

LONG JUMP IN ASIAN GAMES: CONTEXT OF PISA-LIKE MATHEMATICS PROBLEMS

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Abstract

This study aimed to produce a set of PISA-like mathematics problems content of uncertainty and data using long jump context in Asian Games that were valid, practical and had potential effects on the ability of the students' mathematical literacy. This study used the design research method of development studies type in two stages, preliminary and formative evaluation. The subject of this study involved 34 students of Senior High School. The result of this study was a set of PISA-like mathematics problems using long jump context in Asian Games which were valid, practical, and had potential effects. The result of students' answer analysis showed some strategies and arguments used by students. In question 1, 3 out of 34 students were involved in representation, reasoning and argument ability, 31 out of 34 students were involved in reasoning and argument ability. In question 2, 30 out of 34 students were involved in representation and reasoning and argument ability, and 4 out of 34 students were involved in communication, representation, reasoning and argument ability. Also, using the PISA-like mathematics problems with long jump context made students more interested and active during the learning process.

Keywords: Design research, PISA-like mathematics problems, Asian Games

Abstrak

Penelitian ini bertujuan untuk menghasilkan seperangkat soal matematika tipe PISA konten ketidakpastian dan data menggunakan konteks lompat jauh di Asian Games yang valid, praktis, dan memiliki efek potensial terhadap kemampuan literasi matematika siswa. Metode penelitian ini adalah *design research* tipe *development studies* yang terdiri dari dua tahap, yaitu tahap *preliminary* dan tahap *formative evaluation*. Subjek penelitian ini melibatkan 34 siswa Sekolah Menengah Atas. Hasil penelitian ini adalah seperangkat soal matematika tipe PISA menggunakan konteks lompat jauh di *Asian Games* yang valid dan praktis serta memiliki efek potensial. Hasil analisis siswa menunjukkan beberapa strategi dan argumen yang digunakan siswa. Pada soal 1, terdapat 3 dari 34 siswa yang melibatkan kemampuan representasi dan penalaran dan argumen dan 31 dari 34 siswa hanya menggunakan kemampuan penalaran dan argumen. Pada soal 2, terdapat 30 dari 34 siswa melibatkan kemampuan representasi dan penalaran dan argumen, dan 4 dari 34 siswa melibatkan kemampuan komunikasi, representasi, penalaran dan argumen. Selain itu, penggunaan soal matematika tipe PISA dengan konteks lompat jauh membuat siswa lebih tertarik dan aktif selama pembelajaran.

Kata Kunci: *Design research*, Soal matematika tipe PISA, *Asian Games*

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Uncertainty and data is one of the content in Programme for International Student Assessment (PISA) for the domain of mathematical literacy and used in various fields of life especially in sports, business, industry, politics, weather, forecasts, population and so forth (Bakker, 2004; Hannah Muhsetyo, & Sisworo, 2016; Yanti, Nusantara, & Qohar, 2016). Students should have a good understanding and mathematical literacy ability on uncertainty and data content so they could solve the problems in the various situation (Johar, 2012). Despite the fact, the mathematical literacy achievement of Indonesian student in PISA on the uncertainty and data content was still low and always at the lower level compared to other countries. Indonesia's score on uncertainty and data content in 2003 PISA was 385 with the rank of 38 out of 40 countries, while in 2012 PISA only 384 of the

OECD average score, 493, with the rank of 63 out of 65 countries (OECD, 2004; OECD, 2014). This was because Indonesian students were not used to solving context-based problems such as PISA problems in learning process and evaluation, especially for the high-level problems (Dewantara, Zulkardi, & Darmawijoyo, 2015; Novita, Zulkardi, & Hartono, 2012; Ahyar, Zulkardi, & Darmawijoyo, 2014).

