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SOFT TENNIS AND VOLLEYBALL CONTEXTS IN ASIAN GAMES FOR PISA-LIKE MATHEMATICS PROBLEMS

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Abstract

This study aims to produce valid and practical PISA-like mathematics problems of uncertainty and data content by using soft tennis and volleyball contexts in Asian Games. It also aims to find out the potential effect of the problems on students' mathematical literacy. The method used in this study was design research with the type of development studies. The validity was viewed from expert assessment regarding the content, constructs, language, and students' comments to the clarity of the problems in the one-to-one phase. Then, the practicality was viewed in the small group phase, and it was found that the students could understand the problem well. Based on the answers from 33 tenth-grade students of senior high school, it was found that the problems had potential effects that arouse the ability to use symbolic, formal, and technical language, as well as the ability of operation, communication, and representation. With the problem of the soft tennis context, five students could apply the ability to use symbolic, formal, and technical language, and operations, 12 students could apply representation ability, and 16 students could apply the communication ability. Meanwhile, with the problem of the volleyball context, 18 students could apply the communication ability, and nine students could apply the representation ability.

Keywords: Asian Games, Design research, Mathematical literacy, PISA.

Abstrak

Penelitian ini bertujuan untuk menghasilkan soal matematika tipe PISA konten *uncertainty and data* dengan menggunakan konteks cabang olahraga *soft tennis* dan voli pada Asian Games yang valid dan praktis, serta mengetahui efek potensial soal terhadap kemampuan literasi matematis siswa. Metode yang digunakan dalam penelitian ini adalah *design research* dengan tipe *development studies.* Kevalidan soal terlihat dari hasil penilaian validator dari segi konten, konstruk, dan Bahasa, serta dari komentar siswa terhadap kejelasan/keterbacaan soal pada tahap *one-to-one*. Kemudian, kepraktisan soal terlihat pada tahap *small group*, yaitu siswa dapat memahami soal dengan baik. Berdasarkan jawaban dari 33 siswa kelas X SMA, diperoleh bahwa soal memiliki efek potensial yaitu memunculkan kemampuan menggunakan bahasa simbolik, formal, dan teknik, serta operasi, kemampuan komunikasi, dan kemampuan representasi. Pada soal dengan konteks *soft tennis*, diperoleh lima siswa dapat menerapkan kemampuan bahasa dan operasi simbolis, formal, dan teknis, 12 siswa dapat menerapkan kemampuan representasi serta 16 siswa dapat menerapkan kemampuan komunikasi. Sedangkan pada soal dengan konteks bola voli diperoleh 18 siswa dapat menerapkan kemampuan komunikasi dan 9 siswa dapat menerapkan kemampuan representasi.

Kata kunci: *Asian Games, Design Research*, Literasi matematika, PISA.

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In this modern age, mathematical literacy is very important for everyone to face the matter encountered in everyday life. Ojose (2011) mentions that mathematical literacy is the knowledge for knowing and using basic mathematics in everyday life. Also, the main idea of mathematical literacy is the use of mathematical science in human life (Stacey & Turner, 2015). However, the importance of this mathematical literacy has not been in line with the achievements that Indonesian students got in the international assessment. One of the international assessments that assess this mathematical literacy is PISA (Program International Student Assessment). In the PISA study results in 2012, Indonesia was in ranked 64 out of 65 countries with an average score of 375 from the OECD country average score of 494 (OECD, 2013), and in the latest PISA study results in 2015, Indonesia ranked 63 out of 70 countries with an average score of 386 from OECD country average score of 490 (OECD, 2016). Based on the results of the last two periods of mathematical literacy, Indonesia is ranked at the bottom with a low average based on the OECD country average.

In mathematical literacy, it is explained that there are four contents used in PISA problems. One of the content is “uncertainty and data”. This content is the heart of mathematical analysis for many situational problems, and it is also the theory of opportunity and statistics as a technique for data representation and description (OECD, 2016). Therefore, the content is important in mathematical literacy because it can help students to analyze mathematical problems. However, the result of PISA for this content is in line with the achievement of Indonesian students' mathematical literacy, in which based on the 2012 results Indonesia got an average score of 384, which was still below the average score of other countries and the for “uncertainty and data” content was 493 points (OECD, 2014).

