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PISA-Like Problems With Swimming Context

Eko Septiansyah Putra[1, a)], Ratu Ilma Indra Putri[2, b)], Ely Susanti[3, c)]

[1, 2, 3] *Faculty of Teacher Training and Education, Sriwijaya University, Srijaya Negara Street, Palembang, Indonesia*

[a)] Corresponding author: ekoseptiansyah.putra@yahoo.com
[b)] ratu.ilma@yahoo.com
[c)] ely_pasca@yahoo.com

Abstract. PISA or Program for International Student Assessment is an international study conducted every three years to see the academic ability of 15-year-old students in reading literacy, mathematics literacy, and scientific literacy. The low result of PISA Indonesian students was caused by many factors, one of which is due to the lack of high-level problem-solving skills, an evaluation system in Indonesia that still uses low-level questions and students are accustomed to acquiring and using formal mathematics knowledge in the classroom. In addition, Indonesian students are only able to answer the questions in the low category and very few even hardly anyone can answer the questions that demand high-level reasoning. This study aims at developing PISA-like problems with swimming context which valid and practical. Items were validated by four experts at the expert review and three students on one-to-one. The valid-set problem developed by a strong theoretical rationale, which meets the criteria framework and level of the level of PISA. Practicality saw from small group test results involving six students. Practical- easy used, can be administrated and can be interpreted well by students. The research method is design research type development studies. Data collection techniques used include walkthrough, documentation (photo and video), interviews and tests. The item declared valid by a validator consisting of experts. The item had also been tested in small groups to see the practicality of the problem. The results of this study generated PISA-like problems with swimming context which valid and practical.

Keywords: Development Studies, PISA, Swimming

INTRODUCTION

PISA or Program for International Student Assessment is an international study conducted every three years to see students' academic ability, 15 years of age in reading literacy, mathematics literacy, and scientific literacy [1]. Many students' math skills, especially Indonesian students, are revealed in the results of the PISA study. Based on the results of PISA showed that students who can answer questions correctly on the subject of the geometry of 47.5%, statistics 61.96% and quantity 53.7% [2]. The low PISA result of Indonesian students is caused by many factors, one of them is the weakness of problem-solving ability in the high-level problem, the evaluation system in Indonesia still using low-level problem and the students are accustomed to acquire and use the formal mathematics knowledge in the classroom [3], [4]. The low achievement of Indonesian students from PISA results shows that there is something wrong with our education system. Based on observations in schools and interviews with teachers, researchers found that many teachers in schools are accustomed to present learning materials by explaining theories or definitions and then providing an example of a solution and then end with a question exercise. Also, researchers observing books on packages in schools and electronic school books have not integrated the three main components in the PISA problem. It is reinforced by the fact that many of the test materials questioned in the PISA assessment are not contained in the Indonesian mathematics curriculum [5]. Therefore, Kemdikbud advocates the need for a change in the curriculum orientation by prioritizing the essential skills aspects needed by all citizens in the future [6].

According to the principle of assessment on PISA mathematics, the essential ability required by any learner of mathematics is the ability of mathematical literacy. The focus of mathematical literacy ability is that students can formulate, apply, and interpret mathematics into contexts that include mathematical reasoning and use mathematical concepts, procedures, facts, and tools to describe explain, and predict phenomena in life daily [1].

It is certainly in line with the constitution of teacher and lecturer laws which state that teachers should be able to develop their materials. Therefore it is desirable that teachers be able to develop the PISA- like problems using a context close to their students [7]. Learning through the context of everyday life, can not be separated from Pendidikan Matematika Realistik Indonesia (PMRI). Therefore, *Pendidikan Matematika Realistik Indonesia* (PMRI) can be used in developing PISA- like problems using a context close to the learners. PMRI is an approach adapted from realistic mathematics education (RME) in which mathematics learning is a human activity and mathematics must be correlated significantly to the context of the daily life of students as a source of development and application through the mathematical process both horizontally and vertically [8]. PMRI can facilitate students to solve contextual problems, teachers act as mentors, facilitators, or motivators for students, with the aim of exploring ideas or finding a concept to students. Also, student contributions and collaborations in learning are also important in this lesson [9].

