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Quantity Content: Developing Mathematics PISA-Like Problems with Independence Day Contest Context

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ABSTRACT

PISA is an international scale assessment in which it measure mathematical literacy skills. Indonesia was one of the participants who took part in the PISA assessment. PISA results show that Indonesia is still at a low level. In fact, some study show that the ability of Indonesian students to solve PISA questions on the quantity content of students is not good and is still low compared to other content. This research aims to produce PISA-Like math questions with Quantity content that are valid, practical and have a potential effect on mathematical literacy skills. This research using a development research which consists of preliminary, self-evaluation, expert review, one-to-one, small group, and field test stages. The subjects in this study were students of class IX-4 SMP inone of the junior high schools in Medan. The results of this study are PISA-Like questions with Quantity content in valid and practical criteria. From the analysis of students' answers regarding the potential effect involved in mathematical literacy, the results show that students involve communication skills, reasoning and argument skills, mathematical abilities, representation abilities, devising strategies for solving problems, and using symbolic, formal skill, and technical language and operations.

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A. INTRODUCTION

The Program for International Student Assessment (PISA) is one of the international scale assessments that is carried out regularly every 3 years, and Indonesia has also participated in the assessment from 2000 to 2018. The results of the PISA assessment can be used as a reform of educational practice (Liang, 2010) and curriculum development (Wijaya et al., 2014). As opinion by Goos & Kaya (2020) that reform of the school mathematics curriculum has begun to be reconsidered which leads to the organization of mathematical content and an emphasis on improving mathematical thinking processes. This means that there has been an organization of mathematical content in the curriculum so that it is adapted to the content and abilities needed at this time and in the future. PISA assesses several literacy skills, one of which is measuring mathematical literacy skills. Mathematical literacy results are used as standards for curriculum design, analytical tools to assess curriculum relevance, and instructional planning guidelines (Kolar & Hodnik, 2021).

In measuring mathematical literacy, PISA uses the domains of process, context, and content (OECD, 2018). The content domain is the knowledge that must be drawn on students to formulate problems, solve problems, interpret and evaluate the solutions specified. That is, there is a domain covering some content that must be mastered by students. One of the contents in the PISA mathematical literacy assessment is quantity, which is the most pervasive and essential aspect of mathematics to engage and function in our world (OECD, 2018). Questions with quantity content are of course very widely used in everyday life, such as calculating profit and loss, measuring time, exchanging currency exchange rates, calculating taxes, measuring distances and so on.

The challenges of life that continue to roll in various contexts are related to mathematics and must be solved, thus requiring someone to think mathematically. So it requires to use the skills and competencies gained through experience in school and everyday life to solve problems in the real world (Rizki & Priatna, 2019). Suciati, Munandi, Sugiman, and Febriyanti (2020) state that someone who is sensitive to determining mathematical concepts relevant to a problem is someone who has mathematical literacy skills. The person has the ability to understand, analyze, interpret, evaluate and synthesize the information obtained from the problem at hand, and then model it into a mathematical model and determine solutions using effective mathematical concepts. Stacey (2012) revealed that mathematical literacy is useful in dealing with life problems because it is widely used to help someone understand its role and use in everyday life. Mathematical literacy is important for students to have, because it is useful for facing future challenges in processing problem solving in everyday life (Rahmawati et al., 2021; Saputri & Zulkardi, 2019).

However, the urgency of mathematical literacy skills does not match the facts. This is evident from the results of mathematics PISA Indonesia always occupies the lower class. Good news came from the 2015 PISA results, where Indonesia was ranked 62 out of 70 countries with an average score of 490 (OECD, 2016). Furthermore, the bad news was that the decline in PISA math results occurred in 2018, where Indonesia was ranked 73 out of 79 countries with a math score of 379 out of an average score of 489 (OECD, 2019). Even when Indonesian students are given PISA model questions, students' mathematical literacy skills are still categorized as low (Nurutami et al., 2018). The results of research by Jailani, Retnawati, Wulandari & Djidu (2020) state that students' mathematical literacy skills based on content are also still low. From the results of their research, it shows that mathematical literacy skills based on quantity content are still low, most students are only able to reach the level 1 to level 3 categories, even lower than the content of change and relationship, and uncertainty data. Another fact emerges from the research results of Anisah, Zulkardi & Darmawijoyo (2011) that students' mathematical reasoning abilities in solving PISA model questions on the content of numbers (quantity) are still not so good, only some students can use their mathematical reasoning abilities to solve the problems given on the matter.