Various things can cause the low achievement of students in PISA. One of them is the evaluation system in Indonesia that still uses the low-level problem, and the students are accustomed to acquiring formal mathematical knowledge in the classroom so that the ability of non-routine problem solving or high-level problem solving becomes weak (Stacey, 2010: Wu, 2012; Novita, Zulkardi, & Hartono, 2012). Indonesian students are weak in solving problems that require them to give opinions or make reasoning (Firdaus, Kailani, Bakar, & Bakry, 2015). Also, Indonesian students have difficulty in solving PISA-like mathematics problems using the context and in turning them into mathematical problems (Wijaya, van den Heuvel-Panhuizen, Doorman, & Robitzsch, 2014).

Therefore, one of the efforts that can be done is to encourage teachers and students to plan a PISA- based learning and design a learning evaluation which is by the characteristics of PISA (Kohar, Zulkardi, Darmawijoyo, 2014). Besides, teachers are also required to be able to design the problem using a context which is close to the life of their students (Zulkardi & Putri, 2006). The learning emphasizing the context or situation is the PMRI Approach. According to Zulkardi and Putri (2006), PMRI approach is a learning approach that uses context as a starting point for students to develop the understanding of mathematics and simultaneously use the context as a source of mathematical applications. It is one of the learning approaches that will lead students to understand the concept of mathematics by their self-constructing through previous knowledge related to their daily life; which was then, it is hoped that the student learning becomes meaningful (Putri, 2011).

The game is a context that can be used. It has an entertainment side that can motivate students in learning so that there is increasing understanding of students about the concept contained in the game (Wijaya, 2008). This context can be found in one of the sports conducted in the Asian Games. The Asian Games is the Asian sports festival held every four years. The sports branches at the Asian Games can assist students to understand mathematics learning. Putri and Zulkardi's study (2017) employed the context of shot-put, Nasution, Putri, and Zulkardi's study (2017) discussed the context of dayung, Roni, Putri, and Zulkardi's study (2017) discussed the context of sprint, Gunawan, Putri, and Zulkardi's study (2017) used the context of swimming, and Rahayu, Putri, and Zulkardi's study (2017) used the context of hurdles. These studies show that the context of the Asian Games sports can attract students' interest in learning.

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. For example, Mardhiyanti, Putri, and Kesumawati (2013) developed the PISA problem to measure students' mathematical communication ability; Kamaliyah, Zulkardi, and Darmawijoyo (2014) developed level 6 PISA problem for junior high school; and Oktiningrum, Zulkardi, and Hartono (2016) developed the PISA-like mathematics task with the context of Indonesian natural and cultural heritage.

Therefore, we were interested in developing the PISA-like mathematic problem with the sports branches conducted in Asian Games. Based on the description, this study aimed to generate valid and practical mathematical PISA-like problems of “uncertainty and data” content by using soft tennis and volleyball contexts in the Asian Games and to know the potential effect of the problems on students' mathematical literacy.

METHOD

The method used in this study was design research with the type of development studies. This study consisted of two main stages; preliminary and formative evaluation stages (Zulkardi, 2002). In the formative evaluation stage following the developing flow, the steps included self-evaluation, expert reviews, one-to-one, small group and field test (Tessmer, 1998). Moreover, the panel discussion (item panelling) was also conducted in the expert review phase.

In the preliminary stage, we determined and analyzed the place and subjects of the study. The subjects of this research were the tenth-grade students of Senior High School. Also, we conducted the analyses of curriculum and mathematical PISA-like problems based on the 2015 PISA framework. Next, we designed the problem set which included the problem grids, problem cards, and scoring rubric. Then, the next stage was the formative evaluation.

In the formative evaluation stage, the first phase was self-evaluation. It is the phase where the researcher evaluates his own instructional (Tessmer, 1998). In this phase, we evaluated and re-examined the PISA-like mathematics set prepared previously. The result was called prototype I. Then, it proceeded to the expert reviews and one-to-one phases simultaneously. Expert reviews are the phase undertaken by experienced experts to evaluate the problems. The experts assessed prototype I by evaluating it based on the content, constructs, and language. In the expert reviews phase, panel discussion was also conducted. The panel discussion is one of the important step numbers in the development of high-quality test items. The panel discussion was conducted with a lecturer of

Mathematics Education of Sriwijaya University and Mathematics colleagues of Sriwijaya University who also did researches on developing the PISA-like mathematics problems

In the same time, the one-to-one phase was also conducted. At this phase, the prototype I was tested to three students. The students employed were the tenth graders of Senior High School by having different abilities. They were one student with high ability, one student with medium ability, and one student with low ability. The selection of students in this one-to-one phase was based on the discussion with the teacher who taught them mathematics. The focus of this one-to-one was to get students' comments on the clarity/legibility of the problem's intention, a suggestion for improvement and to investigate the reasons for the difficulty of solving the problem. We made the results and findings in the expert reviews and one-to-one phases as a consideration to revise the Prototype I. The result of the revision was called Prototype II.

