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DEVELOPMENT PISA-LIKE MATHEMATICS PROBLEMS WITH FOOTBALL AND TABLE TENNIS CONTEXTS IN ASIAN GAMES 2018

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Abstract

The objectives of this research were to produce valid and practical PISA-like mathematics problems on uncertainty and data content with football and table tennis context and to know the potential effect of problems to mathematical literacy capability of 10th grade students SMA Negeri 1 Palembang. The methodology used was design research with development studies type, with 2 stages of preliminary and formative evaluation stage. Data collecting techniques used were walk through, document, observation, interview, and test. The validity of problems were shown from the validator's assessment of the content, constructs and language and from comments/suggestions one-to-one phase to the clarity / readability of the problems. Then for the practicality of the problems was shown in the small group phase, that the students had been able to understand the problems well. Then from the answers of students in the field test that involving 33 students, the problems had potential effect that showed the capability of communication and representation. On the problem with football context, 6 students answered with communication capability, 3 students with representation capability. Then on the problem with table tennis context, 20 students answered with communication capability, 5 students with representation capability.

Keywords: Design Research, PISA-like, Asian Games 2018, Football, Table Tennis

Abstrak

Tujuan dari penelitian ini yaitu menghasilkan soal matematika tipe PISA konten uncertainty and data dengan konteks sepak bola dan tenis meja di Asian Games 2018 yang valid dan praktis serta mengetahui efek potensial soal terhadap kemampuan literasi matematis siswa kelas X SMA Negeri 1 Palembang. Metodologi yang digunakan adalah design research dengan tipe development studies, dengan 2 tahap yaitu preliminary dan tahap formative evaluation. Teknik pengumpulan data yang digunakan adalah walk through, dokumen, observasi, wawancara, dan tes. Kevalidan soal ditunjukkan dari hasil penilaian validator terhadap soal dari segi konten, konstruk dan bahasa serta dari komentar/saran siswa tahap one-to-one terhadap kejelasan/keterbacaan soal. Kemudian untuk kepraktisan soal ditunjukkan pada tahap small group, yaitu siswa sudah dapat memahami soal dengan baik. Kemudian dari jawaban siswa pada tahap field test yang melibatkan 33 siswa, soal memiliki efek potensial yaitu memunculkan kemampuan komunikasi dan representasi. Pada soal dengan konteks sepak bola, 6 siswa menjawab dengan kemampuan komunikasi, 3 siswa dengan kemampuan representasi. Kemudian pada soal dengan konteks tenis meja, 20 siswa menjawab dengan kemampuan komunikasi, 5 siswa dengan kemampuan representasi.

Keywords: *Design Research*, Tipe PISA, Asian Games 2018, Sepak Bola, Tenis Meja

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The Program for International Student Assessment (PISA) was an international study that was conducted every 3 years to measure the skills and capabilities of students aged 15 years (OECD, 2016). Mathematical literacy was one of the skills and capabilities in the assessed PISA (OECD, 2016). From 2003 until now, Indonesia had participated in this PISA program. However, the results of mathematical literacy were always in lower rank. From the last two periods, Indonesia was ranked 64

out of 65 participating countries in 2012(OECD, 2014). In 2015, Indonesia was ranked 62 out of 70 participating countries (OECD, 2016).

The low achievement of Indonesian students in PISA literacy mathematics could be caused of various factors. One of the reasons was that the students were not used to solve the PISA problems and were only used to solve the routine problems. As the result, many students made some mistakes when working on PISA problems. It went along with Wijaya, Heuval-Panhuizen, Doorman, & Robitzsch (2014) Indonesian students had difficulty in solving PISA-like mathematics problems using context and difficulty in transforming them into mathematics problems.

Uncertainty and data content was an important content in PISA mathematical literacy, because uncertainty and data content was the heart of mathematical analysis of many problems situations, also the theory of probability and statistics as a technique of data representation and description (OECD, 2016). So, through understanding uncertainty and data content, it could train students to analyze mathematical problems. But in reality the result of PISA in 2012, Indonesia was ranked 63 out of 65 countries in uncertainty and data content (OECD, 2014). In addition, based on the results of the PISA study in 2012 on the uncertainty and data content, Indonesian students were only able to do problems to level 2 of 6 levels that exist on PISA (Zuhra, 2015). It showed that Indonesian students were still weak in working on PISA problems on uncertainty and data content.

