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AQUATIC IN ASIAN GAMES: CONTEXT OF PISA-LIKE MATHEMATICS PROBLEM

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Abstract

This study aimed to create mathematical problems of uncertainty and data contents in PISA using aquatic context that were valid, practical and had the potential effect. This study was design research of development study. The subjects in this study were 10th-grade students of Indo Global Mandiri senior high school in Palembang consisting of 20 students. Data were gathered through interviews, observation, and tests. The results of data analysis showed that there were eight valid and practical items of PISA type of uncertainty and data contents. The contents obtained using bicycles and aquatic contexts in Asian Games. The 11 out of 20 students showed reasoning skills and reasonable arguments, and 9 out of 20 students showed reasoning skills and discussions but incomplete. It was because they were not used to solving PISA type problems in learning.

Keywords: task design, PISA, aquatic context

Abstrak

Tujuan dari penelitian ini adalah menghasilkan soal matematika tipe PISA dengan konteks cabang olahraga akuatik yang valid, praktis, serta memiliki efek potensial. Penelitian ini merupakan penelitian pengembangan *design research* tipe *development study*. Subjek dalam penelitian ini adalah siswa kelas X IPA 1 SMA LTI-IGM Palembang yang berjumlah 20 siswa. Pengambilan data dilakukan dengan cara wawancara, observasi dan tes. Dari hasil analisis data penelitian ini menghasilkan 8 soal tipe PISA konten *uncertainty and* data menggunakan konteks sepedan dan akuatik yang valid dan praktis dan dapat disimpulkan bahwa 11 dari 20 siswa menunjukkan kemampuan penalaran dan argumen yang baik dan 9 dari 20 siswa menunjukkan kemampuan penalaran dan argumen tetapi kurang lengkap, hal ini dikarenakan tidak terbiasanya siswa dengan soal-soal tipe PISA dalam pembelajaran.

Kata kunci: *task design*, PISA, konteks cabang olahraga akuatik

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Statistics is part of the mathematical material consisting of ways of data collection, data processing, and drawing conclusions based on data collection and data analysis performed (Bakker, 2004; Chong, et al. 2017; Tanujaya, et al. 2018). Statistics is widely applied in various disciplines like in natural sciences, business, and industry, where almost every decision made in the field uses statistical reasons (Adams & Lawrence, 2018; Salkind & Frey, 2019). Therefore, statistics is one of the essential subject that must be to learn for students.

Many students face difficulties in solving statistical problems that result in low achievement. It happens because students have not been accustomed to solving problems with the characteristics of a real context, and only work on the issues that the teacher exemplifies without knowing the benefits in daily life (Muttaqin, et al. 2017; Saleh, et al. 2018; Cukurova, et al. 2018; Nasution, et al. 2018). It is in line with the results of PISA for uncertainty and data content where in 2003 PISA results, Indonesia was ranked 38 out of 40 countries with a score of 385 (OECD, 2004). While the results of the 2012 PISA, Indonesia was ranked 63 out of 65 countries because the score of Indonesian students, 384, was far below the average OECD score of

493 for uncertainty and data content (OECD, 2014). In addition, the Indonesian students were only able to resolve the matter of uncertainty and data up to level 5 of about 0.3% of students, far below the OECD average of 9.2% of students able to solve level 5 problems, even 3.2% students were able to complete up to level 6 (OECD, 2016). It showed that Indonesian students' mathematical literacy was still very low in resolving problems of PISA type.

The low ability of Indonesian students in PISA is because Indonesian students are not familiar with the contextual problems such as in the PISA problem, especially about the high level both in the process of learning and evaluation (Novita, et al. 2012; Ahyan, et al. 2014; Kamaliyah, et al. 2014; Stacey, et al. 2015; Oktiningrum, et al. 2016). On the other hands, there is the challenging to find contextual problems designed to hone student problem-solving skills and have PISA characteristics and frameworks on mathematics textbooks used by Indonesian students (Stacey, 2011; Wijaya, et al. 2014; Wijaya, et al. 2015). The problems should be the basis for the development of the 2013 curriculum, adjusting the learning in Indonesia with the questions tested on PISA so that the problems used must be adapted to the characteristics of PISA (Kemendikbud, 2014). Therefore, non-routine issues with PISA characteristics are required to familiarize students with the necessary procedures to solve the PISA problems.