Prototype II was tested in a small group phase. Six tenth-grade students of Senior High School with different abilities were involved in this phase to work on the problems and provide suggestions and comments to find out the practicality of the problems. The six students were two students with high ability, two students with medium ability, and two students with low ability. Same as the one-to-one phase, we also discussed with mathematics teachers who taught in the class in determining which students to be involved in this small group phase. The comments and findings at this small group phase were taken into consideration in revising the Prototype II. The revision of Prototype II was called Prototype III.

Prototype III was then field tested to the subjects of the study, 33 tenth-grade students of Senior High School. The result of the field test was to determine the potential effects of the problems. The potential effect was to find out which mathematical literacy ability appeared from the problems developed by analyzing the results of the student's answering strategy.

The data collection techniques in this study included documentation, walkthrough, tests, observations, and interviews. The developed problem set focused on three criteria, namely the validity, practicality, and effectiveness (Nieveen, 2007). The validity of the problems was viewed from the validation results done by experts regarding content, constructs, and language in the phase of expert reviews. Moreover, the instrument is considered to be practical if the problem can be understood by the users. For example, when looking at the problem, students do not find any difficulty in interpreting the intention, language, or how to use the instructions; even if they find one, students can get through it easily.

On the other hand, the instrument is said to be effective if the experts and practitioners based on their experience state that the instrument (problem) has a potential effect on the ability of students (Van den Akker, 1999), and in this study, it is the ability of students' mathematical literacy. Also, the effectiveness implies that the outcome of the use of a product should be consistent with the objectives of the study (Zulkardi, 2002), in which this study focused on the potential effect of the problems on students' mathematical literacy abilities. To find the emerged mathematical literacy can be by analyzing students' answering strategy based on indicators and descriptors of each mathematical literacy ability which is by the PISA 2015 framework.

RESULT AND DISCUSSION

This research produced 14 PISA-like mathematics problems with sports branch contexts in the Asian Games. However, this study focuses on two problems with the context of sports games (soft tennis and volleyball) with the content of "uncertainty and data".

Preliminary Stage

The preliminary stage involved the student analysis, curriculum analysis, as well as PISA problems and the design analyses. We designed the problem by analyzing and studying the existing mathematical PISA problems. For the problem with soft tennis context, we developed a problem by reflecting the 2006 PISA problem "choice" which asks about how many combinations of pizza with different topping that can be selected. From this problem, we designed "soft tennis players formation" mathematical problem using the context of soft tennis sports. This problem had two questions. Question 1 asked how many sets of man and woman's soft tennis players could be formed by the coach using the sample space concept, while Question 2 asked the chance of choosing one soft tennis player by using the concept of probability. The predicted level for the problem was Level 3.

In the problem of volleyball context, we were also inspired by the "choice" problem of PISA in 2006. From this problem, we designed the problem for "women's volleyball" using the volleyball sports context. This problem asked the number of matches that could occur from two groups in the preliminary round. To solve this problem, the concept of sample space can be utilized. The predicted level of the problem was Level 4. In the preliminary stage, the problem set included its problem grids, problem cards, and scoring rubrics which were called the initial prototype. After the initial prototype was designed, the next stage was the formative evaluation stage.

Formative Evaluation Stage

Formative evaluation stage involved self-evaluation, expert reviews, one-to-one, small group, and field test phase. In the self-evaluation phase, we analyzed, evaluated, and reviewed the initial prototype from the preliminary stage. We found the error or the minus of the problems by paying attention to the characteristics that became the focus of the prototype including the three characteristics: content, constructs, and language. The result obtained was called Prototype I.

The prototype I was validated at the expert review phase regarding content, constructs, and language by three experts, namely Kaye Stacey (University of Melbourne, Australia), Ross Turner (ACER, Australia), and Hongki Julie (Sanata Darma University Yogyakarta, Indonesia). The validation process was conducted through mail review with the assistance of Kaye Stacey, Ross Turner, and Hongki Julie. In the expert review phase, the panel discussion was also conducted with three lecturers of Sriwijaya University of Palembang and nine Master's students of Mathematics Education of Sriwijaya University who were also developing the mathematical PISA-like problems.