PISA results were the basis of the 2013 curriculum development where learning in Indonesia had to be adjusted to the PISA problems (Kemendikbud, 2014), so that teachers and collegers in Indonesia should be able to design a learning and evaluation problems in accordance to PISA characteristics such as using context that has been known by students in daily life (Kohar, Zulkardi, & Darmawijoyo, 2014; Zulkardi & Putri, 2006). PMRI approach is one of the learning that fit the objectives of the 2013 curriculum and emphasizes on the contexts familiarized by the students as the starting point of the learning for the formation of models, concepts, and mathematics motivation so that it will make the learning process becomes more meaningful for students (Putri, 2014; Zulkardi & Putri, 2006; Putri, 2011). From the situation, students will be required to be able to find their facts, build concepts, and new values in life during the learning process (Kemendikbud, 2013).

One of the contexts that can be used in learning of uncertainty and data and has been known by students is sport especially long jump sport in Asian Games which has currently been a public concern in Indonesia. Even the president of Indonesia, the governor and the head of the Palembang national education office instructed to the entire society, especially teachers in Palembang, to socialize the 2018 Asian Games in elementary and middle school by using Asian Games as a situation to get more interesting and meaningful learning for students (Instruksi Presiden, 2016; Sumselpostonline, 2015; Sumselpotonline, 2017). Also, the previous researchers have shown that sports in Asian Games as a learning context could help students to understand the materials, enlarge their thinking, and provide more meaningful experience and fun learning (Roni, Zulkardi, & Putri, 2017; Nasution, Putri, & Zulkardi, 2017).

This study aimed to produce PISA like mathematics problems on uncertainty and data content using the context of the long jump in Asian Games that were valid, practical and had a potential effect on the ability of the mathematical literacy students. Based on the 2015 PISA frameworks, the ability of the mathematical literacy students is an individual's ability to formulate, apply, and interpret mathematics that underlined by the seven fundamental mathematical capabilities: communication, mathematising, representation, reasoning and argument, devising strategies for solving problems, using symbolic, formal, and technical language and operations, and using mathematical tools (OECD, 2016).

METHOD

This study is design research with development studies type (Akker, 2006). This study was done by involving the tenth-grade students of Senior High School at the odd semester of the academic year of 2017/2018. This study was conducted in two stages, preliminary evaluation, and formative evaluation. The preliminary stage covered the analysis of research preparation and the design of PISA like mathematics problems based on 2015 PISA framework. Meanwhile, the formative evaluation stage consisted of self-evaluation, expert reviews, one-to-one, small group, and field test

(Tessmer,1999; Zulkardi, 2006).

At the self-evaluation, the researchers evaluated the PISA like mathematics problems by herself and revised the items, so that prototype one was obtained. Then at the expert reviews, prototype one was consulted to the experts and evaluated by the validation criteria of content, construct, and language. Simultaneously, the one-to-one was undertaken where prototype one was tested to three students at this stage. The result of expert reviews and one-to-one was used to revise prototype one so that valid prototype two was obtained. Then at the small group, prototype two was tested to six students in a learning process that fit the lesson plan (RPP) made. The result of the students' answer analysis and their suggestion for the problems were used to revise the prototype two so that the valid and practical of prototype three was obtained. Furthermore, in the field test, prototype three was tested on the research subject through the learning process to find out the potential effects of the PISA-like mathematics problems on the ability of students' mathematical literacy. The data were gathered using walkthrough at the expert reviews, observation of the video recording, interview during the learning process, and students' answer.

RESULT AND DISCUSSION

In this study, there were five units consisting of ten items of PISA-like mathematics problems on uncertainty and data using games and athletics in Asian Games contexts. However, only one unit, using long jump in athletics context, was discussed in this study because there were various students' strategies and arguments in this unit. The steps undertaken in the development process were shown below.