According to Zulkardi & Putri (2006) Context was a situation or phenomenon / natural osccurrence that was associated to the concept of mathematics being studied. In addition, the use of context in mathematics had many benefits, namely: useful for the formation of concepts, access and motivation to mathematics, formation of models, providing tools for thinking using procedures, notations, drawings and rules, reality as the source and application domain, and specific capabilities training in certain situations. Pendidikan Matematika Realistik Indonesia (PMRI) was an innovative learning that adapted from a similar learning approach that was RME (Realistic Mathematic Education) (Putri, 2011). One of PMRI characteristics was using contextual problem. It intended that in learning mathematics students could be motivated to learn mathematics (Widjaja, 2013).

Asian Games 2018 will be held in Indonesia, precisely in Jakarta and Palembang. Asian Games was a sporting event held every 4 years by countries in Asia (Wulandari, & Atmojo, 2014). According to Wijaya (2008) Games had entertainment side that was able to motivate students in learning so that there was increasing understanding of students about the concept that was contained in the game. The sports branch of games at the Asian Games 2018 was a familiar sport in the student and community environment, because students often played or watched it by themselves, like football and table tennis. Therefore the sports branch at the Asian Games 2018 were real context for them. In addition, from the results of research that used the context of sports branch at the Asian Games 2018 to design mathematics learning, such as the research of Nasution, Putri, & Zulkardi (2017) that using dayung context; the research of Roni, Putri, & Zulkardi (2017) that using sprint context; the research of Putri &Zulkardi (2017) that using shot-put context; the research of Gunawan, Putri, & Zulkardi

(2017) that using swimming context; and the research of Rahayu, Putri & Zulkardi (2017) that using hurdles context, the result showed that the learning of mathematics with the context of the sports branch could help students in understanding mathematics material.

Previous researches that developed PISA-like mathematics problems with various focus such as Oktiningrum, Zulkardi, & Hartono (2016) developed the PISA-like problems with the context of Indonesia's natural and cultural heritage context to measure students' mathematical literacy. Then Novita, Zulkardi, & Hartono (2012) who explore the capability of problem solving students by working on the PISA-like problems. Then Kamaliyah, Zulkardi, Darmawijoyo (2013) who developed the level 6 problem of PISA. Then Mardhiyanti, Putri, & Kesumawati (2013) developed the PISA problem to measure students' mathematical communication capability. Then Silva, Zulkardi, & Darmawijoyo (2013) developed a PISA-like problems on uncertainty content to measure students' mathematic problem solving capability. This suggested that many researchers were interested and consider the development of PISA-like mathematics problems needed to be done.In addition, Zulkardi (2010) suggested to design PISA-like mathematics problems and used it in learning mathematics in the classroom.

Based on the description, the objectives of this research were to produce valid and practical PISA-like mathematics problems on uncertainty and data content with football and table tennis context and to know the potential effect of problems to mathematical literacy capabiliy of 10th grade students SMA Negeri 1 Palembang.

METHOD

The method used in this research was design research method with the type of development studies. This research consists of two stages: preliminary and formative evaluation stages which include self evaluation, expert reviews and one-to-one, small group, and field test (Tessmer, 1993; Zulkardi, 2006). In addition, there was also discussion panel (item paneling) in the expert reviews phase (Turner, 2000). The subjects of the research were students of class X in SMA Negeri 1 Palembang who was 15 years old. The data collecting techniques used in this research were walk through, document, observation, interview, and test.

In the preliminary stage, the researcher determined the place and subject of the research, contacted the school, analyzed the curriculum 2013. In addition the researchers designed the problems instrument. In the first phase of formative evaluation was self evaluation. In the self-evaluation phase the researcher evaluated and reviewed the initial prototype. The results were analyzed so that were formed prototype 1.

In the Expert Reviews phase, the product that had been created were validated by the expert in a manner evaluated, reviewed and rated. Expert validation used analysis in terms of content, construct, and language. The prototype 1 validation process phase of expert reviews were done through two ways, namely by sending an e-mail to Dr. Ross Turner, Prof. Kaye Stacey, and Dr.

Hongky Julie, M.Sc and face-to-face with Eriga, M.Pd. The results of expert reviews were used to make product revisions. In the Expert Reviews phase was also done panel discussion (item paneling). According to Turner (2000) Item paneling (panel discussion) was one of the important step numbers in the development of high quality test items. Panel discussion was conducted with lecturer of mathematics education of Sriwijaya University and colleagues of mathematics education of Sriwijaya University.

