport at the Asian Games give the impression of something new and different. Meanwhile, Gunawan, *et al*. (2017) used the swimming context is chosen because it can represent fractions using measurements. The shape of the pool is one model that allows one to represent parts of the whole.

Many studies developed the design of learning mathematics using sports context in the 2018 Asian Games, using the context can help students understand mathematics (Gunawan, *et al*. 2017; Fajriyah, *et al*. 2017; Rahayu, *et a*l. 2017). Pratiwi, *et al*. (2019) states use of PISA-like mathematics problems with a long jump in Asian Games context made students more interested and active during discussions in the learning process. Different with those studies, the researcher developed PISA like problems that using taekwondo context is chosen because the context is used to have the students estimate the maximum number of exercising athletes in the hall with the specified size with their assumptions. Therefore, this research aims to produce a valid and practical PISA math problem with the taekwondo context at Asian Games 2018 and to know the potential effect of the problem on students' mathematical ability.

METHOD

This research method used in the study is design research with the type of development studies which had two stages: the preliminary and formative evaluation. It includes self-evaluation, one-to-one and expert review, small group, and field test (Tessemer, 1993; Zulkardi, 2002). By the provisions of the PISA framework, subjects in this study are 15-year-old students in MIA 3 class of SMA 10 Palembang.

Initially, researchers evaluated and reviewed the prototype draft. The researcher also designed several instruments (lesson plan, question cards, scoring rubrics, and PISA questions on Space and Shape content based on PISA questions criteria). This research was started by describing the validity of the problem. Therefore, the subjects involved in this stage were three students with various levels of ability, high, fair, and low. They were the students in the one-to-one stage who given the Prototype 1. It was what the researcher had developed previously. This prototype was also given to experts at the expert review stage. It was reviewed by PISA experts Kaye Stacey, Ross Turner and Ahmad Fauzan who focused on three characteristics: content, constructs, and languages. The revision of Prototype 1 is called Prototype 2. This prototype was given to a small group of six students who were not the research subject with low, fair, and high-ability. At this stage, the appearance and use of questions were also evaluated to see the responses, assessments, and practicality and the results as input to revise the design for the next stage. The revision result of the small-group stage was called prototype III. It was, then tested with the subject of research by analyzing the results of student answers. It aims to see the potential effects emerging on students' mathematical abilities.

The data were collected using walk-through. It was used in compliance with the PISA framework. Furthermore, documentation was used as physical data of related documents. The test was registered to see comments from students on clarity, legibility. The results of the student answer showed basic mathematical skills. Moreover, interviews served to gather information about what students think after completing the test.

RESULT AND DISCUSSION

This study has produced nine problems of PISA type using taekwondo (2 problems) and game (7 problems, 6 of small balls and 1 of large balls) contexts. From the problems, two were level 3, level 4, and level 5 for each level and one were level 1, level 2, and level 6 also for each level. In this paper, researchers discussed one problem of taekwondo. It was chosen since there were various ways of completion students could use and many resulting assumptions that students use in solving problems given.

Preliminary

At this stage, the researcher determines the place and subject of the research, analyzes and designed Prototype 1, created a test table of specification containing appropriate indicators from the curriculum, designs question cards and scoring rubrics in compliance with PISA framework. Also, the researcher contacted the subject teachers whose working place was used as research locations and prepares other needs such as scheduling and working procedures with classroom teachers.

Formative evaluation

Self-evaluation

In the self-evaluation step, the researcher reviewed the prototype design by examining the compliance of the problem design with the PISA 2015 framework in terms of content, context, language, and level prediction. It aimed at checking the error in the process of resolving the problem before the prototype is used in the next stage. The prototype was given to experts at the expert review stage and one-to-one. Furthermore, we also designed instruments such as test table of specification, question cards, scoring rubrics and PISA problems based on the PISA framework. No revision was needed at this stage for its compliance to PISA framework and it was called Prototype 1.

Researchers were motivated to develop problems from the PISA problem with a rock concert. In this case, researchers change the context into taekwondo. Researchers wanted to estimate the maximum number of taekwondo players who can practice in a hall with a given size. Researchers also want to know whether or not students who solve these problems have determined reasonable, relevant, and accountable assumptions given their assumptions. The content used in these problems were space and shape. Prediction level is at level 5. The comparison between the original PISA problem with the developed problem can be seen in Table 1.