Preliminary Stage

In the early stage of the development, the researchers analyzed the characteristic of the PISA problems, curriculum, and students' analysis. In analyzing the characteristics of the PISA problems, the researchers analyzed the characteristics of the content, context, competence of process capability, and the level of the mathematical ability in PISA framework so that the characteristics of PISA problems in mathematics domain and PISA items on uncertainty and data content were obtained and used for the developing problems. The researchers also analyzed the uncertainty and data content in the curriculum used by the research school, curriculum 2013, and found that the uncertainty and data content was taught at tenth-grade students in probability and statistics subject. While in the student analysis, the researchers identified students who would play a role in the one-to-one and small group phase, and the research subject in a field test with the help of the teachers.

In the design preparation stage, the researchers designed the instruments of the research consisting the question grids, problems card, the assessment rubric, and lesson plan. At this stage, the researchers designed an initial prototype of four units PISA problems on uncertainty the and data content developed based on 2015 PISA framework into five items of PISA like mathematics

problems using the context of football, Asian Games sports, sprint, and Indonesian medals at Asian Games.

One of the problems used was 2006 PISA items with M505 code about garbage. M505 PISA problems used the context of the timeframe of the decomposition process. From the various kinds of garbage and timeframe needed for the decomposition process, students were asked to give a reason why the data was not suitable to be displayed in the bar graph. From the PISA M505 problem, the researchers designed new problems by changing the context using sports and the year of the Asian Games when held. Students were asked to decide whether the data was suitable to be displayed in a bar graph first and gave supporting reasons. The initial problems that designed using long jump context were shown in Figure 1.

Cabang Olahraga Asian Games	
Sejak diadakan pertama kali pada tahun 1951 hingga tahun 2018 yang akan datang, terdapat 51 cabang olahraga yang diselenggarakan di <i>Asian Games</i> . Cabang olahraga tersebut mencakup 39 disiplin ilmu olahraga yang berbeda dan terbagi menjadi sekitar 400 acara/ <i>event</i> . Namun, tidak semua cabang olahraga tersebut dilombakan pada setiap penyelenggaraan <i>Asian Games</i> . Ada beberapa cabang olahraga yang hanya dilombakan selama 2 kali penyelenggaraan <i>Asian Games</i> , hingga cabang olahraga yang hanya ada pada penyelenggaraan <i>Asian Games</i> pada tahun tertentu saja. Berikut ini data penyelenggaraan beberapa cabang olahraga di <i>Asian Games</i> sampai tahun 2018:	
Cabang Olahraga	Tahun
Binaraga	2002–2006
Bowling	1978, 1986, dan sejak 1994
Catur	2006–2010
Panahan	Sejak 1978
Pencak Silat	2018
Sepak Bola	Sejak 1951
Sepatu Roda	2010

(Sumber: www.en.wikipedia.org/wiki/Asian_Games)

Apakah data pada tabel di atas dapat disajikan dalam bentuk diagram batang? Mengapa? Berikan alasanmu.

Figure1. Problem using long jump context at the design stage

Formative Evaluation Stage

a. Self Evaluation

At the self-evaluation, the researchers re-evaluated the research instruments that had been designed in the previous stage. The initial prototype was evaluated regarding content, constructs, and languages. Based on the result of the evaluation, the researchers decided to make some revisions such as adding new questions, changing the context of Asian Games which were still general as in the Asian Games sports and the Indonesian's medal to becoming more specific to the games and athletics sports, and revise the sentences used in the problems.

At the Asian Games sports unit, the researchers decided to change the context of the problems to be the data of the women's long jump record in the 2014 Asian Games so that it would be more appropriate to the sport and athletics in Asian Games context. In question 1, the researchers changed the question of the suitability of the displaying data in a bar graph into a pie graph. Also, the researchers also added one item in this unit where in question, students were asked to determine the winner of long jump based on the available data and criteria.

b. Expert Reviews and One-to-One

Expert reviews and one-to-one were done in parallel to determine the validity of prototype one based on predefined criteria. At the expert reviews, prototype one was consulted to the experts as validators. Then this prototype one was analyzed and evaluated qualitatively by the validators regarding content, constructs, and languages. The validation process in this stage was done in three ways (Tessmer, 1999), that were (1) mail reviews with Masitah Sharill, an assistant senior professor and lecturer at the Hassanal Bolkiah Institute of Education (SHBIE), Brunei Darussalam University (UBD), (2) panel reviews with the mathematics education lecturer in Sriwijaya University and master's students of mathematics education of Sriwijaya University with the research focus on developing PISA like mathematics problems, (3) face-to-face reviews with Idda Mawaddah, a mathematics teacher. Table 1 showed the experts' comments and suggestion to the long jump unit.