In the Asian games 2018 which will be the 18th Edition of the Asian regional multi-event sports event to be held in Indonesia, in two places namely Jakarta and Palembang [10]. The sports branches in Asian Games are very close to everyday life situations. Learning mathematics with the concept of Asian Games can be applied directly across the entire school. By learning about this concept, there will also be two things obtained by each student that students can love math and students can get to know the Asian Games [11]. This is in line with Putri said that learning mathematics through sports can make students prefer mathematics, this is because they will more quickly adapt because it involves daily activities [12]. The concept of learning will be effective and minimize the level of difficulty of students in mathematics. Therefore, this moment, teachers, and students all levels of schools to take advantage of the event as a medium of learning mathematics. There are so many contexts of swimming sports that can be applied to mathematics both from the equipment used, the sporting events and even the sports venues. Zulkardi recommends designing the PISA- like and using it in the practice of mathematics learning in the classroom [13]. With the PISA model problem, it can develop students 'mathematical literacy skills, in line with Putri's statement that the PISA- like a problem is one of the alternative types of questions that can be used to develop students' mathematical literacy skills [14]. Therefore, there are many studies that develop PISA-like problems with various focus, such as measuring student modeling ability, measuring students 'mathematical communication ability, students' math ability, and developing PISA- like problem on connection and reflection process competence. [14], [15], [16]. Based on the description above, this study aims at developing PISA-like problem using the context of swimming sports that are valid and practical ".

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METHODOLOGY

A This research method is design research with the type of development studies [17], [18]. There are two stages in this research: the preliminary study (preparation stage, model development stage) and prototyping (formative study - evaluation and revision phase) including self-evaluation, expert reviews, and one to one, and small group [8], [19].

Data collection techniques used in this study are a document, walkthrough, documentation (photo and video), observation and interview. In the preliminary stage, the researcher determines and analyzes the place and the subject of the research, the researcher also examines some literature on the existing problem development research and analyzes the PISA 2015 framework. Contacts the subject teachers to be used as research sites and prepares other needs such as scheduling and cooperative procedures with classroom teachers which will be used. In this stage, the researcher develops the PISA-like math problem, creates a grid containing the appropriate indicators of the curriculum, designs the problem card, the question grille, the rubric, the interview guide, and the walkthrough sheet. The developing process uses three characterize namely, content, constructs, and language. The three characteristics were validated by the researchers themselves. The resulting product design is called the initial prototype.

At the Expert Review stage, the initial prototype was tested for validity by expert review. Products that are created, viewed, valued, and evaluated by expert review. Experts review the content, constructs and language of the initial prototype that has been created. Experts can also evaluate the prototype regarding the advantages and disadvantages of each item and the whole of the questioning device. Expert review validation process is done by email / electronic mail and by face-to-face (face-to-face). Suggestions from experts and peers will be used for revision of the prototype, where the comments, comments, and suggestions from the expert on the designs that have been made are written on the validation sheet as materials for revision. This problem device was also validated by colleagues through a discussion of "item panel" attended by lecturers and college students. Together with expert review and peers, the initial prototype was also tested to three individual students (One-to-One) with high, medium, and low ability. The focus of this stage is to get students' comments on the clarity of the question intent, propose changes or alternatives, investigate why students are confused or have difficulty or even other

interesting things from some aspect of the problem device. From the revision of expert review, peers, and one to one obtained the second prototype.

At the small group stage, the second prototype was piloted on six students with heterogeneous capabilities. A small group test is used to determine the weaknesses and advantages, effectiveness, and validity criteria of the second prototype that has been designed. The result of the revision of the questions based on suggestions and comments from the small group then produced a prototype third that has been valid and practical.

RESULTS AND DISCUSSION

Preliminary Stage

At this stage the researcher analyzes place and subject of research, the researcher has also studied some literature about the research of problem development that exists and analyzing PISA 2015 framework. Contacting the subject teacher who is used as research place and preparing other needs such as scheduling and cooperative procedure with teacher class which will be used. Then generated PISA-like math problems with swimming context, designing problem cards, grid questions, rubrics, and walk through sheets. After the question device is generated then the question of entering the prototyping stage is the self-evaluation stage, the expert review stage along with the one to one stage.

Prototyping Stage

Self Evaluation- At this stage, the problem device that has been produced will be self-evaluation according to the three characterize that is, content, constructs, and language. The result of self-evaluation is the first prototype consisting of a Pisa-Like math problem with swimming context. Next, the question of entering the prototyping stage, namely the expert review stage in conjunction with one to one.