In uncertainty and data content, researchers are more centered on its data content, where the content of this data is a statistical matter. Statistics learning in Indonesia is generally teacher-centered without the effort to develop students' math ideas through interaction or discussion (Widjaja, Julie, and Suryandari, 2010). Also, Groth (2006) also revealed that the learning was carried out by giving the formula directly without first learning about meaningful basic concepts and procedures for students. Shi, He, and Tao (2009) added one of the causes of students less interested in statistics is because statistics are taught theoretically and less connected to the real world. Thus, the students do not know the application on each of these materials. It has an impact on the decrease in students' motivation and achievement in learning statistics. Therefore, non-routine questions with PISA characteristics are required to make students accustomed to solving problems of PISA type.

Statistics is vital in the field of sports and have a close relationship (Escalante, et al. 2013; Bernards, et al. 2017). Several researcher already develop the PISA-task problem based on the sports context in the 2018 Asian Games (Gunawan, et al. 2018; Rawani, et al. 2019; Efriani, et al. 2019; Yansen, et al. 2019; Pratiwi, et al. 2019; Jannah, et al. 2019). Therefore, this research produce a problems of uncertainty and data contents in PISA using aquatic context that were valid, practical and had the potential effect of reasoning skills for students.

METHOD

This study was design research of development study (Akker, 1999; Bakker, 2004) aiming to produce valid and practical PISA mathematics problems for class X and to examine the potential effects of the issues developed on mathematical literacy skills of high school students. This study was conducted in two stages namely preliminary evaluation and formative evaluation (Tessmer, 1999; Zulkardi, 2006).

The preliminary evaluation stage consists of preparation where at this stage, it becomes the first step of the researchers in developing the problem of PISA type. At this stage, the researchers analyzed the

characteristics of the PISA problem and the essential competencies of the questions to be developed based on the PISA framework. Then, the designing was at this stage; researchers designed the problem device, including the question grids and the question card according to the characteristics of PISA problems.

The formative evaluation stage consists of self-evaluation where in this stage the assessment of the designing problem of PISA type was done by the researchers themselves then it was revised and prototype 1 problem obtained. Then proceed to the expert review stage where at this stage, prototype one made by researchers was consulted to experts to validate and evaluate based on the validation criteria of content, constructs, and language. Simultaneously the researcher performed one to one stage. At this stage, they asked three students who were not the subjects of study as testers and were asked to work on, observe, comment, and respond freely to the question of prototype 1. After the one to one stage, the researchers entered the small group stage where at this stage they tested prototype 2, the revision of prototype 1, to a group of students who were not the subject of study, so that prototype three was obtained.

Then the researcher enters the final stage of the field test where at this last stage the researcher tries the prototype three questions to the field where the situation is realistic where the test is carried out on the research subject. The subject in this study were 10th-grade students of Indo Global Mandiri senior high school Palembang consisting of 20 students aged 15 years old. The data were gathered through the walkthrough, observation, and interview and analyzed qualitatively.

RESULT AND DISCUSSION

Analysis Stage

One activity conducted at the stage of student analysis was to visit the place of research implementation at SMA LTI Indo Global Mandiri (IGM) Palembang. Furthermore, researchers discussed the subject of study with Siti Marfuah, S.Pd., as the classroom teacher. The purpose of this discussion was to explain the research procedure, to determine the subject of research on stage one to one, small group, and field test with 20 students of 10th-grade science 1 LTI-IGM senior high school Palembang.

The subject matter was identified based on the curriculum used in the school where the study was conducted. The curriculum used in LTI-IGM senior high school Palembang is the 2013 curriculum. In this curriculum, the standard content of mathematics learning includes numbers, algebra, geometry, and data management. After analyzing the students and the curriculum, the researcher analyzed the PISA problem based on the PISA framework, then they also studied various things about the Asian Games that could be used as contexts in developing the math problem of PISA type, and three contexts were obtained namely bicycle, swimming, and synchronized swimming.