Along with expert reviews phase, Prototype I was tested to three tenth-grade students of Senior High School with different (high, medium, and low) ability. The three students were S, MA, and AG. During the process, we observed and found out how each student answered and understood the problem. Table 1 describes the comments for Prototype I of soft tennis problem.

Table 1. Comments from experts and students on the soft tennis problem

Validation	Comments/Responses	Revision
Ross Turner	- The Competencies are no longer used in PISA. - The second problem is less appropriate to use the probability because the team selection is not random, and pay attention to the meaningfulness of the questions because mentioning single player is doubtful since the problem concerns a mixed player.	- The competency is no longer used in the problem card. - Change the sentence of the first problem by simply asking the order of players on the soft tennis men's doubles. - The second problem is not used in the next stage because it is not the material for probability.
Hongkie Julie	- Problems are accepted.	
Panel discussion	- Use the first question only.	
Student	- For Problem 1, the sentence is confusing because of it concern about the sets of the team for soft tennis women's double and men's doubles players; it raises the double meaning.	

Furthermore, Table 2 describes the validation comments for the volleyball problem. It also consisted of expert judgement, panel review, and students' response.

Table 2. Comments from experts and students on the volleyball problem

Validation	Comments/Responses	Revision
Ross Turner	- This problem is okay, but you need to design a response coding scheme.	- Sentences in the questions ask about total matches until the final round.
Hongkie Julie	- Questions on the subject should not only be in the preliminary round but add up to the final round.	- Revisions on spelling; 'volli' becomes 'volleyball', and 'grub' becomes 'group'.
Panel Discussion	- The question should cover the matches until the final round.	
Student	- Errors in spelling; 'Volii' should be 'Volleyball' and 'grub' should 'group.'	

The results of the expert reviews and one-to-one were used to revise Prototype 1. The revision of Prototype 1 was called Prototype II. The valid Prototype II was then tested to six tenth-grade students of senior high school in the small group phase with two students with high mathematics abilities named RA and NM, two students with medium mathematics ability named MD and DN, and two students with low mathematics ability named IS and MAG. In the small group phase, it was found that the six students could understand the purpose of the problem, understand the instructions or questions contained in the problem, as well as see and read pictures and tables.

From this stage, there was a revision to soft tennis context. The image and the "female soft tennis" as one of the contents in the table were omitted because they were not used or did not assist students to answer problems and caused different meanings when students completed the answer on the problem. Finally, the problem was revised to produce Prototype III which was tested in the field test phase. The result of Prototype III of the soft tennis problem is illustrated in Figure 1.

SOFT TENNIS PLAYERS FORMATION

Soft Tennis is one of the sports that will be in conducted at the upcoming Asian Games 2018.

Source : https://m.tempo.co/read/news/2013/02/03/100458745/tim-piala-davis-indonesia kalah-telak-dari-jepang

Here are the names of Indonesian Soft Tennis athletes

No	Men's Soft Tennis Athlete
1	Hendri Susilo Pramono
2	Edi Kusdaryanto
3	Prima Simpatiaji
4	Ferdy Fauzi

Determine the formation of men's double soft tennis players that coach can form? write down the reasons that support your answer.

Figure 1. Prototype III on the soft tennis context

The result of Prototype III of the volleyball context is illustrated in Figure 2.

Volleyball Women

There are four rounds in the volley competition, namely preliminary round, the quarter-final round, the semi-final round, and the final round. In the 2014 Asian Games' women's volleyball matches, there were nine volleyball teams who participated in the game. The nine female volleyball teams were divided into two groups in the preliminary round as shown in the table below:

GROUP A
South Korea
Thailand
Japan
India

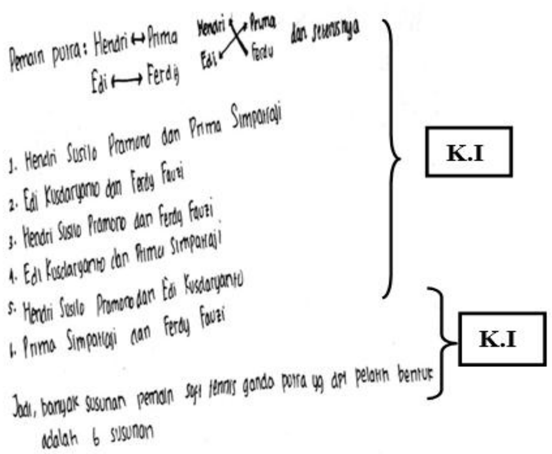
GROUP B
RRC
Chinese Taipei
Kazakthstan
Hongkong
Maldiv

In each preliminary round group stage, each team played with one another. There was one of the women's volleyball teams that had to be eliminated in the preliminary round to continue in the quarter-finals. In the quarter-finals, each team only competed once. Then the game was continued by using the knockout system (the losing team directly eliminated) until the winner was determined . How many total of women's volleyball matches? Write down the reasons that support your answer.