Along with expert reviews, researchers tested individual students (one-to-one). On one-to-one prototype 1 was tested to 3 students with different abilities of 1 high ability student, 1 medium ability student, 1 low ability student. Focus on one-to-one was to see the clarity / readability of the problems. The results from one-to-one were used to revise the product. From the phase of expert reviews, and one-to-one were obtained prototype 2.

Prototype 2 was tested in small group phase consisting of 6 students with different ability, 2 students with high ability, 2 students with medium ability, and 2 students with low ability. Small group phase were used to determine the practicality of the problems that had been developed. The result of the revision of small group phase was called prototype 3 which was then tested in field test phase.

Field test was conducted in SMA Negeri 1 Palembang. In the field test phase prototype 3 was tried to a class consisting of 33 students. Field test phase aimed to determine the potential effects of problems that were developed to mathematical literacy capability of students. To know the capability of mathematical literacy that emerged was by analyzing students answered based on the process on the problem (whether the formulating, employing, or interpreting) and then see the indicators and descriptors of the capability of mathematical literacy based on the PISA 2015 framework that emerged.

RESULT AND DISCUSSION

This research had produced PISA-like mathematics problems uncertainty and data content of 10 units consisting of 13 questions with the context of sports branch at Asian Games 2018 which were game, bridge, martial art, & paragliding. Thirteen questions consist of question level 1 with 1 question, level 2 with 2 questions, level 3 with 5 questions, level 4 with 2 questions, level 5 with 2 questions, and level 6 with 1 question. But in this article would be discussed only 2 units of problems with the sports branch game those were football and table tennis. 2 units were unit 1 (Men's Football Match) and unit 2 (The Arrangement of Table Tennis Players). The 2 units had many different answer strategies when students answered them.

Preliminary Stage

At this stage the researcher determined the place of research that was SMA Negeri 1 Palembang and the subject of research that was the class X students who were 15 years old. Then contacted the school of curriculum representatives and mathematics teachers to ask for procedures and

research schedule in SMA Negeri 1 Palembang. Then the researchers analyzed the existing PISA mathematics problems, as well as the PISA 2015 framework. Furthermore, researchers designed the problems based on the existing PISA problems. Researcher designed the problem instrument with football and table tennis contexts in Asian Games 2018 consisting of probem grids, problem cards, and scoring rubrics. The result of the preliminary stage was the initial prototype. The problems were produced on the initial prototype amounted to 2 units consisting of 4 questions. The following explanation 2 units of the problems at preliminary stage.

In unit 1 problem the researcher developed PISA-like problem from PISA Problem in 2006 that was "Choices". Problem Choices asked the many combinations of extratopping pizza. PISA-like problem on unit 1 was developed was "Men's Football Match" with the sport branch was taken was football. On the problem of asking the number of matches in a men's football match until the winner was found. To solve the problem used the concept of sample space and created a match scheme. The sample space was one part of the uncertainty and data content. The context was used in the problem was social, the process was used was employing, then the level prediction was level 4.

In unit 2 problem, the researcher developed PISA-like problem from PISA problem in 2006 that was "Choices". Choices problem asked the many combinations of extratopping pizza. Problem PISA-like on unit 6 was developed was " The Arrangement of Table Tennis Players " with sport branch taken was table tennis. Unit 2 problem consisted of 3 questions. Question 1 asked the number of women's doubles players. To solve the problem with the concept of sample space. Question 2 asked the probability of the election of the men's double Ficky Supit and Deepash Anik B. if the coach would form the arrangement men's doubles player. Question 3 asked the probability of the election of a mixed double Habibie Wahid and Indriyani Lilis if the coach would form a mixed doubles. The sample space and probability were part of the uncertainty and data content. In unit 2, the context used was occupational, the process used was employing, then the level prediction was level 3.

Formative Evaluation

Self Evaluation

In this stage the researcher evaluated and examined the initial prototype that had been made in the preliminary stage based on the characteristics that became the focus of the prototype in terms of content, constructs, and language. Three characteristics were validated by researcher, peers, and supervisors. The results those were obtained in this stage were prototype 1 which would be tested at Expert Reviews and one-to-one phase.