Design Stage

At this stage, researchers began designing and compiling the PISA math problems using the cycling road and aquatic context. These questions were designed for 10th-grade senior high school students. The result is obtained from developing in the form of instrument consisting of question grids of PISA type mathematics using bicycle and aquatic context, PISA type cards using bicycle and aquatic context for senior

high school level, rubric assessment of PISA mathematics problems using the bike and aquatic context for senior high school level, and lesson plan. The five items were generated in this designing stage, namely bicycle (2 items), swimming (1 item), and synchronized swimming (2 items).

Evaluation Stage

a. Self-Evaluation

At this stage, the PISA mathematical problems using a bicycle and aquatic context had been designed and then reexamined by the researchers. It aimed to find and correct errors or deficiencies in the design process. Supervisors also assisted in the examination of questions that researchers had designed during the consultation before conducting the research.

b. Expert Reviews

The validity of a PISA mathematical problem using a bicycle and aquatic context was carried out in terms of content, constructs, and language. Before giving to the expert, these questions were discussed previously with the supervisors. The experts who reviewed the problems were Hongki Julie, lecturer of mathematics education at Sanata Darma University, Yogyakarta, Zulkardi, professor of mathematics education at Sriwijaya University, Palembang, Somakim, lecturer of mathematics education at Sriwijaya University, Palembang, Rani, assistant professor of mathematics education at Sriwijaya University, Palembang, and Siti, high school math teacher in LTI-IGM Senior High School Palembang. The validation process by Hongki Julie was carried out via email. While the process of validation by Zulkardi, Somakim, and Ranni was executed through the item panel then validation with the model teacher was done face to face in the library LTI-IGM Senior High School Palembang. Table 1 explores a recapitulation of expert suggestions and comments.

Table 1. Recapitulation of Expert Suggestions and Comments

Unit Item	Suggestions and Comments
1	**Honki** Item 1: Clarify again the words “grafik”. Item 2: Is the answer only on the track only?
	Ranni Item 1: the picture needs to be clarified because the description in the image does not exist so it make the students difficult to draw the possibility of the graph. Item 2: The meaning of the question is still unclear. Can be slightly changed to “Based on the picture above, when will the players go at high speed? Give me your reasons”
	Siti In general: Provide a description of the boundary on the picture, so that students can comprehend the meaning of the problem. Item 1: Typo
2	**Ranni** In general: if it can be made into two problems. Problem 3 completing the table and Problem 4 about the question.

3	**Zulkardi** In general: Do not camouflage if you can find the original data. Then avoid using the exclamation mark (!) in the problems. Item 4: a jury in a big game is never absent. Although unable to attend, certainly replace people. So there's no way there's no value at all
4	**Ranni** In general: Add captions when scoring is viewed from the highest point, and if there are similar points, then scoring is seen from goal difference. Then it's Asean Games data. If possible, because we use the Asian Games context so the data used is the Asian Games data
5	**Zulkardi** In general: The numbers and letters in the picture must be the same as the letters in the question, because they are illustrations, so it should be clear.
	Somakim In general: Later there must be fooled students who think that the high bar diagram wins.
	Ranni In general: The correct one is 4 x 100 m or 4 x 10 m, because in the title of relay swimming 4 x 100m but in explanation 4x10m relay swimming. Item 8: this can be added in question "Berdasarkan grafik di atas….. (Based on the graph above …..)" Item 9 questions can be changed to "berdasarkan grafik di atas, pemain manakah yang mempunyai pengaruh lebih besar agar negaranya menjadi emenang dalam perlombaan? (Based on the graph above, which player has greater influence to make his country win in the race?)"
	Siti Item 8: Typo

c. One-to-One

In this stage, the researcher used three levels of student ability, high-ability students (S.R), medium-skilled students (O.V.W) and low-ability students (J.C.T). The students were then asked to read the questions on prototype 1 with ten items and solve the problems. It aimed to observe students' responses and difficulties while working on each question, whether the student understood the intent of each item developed. Researchers here only act as facilitators who oversee and assist students if they have difficulty in answering questions.