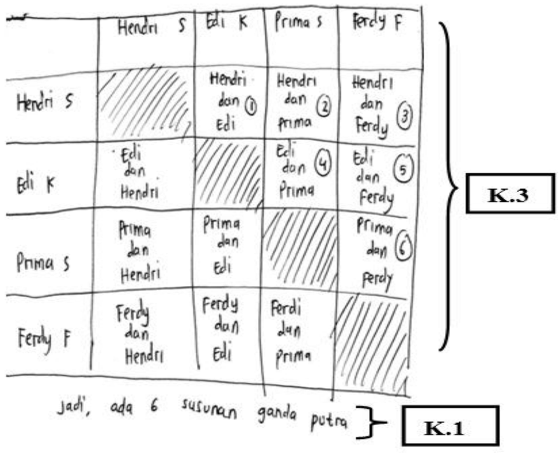
Figure 2. Prototype III on the volleyball context

Potential Effect of the Problem

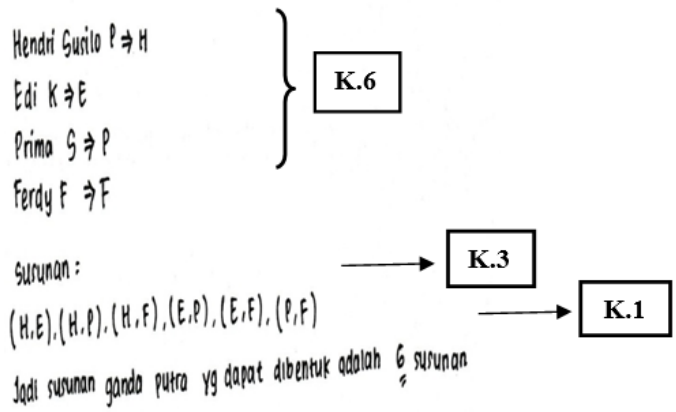
The valid and practical Prototype III was then tested in the field test to see the potential effects on the students' mathematical literacy ability. The implementation of the field test was done with the 33 tenth-grade students of senior high school. The obtained results based on their answers in the field test can be seen in Figure 3.



(a)



(b)

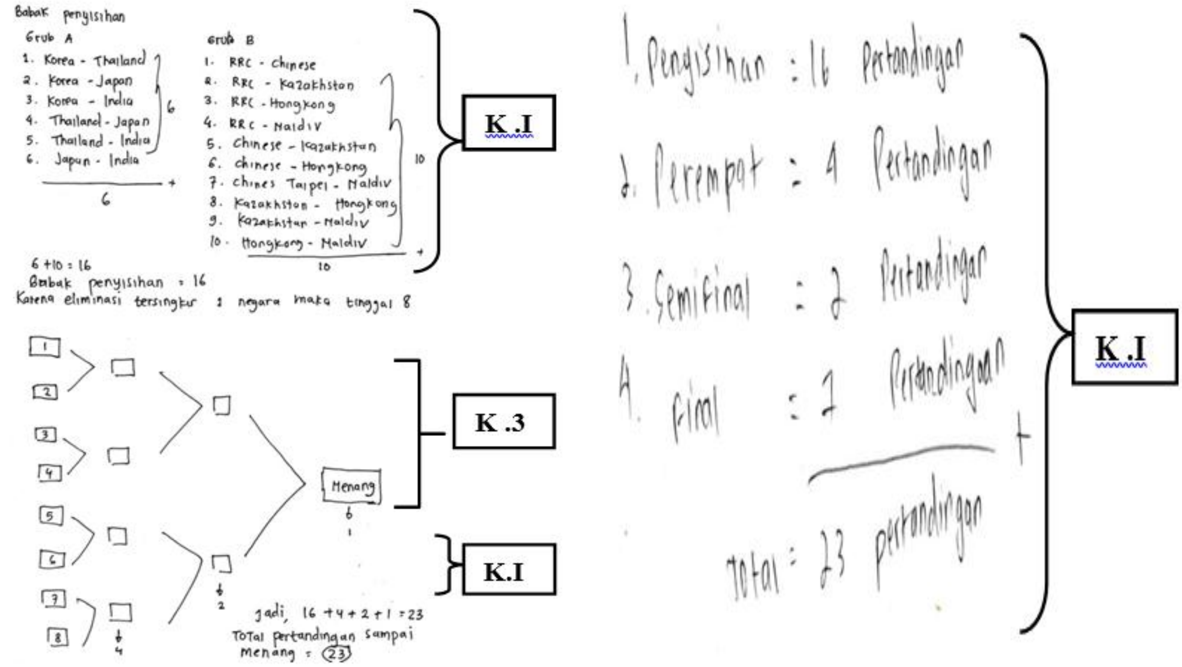


(c)