Expert Review- The expert review stage is a validation stage for the first prototype, qualitatively, regarding content, constructs, and language. The problem device is consulted with experts and peers. The validation process for the first prototype is done through three ways, face-to-face, mails review and discussion of "item panel".

The problem device is consulted with experts, validated in two ways, by way of Mails review involving three experts: Kaye Stacey (Lecturer of Mathematics, University of Melbourne), Ahmad Fauzan (Lecturer of Mathematics, Padang State University) and (Lecturer of Mathematics, Medan State University), and by face-to-face (face-to-face) involving one expert, namely Eriga (Teacher of mathematics, SMA N 1 Palembang). This problem device is also validated by colleagues Arvin Efriani (Student of Graduate University of Sriwijaya) through a discussion of "item panel" with lecturers and students of mathematics education of Sriwijaya University. Discussion of "item panel" is a suggestion from an expert, Prof. Rose Turner, where this discussion is a solution offered when a researcher finds it difficult to get an expert review. In the discussion of "item panel" attended by lecturers and students of Sriwijaya University. In this discussion, the researcher asks peers to validate the design that has been made. In addition to advice and comments provided by peers, comments, and suggestions from lecturers and existing college students can also be used as material to revise.

Based on the validator's observation, it is concluded that the PISA-like math problem with swimming context has met the valid indicator regarding content, construct, and language. At the expert review stage, some experts and peers mostly fix EYD issues, sentences in the matter, layout, some numbers, and schematics. One of expert, Prof. Kaye Stacey commented and suggested that the swimming context has a lot of potentials, and could easily make the questions more sensible. PISA aims to ask a reasonable question than things that look like textbook exercises, such as calculating the speed of a swimming athlete. Based on comments and suggestions from experts and peers, researchers revised the first prototype.

One-to-One - the one-to-one stage is conducted simultaneously with expert and peer tests. At the one-to-one stage, the first prototype question was tested on three students with heterogeneous capabilities. Students are asked to read and observe the problem. This is done so that researchers can observe the responses and constraints faced by students on the given problem. Responses and obstacles observed focus on the legibility and clarity of the meaning of the problem. The one-to-one stage, students are also asked for opinions and comments about the questions that have been given. This comment is taken into consideration for researchers to revise the first prototype.

Based on the results of the expert review, peers, and one-to-one that has been done in parallel, then the first prototype issue was revised again and resulted in a second prototype to be tested at a small group stage. The first prototype and the revision (second prototype) is shown in table 1.

Tabel 1. The First Prototype and The Second Prototype

The First Prototype	The Second Prototype
The item of the first prototype	The item of the second prototype

Renang

Dibawah ini merupakan salah satu cabang olahraga yang ada pada *Asian Games* XVIII, yaitu pertandingan renang gaya bebas.Dalampertandingan renang gaya bebas dibuat beberapa jalur pembatas antar peserta. Jalur ini di buat dengan tali, dimana terdapat dua warna bagian dalam satu tali.

Satu kali gerakan sempurna perenang Indonesia

Satu kali gerakan sempurna perenang Malaysia

Satu kali gerakan sempurna perenang Jepang

Panjang 1 warna dalam satuan sentimeter

Pertanyaan 7:

Bila dalam jarak 96 m perenang Indonesia dapat melakukan 40 gerakan sempurna, estimasi berapa gerakan sempurna dan bagian tali yang dapat dilewati oleh perenang Malaysia dan perenang Jepang dengan jarak yang sama?

Swimming Women's* 4x100 m *Freestyle Relay

Swimming Women's 4x100 m *Freestyle Relay* merupakan salah satu cabang olahraga akuatik, dimana satu tim terdiri dari empat perenang. Perenang pertama akan berenang dengan jarak 100 m, dilanjutkan oleh perenang kedua, ketiga, dan keempat secara estafet. Rekor pertandingan ini dipegang oleh tim Cina dengan waktu 3: 35.63. Pada pertandingan terakhir tim Indonesia mencatatkan waktu 3: 53.18 dengan catatan waktu masing- masing perenang sebagai berikut:

Tabel 2. Catatan waktu *Swimming Women's* 4x100 m *Freestyle Relay* Tim Indonesia

Perenang ke-	Waktu	Jarak ke- (m)
1	28.05	50
	57.99	100
2	1: 26.21	150
	1: 56.78	200
3	2: 24.29	250
	2: 54.79	300
4	3: 22.82	350
	3: 53.18	400

Untuk mempersiapkan tim *swimming women's* 4x100 m *freestyle relay* diajang *Asian Games* 2018, pelatih renang Indonesia akan memberikan beberapa latihan untuk memperbaiki teknik dan mental atlet. Adapun fokus yang jadi inti dari latihan tersebut adalah latihan keseimbangan, latihan otot- otot inti, dan latihan dalam mekanisme dorongan tubuh.