d. Small Group

At this stage, researchers tested the revision of prototype 1 called prototype to 6 students of 10th one class of Year 10 students from one Senior High School at Palembang consisting of 2 high-ability students (IF and RH), 2 medium-skilled students (TW and DR), and 2 students low-performing (NF and APW). At this stage, researchers began learning by providing an apperception of the Asian

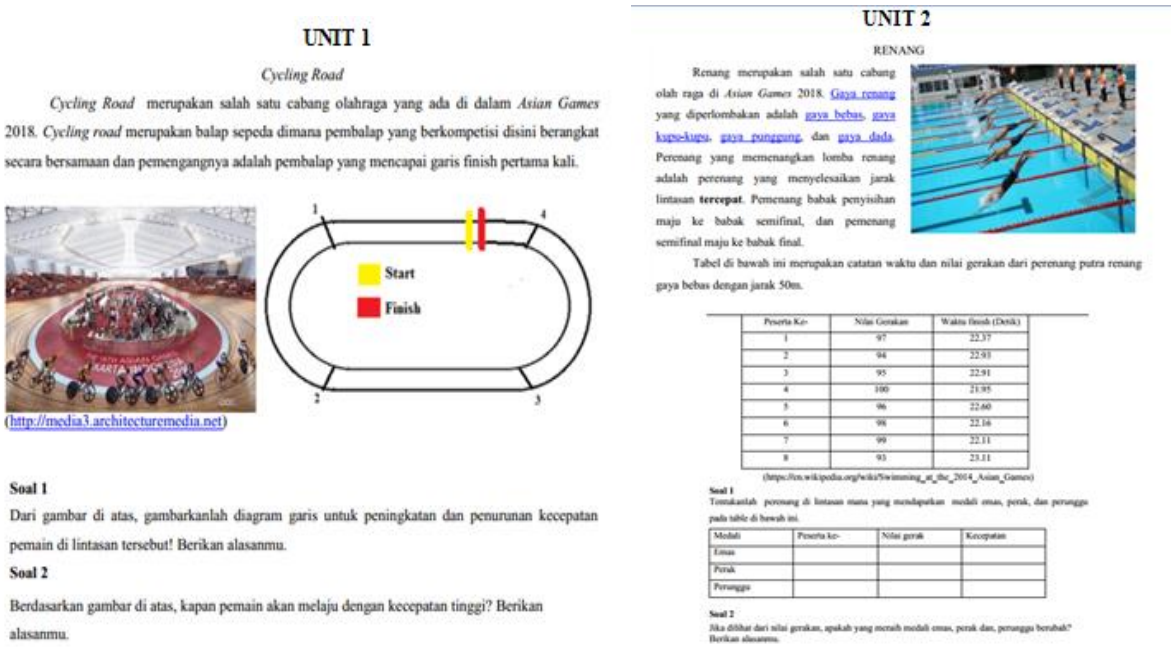
Games, sports at the Asian Games, statistical materials and links to sports at the Asian Games. Then the researchers distributed the activities of prototype 2 units 1 and 2 to students and students were required to understand in advance the activities that had been distributed. Then the students did the questions individually for 5 minutes, then discussed in groups where one group consisted of 3 high-ability students, moderate, and low. After the discussion, the researchers asked representatives of each group to present their work.

e. Field Test

The field test was conducted on November 20, 2018. At this stage, the prototype three questions were tested to the research subjects, i.e. students of class X IPA 1 SMA LTI-IGM, which in 1 class consisted of 20 students. In this field test, the data collection techniques are in the form of walkthrough, observation, interview, and analyzed qualitatively that can be seen in Figure 1.

Figure 1. Teacher guiding student discussion during field test

At the first meeting, Miss Siti began learning by giving apperception on the Asian Games, sports at the Asian Games, statistical materials and links to games at the Asian Games. Then the teacher distributed the activity in the form of prototype three units 1 and 2 to the students, and the students were asked to understand first the events that had been distributed. Then the teacher asked students to do the questions on the individual activities for 5 minutes, later discussed in groups where one group consists of 3-4 students. There were four groups in this class. After the discussion, the teacher asked representatives from each group to present their work. M.N. is one of the students who work on the activities of prototype three units 1 and 2 (Figure 2).