Table 1. The comparison between the original PISA problem with the developed problem

PISA problem	Developed problem
M552: Rock Concert **Question 1: ROCK CONCERT** M552Q01 For a rock concert a rectangular field of size 100 m by 50 m was reserved for the audience. The concert was completely sold out and the field was full with all the fans standing. Which one of the following is likely to be the best estimate of the total number of people attending the concert? A 2 000 B 5 000 C 20 000 D 50 000 E 100 000 **(PISA, 2009)**	 Taekwondo training hall Taekwondo National Training Camp will hold a series of warm-up training before participating in the 2017 Asian Games in Kuala Lumpur. It will be held in a rectangular hall measuring 150 meters in length and 75 meters wide. What is the maximum number of taekwondo athletes who can exercise in the hall?

Expert review and one to one

Experts then validated it at the expert review stage and by students at the one-to-one stage. Both stages were carried out simultaneously. This stage tried to see the validity of the instrument using the context of taekwondo. The expert review is a qualitative stage of validation, which was done through emails. The experts were Kaye Stacey, Ross Turner, and Ahmad Fauzan. While experts at the review panel item were Zulkardi (Sriwijaya University Lecturer), Somakim (Sriwijaya University Lecturer) and Ika Pratiwi (Sriwijaya University graduate students).

The three experts provided the following inputs, Ross Turner states that the problem was categorized as a modeling problem, so the assessment rubric will include whether or not students can determine reasonable, relevant or accountable assumptions by each student. Kaye Stacey adds that the matter can match the actual number of athletes at the Asian Games 2018, so the estimated number of athletes does not exceed the actual capacity in the Asian Games 2018. While Ahmad Fauzan has no comments on this problem so that this matter can be forwarded. While from the panel item, it was suggested to add a goal or reason why the context was used in developing the problem to give students more motivation in solving the problem.

In the one-to-one stage, Prototype 1 was also tested to three students whose abilities were of high, fair, and poor. The focus was to get students' comments on the clarity of the purpose of the question, to propose changes or alternatives, investigate why students are confused or have difficulty or even other interesting things from some aspect of the problem. The three students were CAR, MFR, and NA. NA finds the word maximum confusing to interpret while CAR was confused because he did not know the number of movements done in the exercise.

Based on the comments and suggestions from the validator and students at the one-to-one stage, the researcher revised Prototype 1 by adjusting the length and width of the hall by the actual number of taekwondo athletes in the Asian Games 2018 so the estimate does not exceed the capacity of the actual number of an athlete. Then the problem-solving strategy was added to the scoring rubric. Based on the revision of suggestions and comments from expert review and one to one conducted in parallel was Prototype 2.

Small group

On the small group stage, it was tested to 6 students whose ability of every two students were of high, fair, and poor. They were given Prototype 2 simultaneously and were given time to work on the problem individually; then after a few minutes, they were asked to discuss with their group members to solve the problems.

The researcher's focus at this stage was to see whether or not information such as tables, figures, numbers can be seen and well understood. While they were doing it, the researcher went around to see whether or not there are any problems the students encountered in the process of solving the given problem. After they had completed the given problem, one of the group representatives was interviewed to ask how the problem was solved. On this stage, all students could solve the problem without difficulty. So no revision was needed. The result of this stage was called Prototype 3. It is shown in Figure 1.

Taekwondo training hall

Taekwondo National Training Camp will hold a series of warm-up training before participating in the 2017 Asian Games in Kuala Lumpur. It will be held in a rectangular hall measuring 16 meters in length and 5 meters wide. What is the maximum number of taekwondo athletes who can exercise in the hall?

Figure 1. Prototype 3

Field test

In the field test phase is tested on the subject of which was students of grade X MIA 3 SMA Negeri 10 Palembang, 33 students worked on prototype 3. Researchers also observed students in working on the problem to find out the difficulties they faced. One of the goals of the field test stage is to know the potential effect of the problem on the students' mathematical literacy ability, which was seen from the result of the student's answer. The discussion of the results of student answers in solving problems with their respective strategies will be presented in Figure 2.