Pertanyaan 4:

Berdasarkan kecepatan dari keempat atlet tersebut, menurut pendapat kalian perenang manakah yang akan di beri porsi latihan lebih banyak oleh pelatih? Jelaskan alasanmu.

Small Group- At the small group stage, the second prototype, which has been valid, is tested to six students. The students involved at this stage are students with diverse mathematical abilities. The results seen in the small group stage are practical problems for students. During the process of answering the question, the researcher records the things that become the students' questions about the problem being done and the researchers also interviewed the students to know the responses, comments, the suggestion as well as to know what difficulties experienced by students.

In practice, in general, the question has been understood and resolved, there are only some parts of the problem that needs to be revised because at first it still raises a different interpretation from the real intention of the question. From these findings, the second prototype will be revised, the result of the revision of the question, based on the suggestions and comments of the students at the small group stage, the resulting third prototype, consisting of one question, is valid and practical. Figure 2 is the third prototype that has been valid and practical.

Swimming Women's* 4x100 m *Freestyle Relay

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Pertanyaan 4:

Berdasarkan tabel 2, menurut kalian perenang manakah yang akan diberi porsi latihan lebih banyak? Jelaskan alasanmu.

Figure 1. Third Prototype

Discussion

The third prototype generated in this research is nine math problems of PISA-like with the context of aquatic sports and bike racing is valid and practical. Viewed regarding PISA content, seven items are included in content change and relationship and two items of quantity content. If based on the PISA context the seven items developed are included in the personal context, one item of scientific context and one item of societal context. Then reviewed by PISA level, one item for each level 1, 2, and 6 and two questions for each level 3, 4, and 5.

However, in this article will be discussed and focused on one item, this problem uses the context of aquatic sports that is swimming context. Based on PISA content, this item is included in the quantity content. If based on PISA context and PISA level, this item is included in the personal context and level 5. Based on small group results, it is found that this item raises many strategies used by students in solving problems on this item. The student strategy that appears on this item is so unique and interesting to discuss, so the researcher is very interested to discuss this item.

At the small group stage, the second prototype was valid and tested to six students. The students involved at this stage are students with diverse mathematical abilities. At this stage two groups were created, each group consisting of three students with varying abilities. During the process of the problem, the researcher recorded the things that become the students' questions about the problem being done and the researchers also interviewed the students to find out the responses, comments, suggestions and to find out any difficulties experienced by the students. Findings, student comments and revision decisions by the researchers when small groups are described in table 2.

Tabel 2. Description of Student Findings/ Comments and Revised Decisions

Nu	Description of Student Findings/ Comments	Revised Decisions
1	Students have understood the meaning of the matter, the table on the problem is clear and very supportive	Problems are maintained without revision
2	Students have understood the purpose of the problem, information about the problem and the table on the matter is clear and very supportive	Problems are maintained without revision
3	Some students still find it difficult to understand the question, the sentence of the question is too long so it makes the question difficult to understand.	Question sentences are shortened.

Nu	Description of Student Findings/ Comments	Revised Decisions
	"Based on the speed of the four athletes, in your opinion which swimmer will be given more training portion by the coach? Explain your reasons."	"According to Table 2, which swimmers will be given more training portion? Explain your reasons."

The following are some discussion of the answers of two groups obtained during the small group stage. In this study, the problem developed and will be discussed a matter that uses the swimming context. Swimming context is chosen because the swimming context is very close to everyday life. The swimming context can also be applied to the math either from the equipment used, the sporting event situation even the sports venue. As well as the swimming context has a lot of potentials, and can easily ask questions more sensible. The following is shown in picture 2, the answers of one student from group 1.