UNIT 1

Cycling Road

Cycling Road merupakan salah satu cabang olahraga yang ada di dalam *Asian Games* 2018. *Cycling road* merupakan balap sepeda dimana pembalap yang berkompetisi disini berangkat secara bersamaan dan pemengangnya adalah pembalap yang mencapai garis finish pertama kali.

(http://media3.architecturemedia.net)

Soal 1

Dari gambar di atas, gambarkanlah diagram garis untuk peningkatan dan penurunan kecepatan pemain di lintasan tersebut! Berikan alasanmu.

Soal 2

Berdasarkan gambar di atas, kapan pemain akan melaju dengan kecepatan tinggi? Berikan alasanmu.

UNIT 2

RENANG

Renang merupakan salah satu cabang olah raga di *Asian Games* 2018. Gaya renang yang diperlombakan adalah gaya bebas, gaya kupu-kupu, gaya punggung, dan gaya dada. Perenang yang memenangkan lomba renang adalah perenang yang menyelesaikan jarak lintasan **tercepat**. Pemenang babak penyisihan maju ke babak semifinal, dan pemenang semifinal maju ke babak final.

Tabel di bawah ini merupakan catatan waktu dan nilai gerakan dari perenang putra renang gaya bebas dengan jarak 50m.

Peserta Ke-	Nilai Gerakan	Waktu finish (Detik)
1	97	22.37
2	94	22.93
3	95	22.91
4	100	21.95
5	96	22.60
6	98	22.16
7	99	22.11
8	93	23.11

(https://en.wikipedia.org/wiki/Swimming_at_the_2014_Asian_Games)

Soal 1

Tentukanlah perenang di lintasan mana yang mendapatkan medali emas, perak, dan perunggu pada table di bawah ini.

Medali	Peserta ke-	Nilai gerak	Kecepatan
Emas			
Perak			
Perunggu			

Soal 2

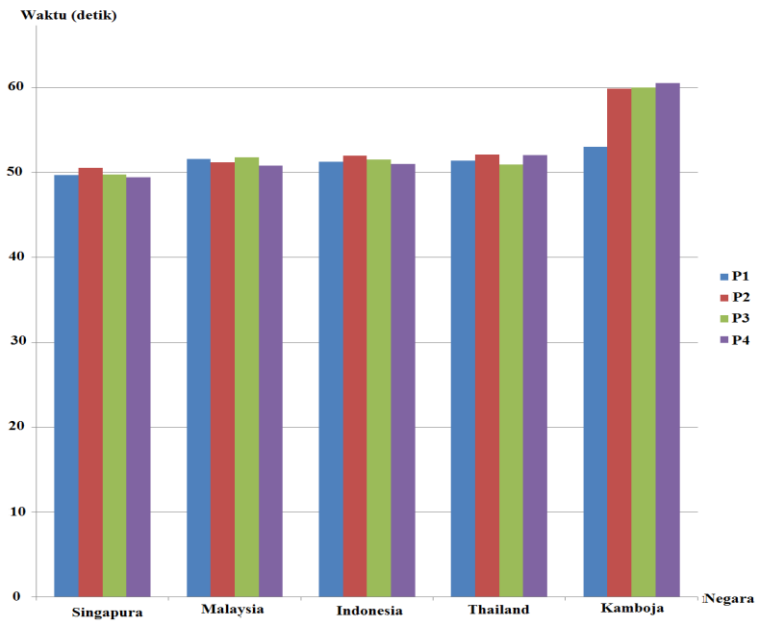
Jika dilihat dari nilai gerakan, apakah yang meraih medali emas, perak dan, perunggu berubah? Berikan alasanmu.

Figure 2. Prototype 3 Unit 1 (left) and Unit 2 (right)

At the second meeting on November 21, 2017, the teacher held a test, where the test questions are prototype three units 3 and 4. Here is a description of the students when conducting the test. The model teacher monitored the test for IPA 1 class X, so no students were allowed to discuss something. Students are given 90 minutes. Here is one of the student answers. Figure 3 is one of the problems that have been developed by researchers.

Renang Estafet 4 x 100 m

Diagram di bawah ini menunjukkan hasil perlombaan renang estafet 4×100 m untuk 5 besar Negara pemenang. Negara dengan pencetak waktu tercepat itulah yang mendapatkan medali emas.