Figure 3. Students' answer strategies for soft tennis context problem

Figure 3 shows that the students' answering strategies were different, but their answering conclusion was the same. Figure 3a shows the result of the students' answers which indicated that the problem could elicit communication ability (K.I) because they could write the process in reaching the solution and conclude the mathematical result which was the indicator of their communication ability. Students could write the process of achieving the solution because they could read the table of the man's athletes' name then wrote the pair of men's doubles consisting of 4 athletes. At the end of the completion, the students concluded the mathematical result by stating that there were six sets of men's doubles players that could be formed. In contrast to the student's answering strategy in Figure 3b, the students' answers emerged the representation ability (K.3) because the students had used the representation in the table to solve the problem. It is an indicator of representation ability which used various representations in problem-solving.

Meanwhile, at the end of the completion, the students concluded the answer to the representation made. There were six sets of men's athlete which could be formed. This phenomenon showed that the students could conclude mathematical results, and this was one of the indicators of communication ability. Meanwhile, the students' answering strategy in Figure 3c triggered the ability to use symbolic, formal, and technical language, and operations (K.6) because the students used variables to write men's athletes' names, this was an indicator of K.6 which used the formal form based on mathematical definitions and rules. After assuming the names of those soft tennis athletes in the form of variables, students paired each variable to form the formation of players. Students used the concept of sample space by registering. It shows their answering strategy that raised the representation ability (K.3). Then, they concluded there were six men's doubles players who could be formed, and this was an indicator of communication ability (KI), namely concluding the mathematics result. Based on the answer strategy of 33 tenth-grade students of Senior High School on the problem of soft tennis context that we found during the field test process, 5 students could apply the ability of using symbolic, formal, and technical language, and operations, 12 students could apply representation ability and 16 students could apply communication ability.



(a) (b)

Figure 4. Students' answer strategies for volleyball context problem

Figure 4 shows the two students' response strategies. Figure 4a showed the result of students' answers that emerged the communication ability (K.I). This phenomenon was based on the indicator of the communication ability, namely writing the process to get the solution. It can be seen from the students who wrote the process of getting the number of matches in the preliminary round by outlining every game in group A and group B so that the students could get 16 matches in the round. They continued creating a scheme to know the number of rounds up to the final round. Their steps in creating the scheme to show the answering strategy emerged the representation ability (K.3), with the indicator of using various representations in problem-solving. Then, the steps also emerged the communication ability because it concluded the mathematical results of summing each total match obtained up to the final round with the 23 total numbers of matches.

On the other hand, Figure 4b from the results of students' answering strategies could generate the communication ability (KI) because students could write the amount of every match in the preliminary, quarterfinal, semifinal, and final rounds. This result shows the communication ability (K.I)'s an indicator that is writing down the process of getting the solution. Then the students added up the overall match that had been implemented so that they obtained 23 games as a conclusion for the mathematical results. It was an indicator of communication ability (K.I).

From the results of 33 students' answering strategy on the problem of volleyball context which we found during field process, it was obtained that 18 students were able to apply communication ability and nine students who could apply representation ability.

CONCLUSION

This study produced PISA-like mathematics problems of uncertainty and data content by using soft tennis and volleyball contexts in Asian Games. The validity was viewed from the assessment of experts regarding content, constructs, and language, as well as from students' comments on the clarity/readability of the problems in the one-to-one phase. In addition to that, the practicality was seen from the way students understand and use mathematical PISA-like problem well enough. Information or guidance in the form of either picture or table contained in problems could be read clearly in the trial small group phase. Based on the analysis of students' answering strategies at the field test phase, it was found that the problems had potential effects that increase the ability to use symbolic, formal, technical language, and operations, communication ability, and representation ability. To sum up, it is suggested for teachers and students to use PISA-like mathematics problems with soft tennis and volleyball context to familiarize students with PISA problems.

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