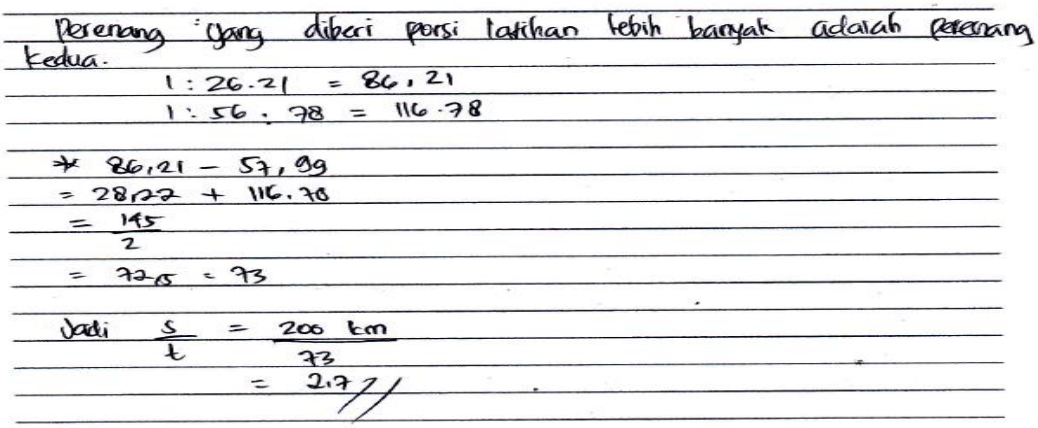
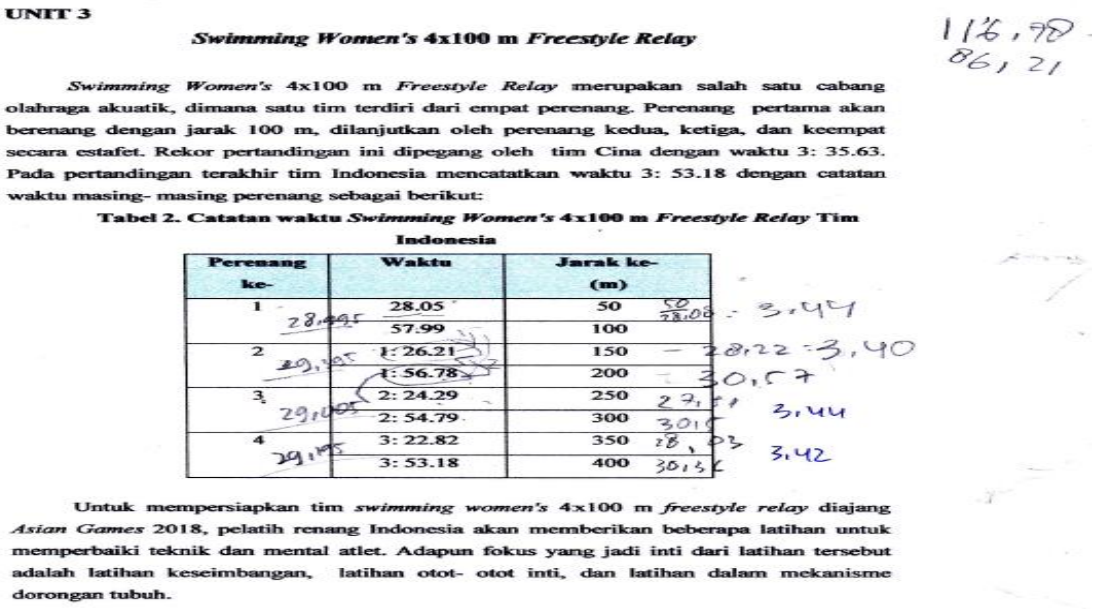

Perenang yang diberi porsi latihan lebih banyak adalah perenang kedua.
1 : 26.21 = 86,21
1 : 56 : 78 = 116.78
* 86,21 − 57,99
= 28,22 + 116.78
= 145/2
= 72,5 = 73
Jadi s/t = 200 km / 73
= 2,7

Figure 2. Answers from One Student in Group 1

In the answer presented in Figure 2, it can be seen that group 1 has understood the meaning of the problem and can answer the problem correctly. Figure 3 also shows that group 1 has solved the problem as expected by the researcher. Group 1 solves the problem using the velocity formula. Group 1 solved the problem by finding all four swimmers' speeds and managed to conclude that the second swimmer received more training portion than other swimmers because the second swimmer had the lowest speed compared to the other swimmers. Here is shown in figure 3, the answer of one of the students from group 2.