Soal 7

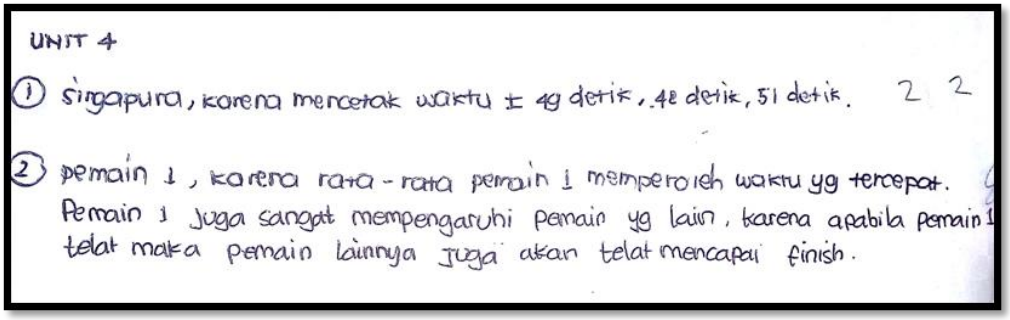
Berdasarkan grafik di atas negara manakah yang menjadi pemenang dalam perlombaan? Berikan alasanmu**.**

Soal 8

Berdasarkan grafik di atas, pemain manakah yang mempunyai pengaruh lebih besar agar negaranya menjadi pemenang dalam perlombaan? Berikan alasanmu.

Figure 3. Prototype 3 Unit 4

Based on field test results, from 20 students, only one student answered wholly and correctly, 13 students responded incompletely, and six students reacted wrongly. Here are some students' answers on 1 unit about running relay.

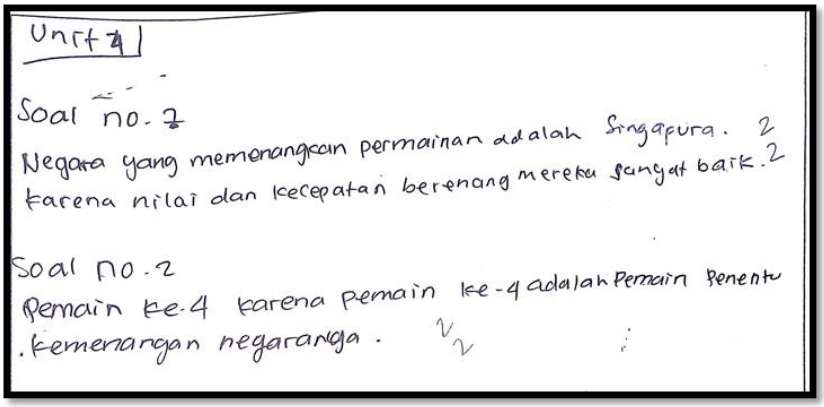

UNIT 4

① singapura, karena mencetak waktu ± 49 detik, 48 detik, 51 detik. 2 2

② pemain 1, karena rata-rata pemain 1 memperoleh waktu yg tercepat. Pemain 1 juga sangat mempengaruhi pemain yg lain, karena apabila pemain 1 telat maka pemain lainnya juga akan telat mencapai finish.

Figure 4. Student's Answer (H.A.)

In Figure 4, the student responded to player 1, a player who was very influential on the win of the relay swimming race. It was because player 1 was a player who started the start so players must start the race with high speed to win the swimming relay race.