Table 1. The validator's coments and suggestions at the expert reviews

Validator	Comments and Suggestions
Masitah Shahrill	<ul style="list-style-type: none"> a. The context of the chosen questions (regarding long jump for the female athletes) showed good and interesting connections to real-life knowledge and experiences. And so far, it showed fairness about the distribution of gender questions. b. Please try not to use the exclamation mark (!) for any statements or questions. It reads as if you are forceful.
Elika Kurniadi	<ul style="list-style-type: none"> a. Add information of the empty table in the description. b. Add information of Asian Games data in the description of the problems if it is the original data of Asian Games
Riya Dhotul Jannah	<ul style="list-style-type: none"> a. In the data table, you should add a column for the name of the participating country, and the flag in the name of the athletes should be removed b. Give the unit of distance used in the data table c. Describe the empty table data

While at the one-to-one, prototype one was tested to three students of Senior High School with high, medium, and low ability. This stage was to look at the students' thinking on the prototype one problems and to know the students' difficulties in understanding and solving the problems on prototype 1. From the analysis result of students' answer, it was found that most students had a little difficulty in understanding the empty data on the table and the criteria of long jump winner regarding the furthest jump achieved by the athlete in question 2. After the students were given a little direction about the meaning of the furthest jump criteria, they were able to solve the problem well.

Based on the result of the expert reviews and one-to-one, the researchers decided to make several revisions to prototype 1. The result of the revisions was prototype two that had been valid. At the long jump unit, the researchers revised the problems by adding the information that the given data on the table was the data from the women's long jump result at the 2014 Asian Games. The researchers also added the information that empty data on the table means that the athlete did not

jump. While in question 2, the researchers changed the sentence on the criteria of the winner of the long jump event. So that the students could identify the winner easily.

c. *Small Group*

At this stage, prototype two was tested to six students of Senior High School with high, medium, and low ability in three meetings, two meetings for learning and one for the final test. Based on the result of small groups, it was found out that most students were able to understand the problems well, could use the table or diagrams contained in the problem, and understood the context used in the problems.

At the long jump unit of the question 2, the researchers decided to change the sentence on the first criteria of the long jump winner of “the furthest jump achieved by the competing athletes from the sixth of jumping trials” to the “the furthest jump in all trials from the competing athlete.” Besides revising the words that were still difficult to understand, the researchers also decided to make one meeting for learning and one meeting for the final test in the next stage. It was done to save the time because according to the researchers, the time used in the previous learning process should be made more efficient.

d. *Field Test*

At field test, the researchers tested the prototype 3 to the research subject, students at the tenth grade of Senior High School consisting of 34 students. At the field test, the researchers tested prototype 3 at one learning process and one final test with the classroom teacher, Idda Mawaddah, as a model in the learning process. Figure 2 showed the long jump unit in prototype 3.