Expert Reviews and One-to-One

In the Expert Reviews phase the problems were validated by the expert / validator in terms of content, constructs, and language. As for the validator those were:

1. Dr. Ross Turner (TIM ACER Australia)
2. Prof. Kaye Stacey (Professor of Mathematics Education at the University of Melbourne, Australia)

3. Dr Hongki Julie, M.Si. (Sanata Darma University)
4. Eriga, M.Pd. (Mathematics Teacher of SMA Negeri 1 Palembang)

In the expert reviews phase researcher also conducted panel discussion (item paneling). The panel discussion was conducted with 9 master students of mathematics education of Sriwijaya University, namely: Arvin Efriani, Dedi Yansen, Dewi Rawani, Dian Fitra, Eko Septiansyah, Ika Pratiwi, Levana Maharani, Ranni Permatasari, Riya Dhotul Jannah, 3 students of Sriwijaya University mathematics, Sahala Martua Ambarita, Diah Octavianty, and Lutfiah Asri, and 3 lecturers of mathematics education of Sriwijaya University, Prof. Dr. Zulkardi, M.I.Komp., M.Sc., Dr. Somakim, M.Pd., and Elika Kurniadi, M.Sc.

Along with the expert reviews phase the problems are tested in one-to-one phase. In one-to-one phase, the PISA-like mathematics problems those were developed in prototype 1 was tested to 3 students of X IPA 1 class of SMA Negeri 1 Palembang with different abilities. The three students were FA, AL, and AR. The three students were asked to work on the problem and then each student asked for opinions, comments and suggestions on these problems. This aimed to allow researcher to observe the responses and constraints of students when working on the problems and focus on the readability and clarity of the problems. Here were comments / suggestions from Experts and Students as well as the revision decision on unit 1 and 2 in tables 1 and 2.

Table 1. Comments / Suggestions from Experts and Students on Problem Unit 1

Validation	Comments/Suggestions	Revision
Dr. Ross Turner	1. The problem was given what desirable explanation to the question 2. Added possible ways to answer other students on the rubric	1. Repetitive "game" words was made only once 2. change the word. "Then" to "will" 3. change the sentence to the question "Give your explanation!" To "Write down the reasons that support your answer"
Dr. Hongki Julie	1. the problem was acceptable	
Dr. Eriga, M.Pd.	1. "the match" words on the problem were quite written once	
Panel Discussion	1. the words "then" should be changed to "will"	
Students	1. students could understand the purpose of the problem, and could read table division of men's football group clearly 2. "match" words were twice, should be written just once	

Table 2. Comments/Suggestions from *Experts* and Students on Unit 2 Problem

Validation	Comments / Suggestions	Revision
Dr. Ross Turner	1. Answering question 6.1 could use other means example by formula	1. Question 6.1 was not revised 2. Questions 6.2 and 6.3 were

	2. Questions 6.2 and 6.3 were not an probability because for the team structure had been determined based on the sport factor of table tennis	not used in the next phase because they were not probabilities. 3. The word "Name" on the words "The Name of the Men's Table Tennis Athlete" and " The Name of the Woman's Table Tennis Athlete " were deleted
Dr. Hongki Julie	1. the problem was acceptable	
Dr. Eriga, M.Pd.	1. The word "Name" on the words "Name of the Table Tennis Athlete" and "Name of The Table Tennis Athlete's Name" was deleted	
Panel Discussion	1. the words "coach trained" changed to "trained by coach"	
Students	1. students could understand the meaning of the problem, and could read table name athletes table tennis men and name athletes table tennis woman clearly	

Based on suggestions / comments from expert reviews, and one-to-one then the problems on prototype 1 were then revised again become prototype 2 that had been valid. The validity of problems from the validator's assessment of the content, construct and language and from comments / suggestions one-to-one phase to the clarity / readability of the problems.Prototype 2 was tested in small group phase.

Small Group

In this phase the problems were tested by 6 students with different abilities. The six students are TM, MF, MRF, AN, AM, and MHD. Based on the small group phase could be concluded that the six students already understanded the problem, understanded the questions and instructions contained in the problems, most students have no difficulty in answering the question, most of the students there was no difficulty in answering the problems, most of the students have been able to answer the problems correctly, but there were still students who had not provided a reason with complete evidence.

At the small group phase in unit 2 problem was found that one of the contents of the table was not used in answering the problem, namely the contents of table "Men's Table Tennis Athlete" so that the problem was revised by eliminating the contents of the table " Men's Table Tennis Athlete ". Based on the small group phase the problem was revised and obtained valid and practical prototype 3. Practicality was seen from the ease of students in understanding the problems. Prototype 3 was then tested in the field test phase. Here were prototype 3 unit 1 and unit 2 problem in figures 1 and 2.

Men's Football Match

Source: //img.antaranews.com

In the men's football match in Asian Games 2014 in Incheon, South Korea, there were 29 football teams that follow the match. The twenty-nine teams were grouped into 8 groups just like the table below.