UNIT 3

Swimming Women's* 4x100 m *Freestyle Relay

Swimming Women's 4x100 m *Freestyle Relay* merupakan salah satu cabang olahraga akuatik, dimana satu tim terdiri dari empat perenang. Perenang pertama akan berenang dengan jarak 100 m, dilanjutkan oleh perenang kedua, ketiga, dan keempat secara estafet. Rekor pertandingan ini dipegang oleh tim Cina dengan waktu 3: 35.63. Pada pertandingan terakhir tim Indonesia mencatatkan waktu 3: 53.18 dengan catatan waktu masing- masing perenang sebagai berikut:

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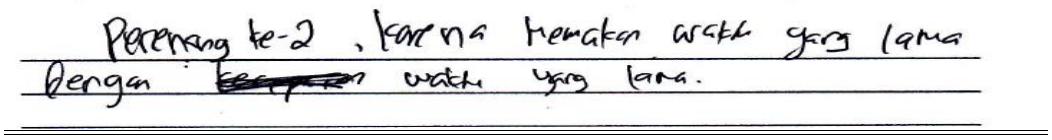

Figure 3. Answers from One Student in Group 2

In the answer presented in Figure 4, it can be seen that group 2 also has understood the meaning of the problem and can answer the problem correctly. In solving the problem group, 2 uses a different way from group 1. Group 2 solves the problem by finding all the average time that the four swimmers have achieved and draws the conclusion that the second swimmer who gets more training portion than the other swimmers because the second swimmer takes the most time compared to other swimmers.

Based on the description above, this problem is declared valid after going through validation process from some validator. The validators assess the problem device in terms of content, constructs, and language. Then give comments and suggestions on the matter. These comments and suggestions are used as a consideration in fixing the problem.

The content rating points consist of the conformity of questions developed with PISA characters. In the validation process, the expert states that the developed questionnaire has met the content rating points of the PISA character. This is visible from the answer on the validation sheet. Therefore it can be concluded that the question device developed has been valid in terms of content.

In the assessment of the construct side, the rating points consist of whether the question of the rich in concepts in everyday life, there are clear instructions for doing the questions, as well as diagrams, drawings, tables, and the like are clearly legible and functional. In general, the expert states that the questioning device has fulfilled the assessment points of the construct. But on some questions, one of the validators thinks the graph on the problem has not been explained clearly. Based on the results of validation and improvements that have been done can be concluded that the question device developed has been valid in terms of construct.

Next is a validity assessment of terms of language. The assessment points in this section consist of the correct and correct Indonesian language formulation according to EYD, the language used by the students to be easy to understand, using uncomplicated sentences, the sentence does not lead to multiple interpretations and the limits of clear questions and answers. Generally, the validator declares the problem device has met the points of assessment in terms of language. It's just that there are some problems that still need to be corrected, editor. Based on the results of validation and improvements that have been done, it can be concluded that the question device developed has been valid in terms of language.

Practical problems that have been developed seen from the observations of researchers and comments/suggestions of students at the small group stage. Practical aspects can be met if experts and students show that what is developed (problems) can be applied operationally in the field [17]. In this case, students can understand the problem device well, in accordance with the student's thinking flow, easy to read, and does not cause a variety of interpretations. At the time of small group trials, there are students who still encounter obstacles in understanding the purpose of the question and the solution. However, after being asked to re-read slowly and repeat certain words, finally, students can understand the intentions of the question well Based on the results and improvements can be concluded that the problem device has been practical.

CONCLUSION

Based on the results of research and discussion it is concluded that one item about PISA-like problems with swimming context developed has valid and practical. The validity of the problems is obtained from the validation process at the expert review stage, the experts and peers evaluate regarding content, construct and language, while the one-to-one results are done to see students' clarity and readability. The practicality of the problems depicted from the small group stage where students can understand the meaning of the problem well, by the students' minds, easy to read, and does not cause a variety of interpretations.

Based on the results of research and conclusions, it is suggested to use PISA mathematics problems with swimming context that has been developed by teaching materials to familiarize students with PISA problem.

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