Lompat Jauh

Pada *Asian Games*, lompat jauh termasuk dalam cabang olahraga atletik. Pada pelaksanaannya, masing-masing atlet diberikan kesempatan sebanyak 6 kali untuk melompat. Berikut ini catatan jarak yang dicapai oleh para atlet putri dalam even lompat jauh di *Asian Games* 2014:

Nama Atlet	Percobaan ke-					
	1	2	3	4	5	6
Jung Soon-ok (KOR)	X	X	6.26	6.34	6.20	6.12
Lu Minjia (CHN)	6.24	6.22	6.28	6.21	6.22	6.03
Marestella Torres (PHI)	X	X	X			
Keshari Chaudhari (NEP)	4.71	4.76	X			
Yanfei Jiang (CHN)	X	6.24	6.34	6.24	6.19	6.29
Bae Chanmi (KOR)	5.67	6.34	6.14	X	X	5.89
Mayookha Johny (IND)	6.04	6.12	6.02			
Darya Reznichenko (UZB)	6.25	6.04	6.01	6.11	6.05	6.10
Bashair Obaid (QAT)	4.07	X	4.34			
Maria Natalia Londa (INA)	X	6.19	X	6.40	X	6.55
M.A Prajusha (IND)	6.23	X	X	6.17	X	X
Bui Thi Thu (VIE)	6.35	X	6.44	6.31	6.30	6.33
Yulia Tarasova (UZB)						

(Sumber: en.wikipedia.org)

Catatan : X : Gagal
Kosong : Tidak melakukan lompatan

Soal 1
Apakah data pada tabel di atas sesuai untuk disajikan dalam bentuk diagram lingkaran? Berikan alasanmu.

Soal 2
Pemenang dalam even lompat jauh ditentukan oleh :

- Lompatan dengan jarak terjauh pada seluruh percobaan dari para atlet yang bertanding
- Jika terdapat jarak lompatan yang sama, maka atlet dengan kegagalan lebih sedikit dalam percobaan lompatannya akan lebih unggul daripada atlet yang lain

Berdasarkan data di atas, identifikasi atlet yang berhasil memperoleh medali emas, perak, dan perunggu. Isi tabel berikut ini dengan nama atlet yang menjadi peraih medali dan catatan jarak lompatan terjuahnya. Berikan alasanmu.

Medali	Atlet	Jarak Lompatan (meter)
Emas		
Perak		
Perunggu		

Figure 2. Long jump unit in prototype 3

At the beginning of the learning process, the model teacher gave two situations to students: football and sprint in Asian Games. Then students were given time to understand and tried to solve individual problems first. Then students were asked to discuss in groups that had been previously divided, a group of 4-5 students with high, medium, and low ability. After the discussion finished, the model teacher asked one of the groups to present the results of their discussion. The model teacher acting as a facilitator looked at the students' interaction and contribution during the process.

In the learning using the PISA like mathematics problems with long jump context, it showed that students were more interested in the situation used in the learning and more interactive during the discussion. It was inline with the study conducted by Gunawan, Putri, and Zulkardi (2017) saying that students were more enthusiastic and active during the learning that used the sports context in Asian Games. Also, the learning that used the sports context in Asian Games could be a bridge of students' thinking and helped students to understand the materials with more meaningful experience and fun learning (Nasution, Putri, & Zulkardi, 2018; Rahayu, Putri, & Zulkardi, 2017).

At the final test, the teacher gave three units of PISA-like mathematics problems on prototype 3 consisting five items to students and asked them to solve it individually within two lesson hours. The model teacher kept watching the final test so that students could not discuss the problem with others. Then, the students' answers were analyzed to look at the potential effects of the PISA-like mathematics problems on the ability of the students' mathematical literacy. It could be seen from the basic math skills used by the students in solving the problems. The following were some of students answers on the long jump unit.

1. tidak bisa . karena diagram lingkaran bisa menggunakan (%) sedang kan status tersebut memskai (%) di belakarnya dan tidak bisa dibuat persentasenya dan kait arakanya .