Grup A	Grup B	Grup C	Grup D
Korea Selatan Malaysia Arab Saudi Laos	Uzbekistan Hong Kong Bangladesh Afganistan	Oman Palestina Singapura Tajikistan	Jepang Kuwait Irak Nepal
Grup E	**Grup F**	**Grup G**	**Grup H**
Thailand Maladewa Timor Leste Indonesia	Korea Utara Republik Rakyat Tiongkok Pakistan	Uni Emirat Arab India Yordania	Iran Vietnam Kirgizstan

(Source: https://id.wikipedia.org/wiki/Sepak_bola_pada_Asian_Games_2014)

In the group stage using a half-competition system (each team played one match againts the others). Two teams which had the highest rank in each group then qualified to the next round by using knockout system (if lost directly fall) until the winner was found. How many matches were in the men's football? Write down the reason that support your answer.

Figure 1. Prototype 3 of Unit 1 Problem

The Arrangement of Table Tennis Players

Source: www.google.com

Table tennis is one of the sports in Asian Games 2018. Indonesian table tennis coach will make the arrangement of table tennis players. Here are the list of Indonesian table tennis athletes:

Female Table Tennis Athlete
Hani Tri Azhari
Novita Oktariyani
Indriyani Lilis
Gustin Dwijatlyanti

Question 1

How many arrangement of women's double table tennis players can be formed by coach? Write down the reason that support your answer.

Figure 2. Prototype 3 of Unit 2 Problem

Field Test

In this phase prototype 3 tested to one class of students of class X IPA 3 consisting of 33 students. In this phase all students worked on prototype 3. The focus of this phase was to determine the potential effects of the problems that were developed on mathematical literacy capability students. Based on the students' work on the field test phase were obtained results those were.

Unit 1 Problem

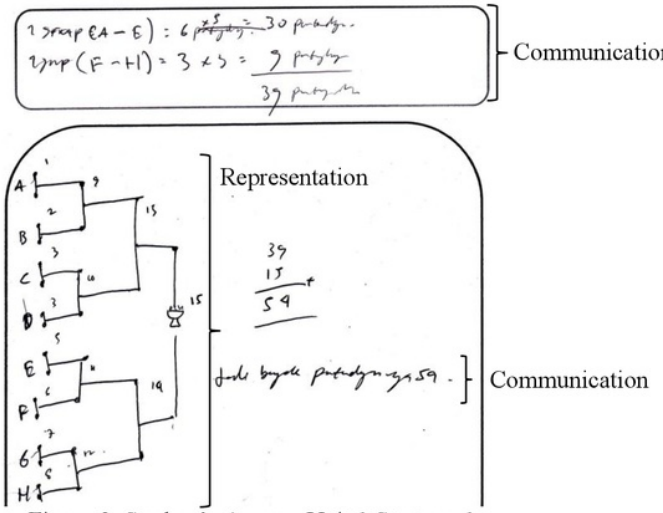


Figure 3. Student's Answer Unit 1 Strategy 1

In Figure 3 was a student's answer strategy in answering unit 1 problem. Based on the student's answer could be seen that the emerging capability was the capability of communication, because students could write the process in reaching the solution that was by using the calculation in the group stage to get the first champion. It showed indicator of communication capability that was writing down the process in achieving solutions. Students could write the process in reaching the solution. In addition the students had concluded the number of men's soccer matches as many as 54 matches. It showed an indicator of communication capability that was concluded mathematical results. Students could conclude mathematical results.

Then from the student's answer could be seen the capability that emerged was representation capability, because students used the match scheme in determining the number of matches after the group stage in Asian Games 2018 to get the first champion, this showed the indicator of representation capability that was using various representations in problem solving that was students can use various representations in problem solving.

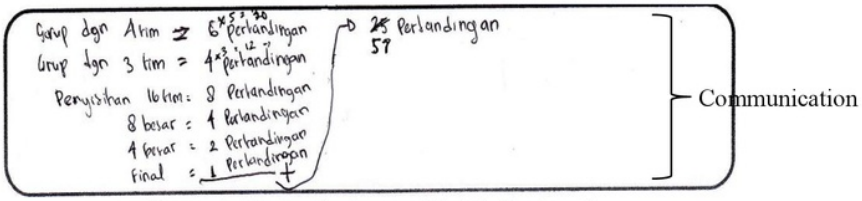


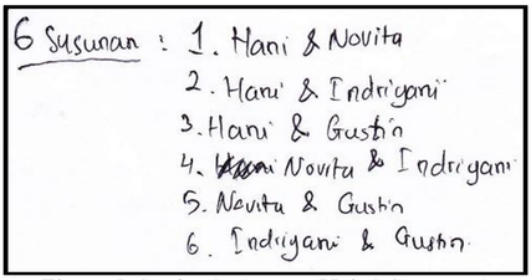
Figure 4. Student's Answer Unit 1 Strategy 2