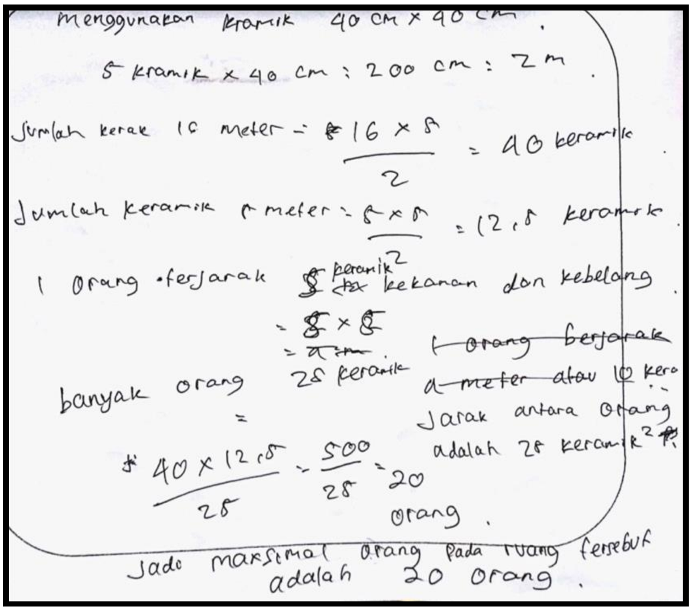
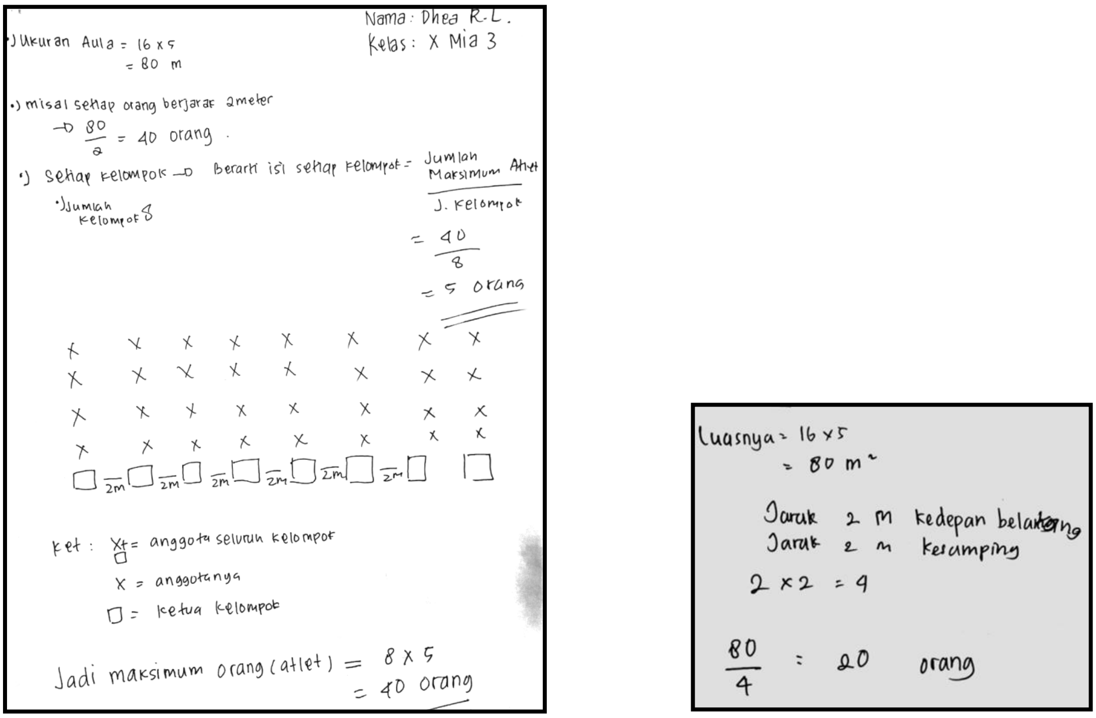


Figure 2. MDF's answer

From the analysis of students' answer, it appeared that the MDF estimates the maximum number of taekwondo athletes who can exercise in the hall using ceramic tiles measuring 40 cm x 40 cm as a benchmark of the distance between athletes. Although as it was seen in the picture that the hall's floor was made of parquet wood, he tried using ceramic tiles as a strategy to answer the problem. In this case, students were able to use representational skills. It was also visible students made explanations and reasoning supporting in qualifying a mathematical solution to a contextual problem. In this case, he was able to use reasoning and argument ability.

Initially, MDF estimates the distance required for one athlete. By applying for 5 ceramics x 40 cm = 200 cm = 2 m. Here, MDF estimates the space required for athletes to avoid touching each other. Furthermore, MDF calculates the area of the hall by adjusting to the width and length of the hall using ceramics tiles. After that, MDF concluded that one athlete requires 25 tiles, five tiles' extending sideways, and five backward. So, MDF concluded that the maximum number of athletes who could exercise in the hall was 20 people. Nasution (2017) stated each activity in the learning used the problems of rowing context provided in a series of activities showed that most students had to understand and know the rowing context so that it can be integrated into the learning. The students answer by using other strategies to prove their answers (see Figure 3).