2. Medali Atlet Jarak lompatan .

① emas	Maria Natalia Londa	6.55 .
② Perak	BUI THI THU	6.44 .
③ perunggu	Yanfei Jiang .	6.34 .

karena jarak dia paling jauh .
 • karena jarak dia paling jauh setelah Maria Natalia Londa .
 • Jarak mereka sama 6.34 karena atlet dan keagakan lebih sedikit dalam peredaran lompatannya akan lebih unggul dari pada atlet us lain

Figure 3. Student's answer in field test

Figure 3 showed that in question 1, students were able to involve the ability of the reasoning and argument of the indicator to make the explanation that supports the solution (RA2) by suggesting the reason of why the data were not suitable to be displayed in a pie graph because the data was difficult to be made in percentage form as in the pie graph. While in question 2, students were able to involve the ability of representation of the indicator to interpret the result in a form of representation (R1) by making the table of the result of the medal identification and the ability of the reasoning and argument of the indicator to make the explanation that supports the solution (RA2) by arguing the athlete able to win the medal.

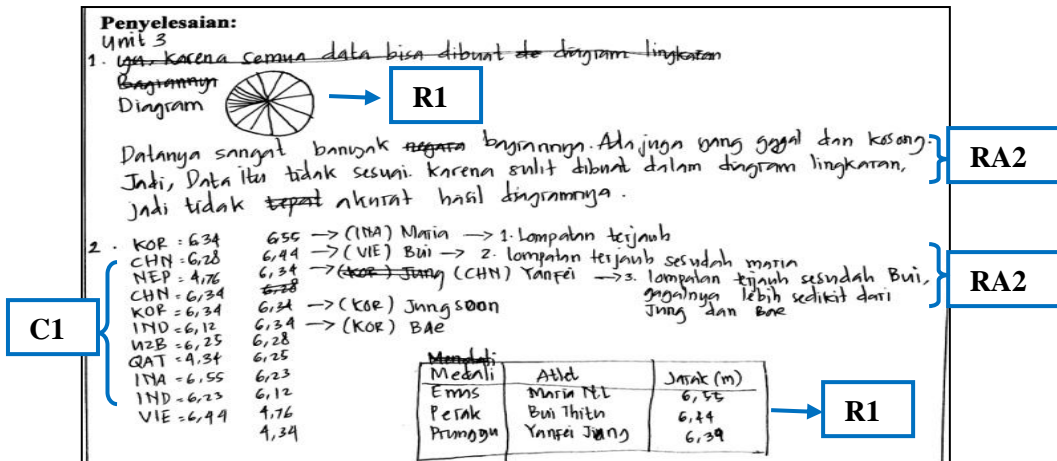


Figure 4. Student answer in field test

Figure 4 showed that in question 1, students were able to involve the representation ability of the indicator to interpret the result in the form of representation (R1) by trying to make a model of the pie graph from the data on the table. Then student involved the ability of the reasoning and arguments of the indicator to make explanations that supports the solution (RA2) by suggesting the reason of the data that were not suitable to be displayed in a pie graph because of the large number of the data so it would be inaccurate when it was made in pie graph. While in question 2, the students were able to involve the ability of communication of the indicator to make an explanation in the context of the problem (C1) by writing the sequence of the furthest jumps achieved in each athlete, then involved the ability of reasoning and arguments of the indicator to make explanations that supports the solution (RA2) by writing the reason for the athlete obtaining the medal, and the ability of the representation of the indicator to interpret the result in a form of representation (R1) by creating a table of the result of the medal identification.