Figure 4 was another student's answer strategy. From the student's answer it could be seen that the emerging capability was communication capability because students could read and write data from the number of teams in the table of men football group division at Asian Games 2014 then counted the many matches but there was still error in counting the number of matches on each team whose group 3 teams. It showed an indicator of communication capability that waas writing down the process in reaching the solution. Students could write down the process in reaching the solution. In addition the students had already concluded the number of matches that was as much as 57 matches. It showed an indicator of communication capability that was concluded mathematical results. Students could conclude mathematical result.

From the answers of students there were 6 of 33 students could write the process in reaching the solution. Then from the students' answers there were 6 out of 33 students concluding the mathematical results. This showed that students were able to employ communication capability. In addition from the students' answers there are 3 of 33 students could use various representations in solving the problem. This showed that students were able to employ representation capability.

Unit 2 Problem

Communication



Communication

Figure 5. Student's Answer Unit 2 Strategy 1

In Figure 5 was one of the student's strategy to answer unit 2. From the student's answer could be seen the capability that emerging was the communication capability because students could read the table and write women's doubles table tennis consisting of 4 athletes, this showed the indicator of communication capability that was writing down the process in reaching the solution. Students could write the process in reaching the solution. In addition students had concluded the number of arrangements of women's double table tennis player was "6 arrangement" so it showed indicator of communication capability that was concluded mathematical result. Students could conclude mathematical result.

Communication

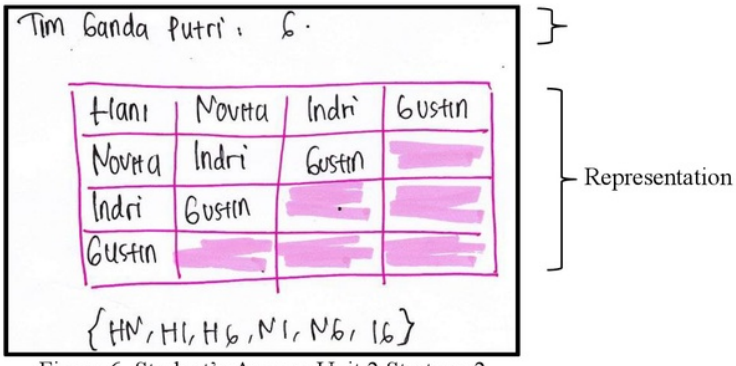


Figure 6. Student's Answer Unit 2 Strategy 2

Figure 6 was another student strategy that researcher was found during the field test. From the student's answer could be seen the capability that emerged was representation capability because students used the table in determining the number of arrangements of women's doubles table tennis players, this showed the indicator of representation capability that was using various representations in problem solving. Students could use various representations in problem solving. Then the students had concluded the number of women's doubles table tennis arrangement was "Tim Ganda Putri: 6" so it showed indicator of communication capability that was concluded mathematic result. Students can deduce mathematical result.

From the student's answers there were 20 of 33 students could write process in reaching solution and could conclude mathematic result. This showed that students were able to employ communication capability. Then from the student answers there were 5 of 33 students could use various representations in solving the problem. This showed that students were able to employ representation capability.

CONCLUSION

This research had produced PISA-like mathematics problems uncertainty and data content as much as 2 units of problems consisting of 2 questions with football and table tennis contexts at the Asian Games 2018. Unit 1 with level 4 and with football context. Then unit 2 with level 3 and with table tennis context. The validity of problems from the validator's assessment of the content, construct and language and from comments / suggestions one-to-one phase to the clarity / readability of the problems. Then for the practicality of the problems was shown in the small group phase, that was students had been able to understand the problems well.

Then the problems those were developed also had a potential effect on mathematical literacy capability students. Mathematical literacy capability that emerged were communication and representation.. Communication capability was shown from students could write the process in achieving solutions and students could conclude mathematic results. Furthermore, the representation capability was shown by the students could use various representations in problem solving. Based on

the results of research and discussion was recommended for teachers and students to can use PISA-like mathematic problems with the context of soccer and table tennis to accustom students working on PISA-like mathematic problem and train mathematical literacy capability students.

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