(a) (b)

Figure 3. DRL's answer (a) and N's answer (b)

It appears that a student with the initials DRL answered with a strategy that simultaneously shows the sketch assumed himself. DRL assumes that everyone has space 2 meters for eight groups. So with 80 m^2 hall and 2 meters for every athlete, it could be concluded 40 athletes could exercise in the hall with each group having five athletes. While the student initials N estimates the maximum number of athletes who can practice in the hall was 20 people. She used a similar strategy taken by MDF and DRL, N also estimated that there was a distance between athletes. N estimates the required distance was 2 meters to the front and 2 meters to the side (right and left). So one person had a $4m^2$ area. He concluded that the estimated maximum number of athletes in the hall was 20 people.

Based on field test results, 17 out of 33 students can use reasoning and arguments ability. It appears that students can make the explanation and reasoning from the mathematical solution to the contextual problem completely. It could be seen when students argued that situations, they were assumed to be reasonable, such as the assumption of distance size between students. There are also 6 out of 33 students who could define the complete range of mathematical solutions. They stated the reasons for limiting the distance required from each athlete. So, in this case, students were able to use the ability of mathematization.

Also, there are 14 out of 33 who could communicate their explanations and arguments in the context of the problem completely. In this case, students were able to use communication ability. There were also 15 out of 33 who could use a representational ability. It appeared that students could interpret mathematical results in the form of representation completely. Based on students' answers, the potential basic mathematical ability emerging in this problem includes communication ability, as seen from the ability to read and to interpret questions from the images given. It also showed that students were capable of reasoning and argumentation, mathematical ability, and representational ability. It can be seen from students' ability to represent real-world situation problems into math problems. Hapizah (2014) states the ability of reasoning is the ability to direct the mind to produce a statement in reaching conclusions when solving a problem.

In general, the achievement of students in the field test stage in working on the problem in Prototype 3 had shown a potential effect. The problem has the potential to bring up various basic mathematical skills in the process of completion. Based on the results of the interview, the students stated that the test had provided a new experience for them since the questions given were interesting because they use various sports contexts and varied according to their level. As a result, they could imagine more in answering the problem and make use of assumption and logic. The context was the main point for students in developing mathematics ability, and the context itself should be meaningful for them and real for their mind (Putri, *et al*. 2015; Prahmana & Suwasti, 2014).

Furthermore, Nasution, *et al*. (2018) also states the use of the rowing sport can be a bridge of students' thinking and help students in understanding the operation of addition and subtraction of fractions. Gunawan, *et al*. (2017) added with the support of context and learning media, students learning will be more enthusiastic. Moreover, many students revealed that solving the problem requires sufficient reasoning and problems solving ability. This argument is in line with Putri, *et al.* (2015) saying that learning mathematics through sports can make students like it because they will adapt faster since it concerns daily activities. The concept of learning will be effective and minimize the level of difficulty. As stated by Jurnaidi & Zulkardi (2013) in their research which concluded that in the results of interviews with 5 students in the field test, that it was illustrated that in general the problems of mathematical reasoning PISA model can trigger to reason in solving the problem, even though some students still have problems in understanding and resolving it. This condition means that the PISA model with sports content is capable of exploring students' mathematical ability and give positive effects. It is concluded that the problem has potential effects for the students.

CONCLUSION

This research has produced PISA mathematical problem with Taekwondo context in Asian Games 2018. In the preliminary stage, the researchers developed about 9 item using sports context in Asian Games 2018. All the item, at the expert review stage and one-to-one, had some revision. In a small group, all the problems have fulfilled the needed characteristics. As a result, in prototype 3, it was produced nine items. This prototype generated is a valid and practical PISA type using the context of taekwondo. Student achievement in the field test stage in working on the problem of prototype 3 showed that it could develop students' mathematical literacy skills and explore students' potentials. Based on the analysis of the results on 33 students, it displayed potential effects on basic mathematical abilities, including the ability of reasoning and argument. It also exhibited that students can develop and solve problems with modeling using their assumptions. In addition, the ability to design problem-solving strategies emerged in using various procedures in solving problems that led to the conclusion.

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