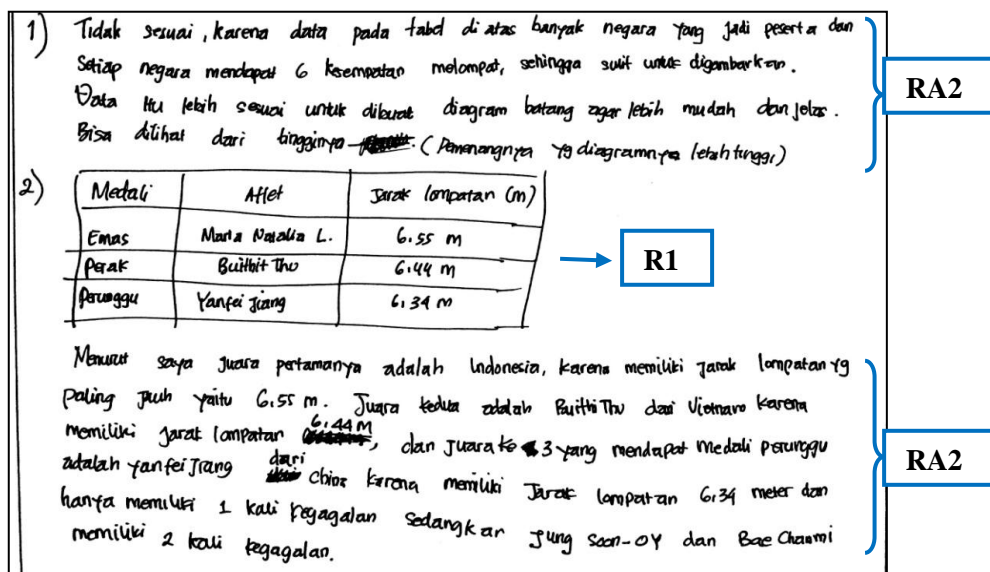


Figure 5. Student answer at field test

Figure 5 showed that in question 1, the students were able to involve the ability of the reasoning and argument of the indicator to make the explanation that supports the solution (RA2) by suggesting the reason of why the data were not suitable to be displayed in a pie graph because the data had many categories, so it was easier to be displayed in a bar graph. While in question 2, the students were able to involve the ability of representation of the indicator to interpret the result in a form of representation (R1) by making the table of the result of the medal identification and the ability of the reasoning and argument of the indicator to make the explanation that supports the solution (RA2) by arguing that the athlete was able to win the medal.

In question 1, from the result of the analysis, it was found out that 3 out of 34 students involved the ability of representation and the reasoning and argument where two students were able to answer correctly and completely, and a student answered correctly but not complete. While 31 out of 34 students involved only the ability of the reasoning and argument where nine students were able to answer correctly and completely, 18 students were able to answer correctly but not complete, and four students' answers were wrong.

In question 2, from the result of the analysis, it was found out that 30 out of 34 students involved the ability of representation and the reasoning and argument where 10 students were able to answer correctly and completely, 10 students were able to answer correctly but not complete, and 9 students' answers were wrong. While 4 out of 34 students involved the ability of communication, representation, and reasoning and argument where two students were able to answer correctly and completely, a student was able to answer correctly but not complete, and a student's answer was wrong.

The result of the students' answers analysis showed that most of the students were able to solve the problems by involving some of the fundamental mathematical capabilities such as the ability of communication, representation, and reasoning and argument. Some students still had difficulty to solve the problems because they were not accustomed to PISA-like mathematics problems. It was in line with the research of the Mujulifah, Sugiatno, and Hamdani (2015) saying that students had not been trained and accustomed to solving PISA-like mathematics problem that required the ability of understanding, employing, and reasoning. Also, there were still some students who were unable to make an explanation and argument that supports the solution correctly and completely. This was in line with the research of the Mardhiyanti, Putri, and Kesumawati (2013) that students were not accustomed to solving PISA-like mathematics problems that required students to communicate their answer in writing along with the explanations and reasons.

CONCLUSION

This study produced a set of PISA like mathematics problems on uncertainty and data content using the context of the long jump in Asian Games that were valid, practical, and had a potential effect on the ability of the students' mathematical literacy. Valid criteria for this problems was seen

regarding content, constructs, and languages at the expert reviews and one-to-one. While the practicality criteria were seen from the result of the small groups where the problems using the context recognizable by students could be understood and applied in the learning. Potential effects of this PISA-like mathematics problems using long jump context on the ability of the students mathematical literacy were seen from the result of the students answer analysis where in question 1 students could show the ability of representation and the reasoning and argument, and in question 2 students could show the ability of the communication, representation, and the reasoning and argument. Also, the 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.

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