Unit 4

Soal no. 1

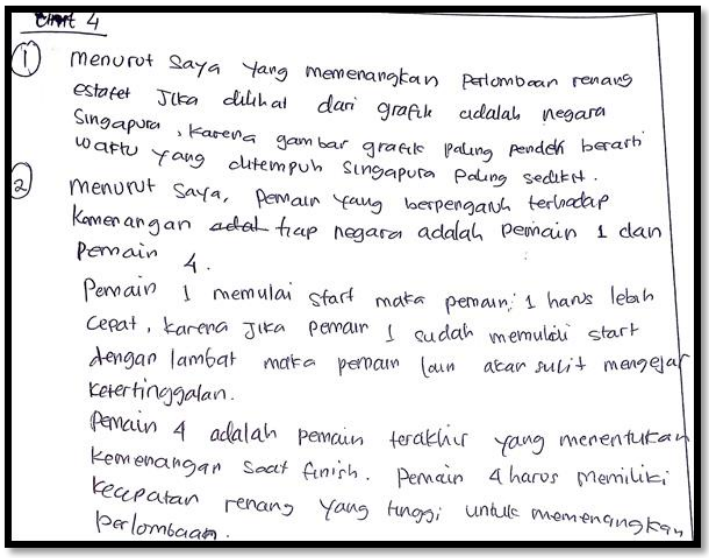
Negara yang memenangkan permainan adalah Singapura. 2
karena nilai dan kecepatan berenang mereka sangat baik. 2

Soal no. 2

Pemain ke-4 karena pemain ke-4 adalah Pemain penentu kemenangan negaranya.

Figure 5. Student's Answer (S.A.D)

In Figure 5, S.A.D replied that the most decisive player of victory was player 4. It was because the 4th player was the last player to reach the finish. Then, the 4th player was the winner of every country.


Unit 4

1) Menurut saya yang memenangkan perlombaan renang estafet jika dilihat dari grafik adalah negara Singapura, karena gambar grafik paling pendek berarti waktu yang ditempuh Singapura paling sedikit.

2) Menurut saya, pemain yang berpengaruh terhadap kemenangan ~~adal~~ tiap negara adalah pemain 1 dan pemain 4.
Pemain 1 memulai start maka pemain 1 harus lebih cepat, karena jika pemain 1 sudah memulai start dengan lambat maka pemain lain akan sulit mengejar ketertinggalan.
Pemain 4 adalah pemain terakhir yang menentukan kemenangan saat finish. Pemain 4 harus memiliki kecepatan renang yang tinggi untuk memenangkan perlombaan.

Figure 6. Student's Answer (B.P)

In Figure 6, B.P responded that the influential players were payer one and player 4. It was because player 1 was a player who started the start while player 4 was a player who reached the finish line. Then the speed of player one should be superior so that other players, especially player four, do not have difficulty to achieve the finish. If player 1 starts to start slowly, then player four will be difficult to catch up. Besides, four players must also be faster; it is because four players are the winner of each country.

In unit 4, obtained mathematical literacy abilities that appear on students' answers, namely the strength of reasoning and argument. Based on the analysis of the solutions of students in this unit, it seems that the ability that is owned by students is the ability of reasoning and argument wherein the first problem students do not understand the available charts and have errors in answering which countries won the race. Furthermore, in the second question, there are still many students who answer the statement, but it is incomplete. The results supported from several research stated that some students also find it difficult to give statements that support or refute their arguments to answer given questions (Novita, et al. 2012; Kamaliyah, et al. 2014; Oktiningrum, et al. 2016; Wijaya, et al. 2014; Wijaya, et al. 2015; Mumu, et al. 2018; Gunawan, et al. 2018; Sukirwan, et al. 2018; Pratiwi, et al. 2019).

CONCLUSION

There are eight valid and practical items of PISA type of uncertainty and data contents obtained using bicycles and aquatic contexts in Asian Games. Characteristics constructed in the development of this problem were PISA characteristics and used the context within the scope of Asian Games, a personal context consisting of 1 issue of application ability and seven issues of interpretation. The validity of the questionnaire could be seen in terms of the content, whether the question was compatible with the dominant PISA literacy for context, content, and process capability. Construct, whether the problem was in line with the characteristics of PISA and the ability of the students of

class X, and language, was it a matter of using a style compatible with EYD and understood by students. It was done in expert reviews and one to one phase. The practicality criteria of the problem revealed from the results of the small groups where this type of PISA math problem used contexts known, understood, and applied in learning. The potential effects on PISA math problems can be obtained from the analysis of student responses in the field test phase in order to see the ability of mathematical literacy that appears in the student's answer. Judging from the issues discussed, it showed students' reasoning, and argumentation abilities, where 11 out of 20 students demonstrated reasoning skills and reasonable arguments and 9 out of 20 students showed reasoning skills and discussions but incomplete.

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