The low literacy skills of students are caused by various factors, one of which is that mathematical literacy skills have not been trained optimally (Machromah et al., 2020). Students are not used to being faced with non-routine, complex problems, and only working on ordinary questions (Yansen et al., 2019) and problems with PISA characteristics (Junika et al., 2020). Students' unfamiliarity in solving questions that require literacy skills is caused by unavailable questions. This makes sense because the presentation of problems that require solving everyday problems as tested by PISA in mathematics textbooks is still lacking (Munayati et al., 2015) and the limited problems given by teachers and schools (Junika et al., 2020). Likewise, based on opinion of Pulungan (2014), there is no mathematical literacy test in schools, especially for junior and senior high school students. This is in line with the facts found at the research place, the results of interviews with mathematics teachers show that teacher often give questions that are similar to exercises in mathematics textbooks and only replace the numbers. Furthermore, tecaher often do not present problems with PISA characteristics to be used in learning. The teacher also does not facilitate students with characteristic questions and requires students to use mathematical literacy skills, especially on quantity content. The limitation of high-level skills is also a factor that results in low mathematical literacy skills (Putri & Zulkardi, 2018) this results in students being only able to solve problems that require low-level abilities and are unable to answer problems that require students to think at a higher level (Stacey, 2011, 2012). Furthermore, according to Murtiyasa, Rejeki & Setiyaningrum (2018) Indonesian students still have difficulty in formulating, understanding and transforming problems using context in everyday life. and cannot use mathematical modeling that translates back and forth between the contexts presented by turning them into formal mathematical problems and then evaluating solutions back into real-world contexts (Edo et al., 2013; Jupri et al., 2014). In fact, according to Unver, Hidiroglu, Dede & Guzel (2018) mathematical literacy uses problems in interesting real-world contexts, and requires the use of real-life data in problem modeling. As stated by Charmila, Zulkardi & Darmawijoyo (2016)that contextual questions are able to attract students' interest and motivation so that they are challenged to solve problems, and provide stimulus to students to think critically using their own reasoning in solving them. In addition, questions that use context will make it easier for students to put mathematics into context so that it will help students use literacy skills in answering questions, and can help students use literacy skills in answering questions, and can challenge mathematical thinking patterns (Putra, Zulkardi, & Hartono, 2016).

Effort can be made further train student's mathematical literacy skills, namely by to familiarize students with solving PISA characteristics questions with PISA characteristics are needed (Maharani et al., 2019). So it is necessary to use PISA characteristic questions that are used in learning mathematics. This is supported by the opinion of Hill, Friedland, & McMillen (2016) that the development of mathematical literacy is a demand that must be done by getting used to it in the learning process. Therefore, it is necessary to develop PISA-Like questions that are integrated into the mathematical literacy domain especially in quantity content. Another way to relate to context is by developing problems with PISA characteristics using local contexts, so that the development of mathematical literacy instruments is integrated into learning to make students understand and be close to mathematical literacy problems with PISA characteristics (Pulungan, 2014).

Many researchers have paid attention to the development of PISA-Like questions based on various dimensions of content, context, and process. However, there are still few who develop PISA-Like questions that specifically use the quantity content dimension. Like the study conducted by Putra, Zulkardi & Hartono (2016) who developed the PISA model of math problems with number content to determine students' literacy skills. Furthermore, research from Putra, Putri & Susanti (2018) developed 7 PISA questions with two of them using quantity with swimming context content. However, there has been no research that has developed the PISA-Like question using quantity content with Indonesian independence day contest context. This encourags researchers to develop quantity content questions by integrating them into the Indonesian independent day contest contetx, this is important because the development of PISA characteristic problems can be used as a way to train students with mathematical literac skills.

Based on the problems described earlier regarding students' mathematical literacy skills in the quantity content domain, the development of PISA-Like questions for quantity content with Indonesia independent day contest cotext that is valid, practical and has a potential effect on mathematical literacy skills is considered important to be used by various parties who need it, especially to be used in the learning process. .

B. METHODS

This type of research is development research with design research methods using formative evaluation model ofe development. This research was conducted in two stages, namely preliminary and formative evaluation (Tessmer, 1993), in the formative evaluastion stage which includes self-evaluation, one-to-one, expert review, small group, and field tets. The author uses students of class IX-4 in one of the junior high school in Medan as research subjects. Class was selected based on the availability and timeliness of the study. Data were collected using walk through, document, observation, and interviews using PISA-Like math questions and interview guidelines as research instruments.

The preliminary stage begins with determining the research location, analyzing students, analyzing subject matter, the curriculum used by schools, as well as PISA problems and the 2018 framework. Next, the author makes a draft containing questions that have been developed to be tested for the next stage. The formative evaluation stage consists of stages, self-evaluation, expert review, one-to-one, small group, and field test. In the self-evaluation stage, the question development draft is evaluated and reviewed independently by the researcher. The self-evaluation stage is carried out to review the draft that has been made, the result of the draft improvement is called prototype 1.

Protoype 1 was validated by experts at the expert review stage. The validation of prototype 1 was assessed based on the characteristics of content, construct and language. The author also conducted panel discussions with lecturers and students. The expert review stage is carried out to see the validity of the developed questions. At the same time, the one-to-one stage is carried out by testing questions to three students who have different mathematical abilities. The one-to-one stage is carried out to see the readability of the developed questions. The results of improvements from prototype 1 are called prototype 2. Prototype 2 was tested on students at the small gr oup stage. Six students with different mathematical abilities were appointed to solve problems and provide feedback. The small group stage is carried out to see the practicality of the questions developed. The results of the revise of prototype 2 are called prototype 3. Prototye 3 was tested on students at the filed test stage. A total of 30 students of class IX-4 are intended to solve problems. This stage is carried out to see the potential effect on the mathematical literacy ability. Qualitative descriptive method was used to analyze the data obtained during the study.

C. RESULT AND DISCUSSION

This study resulted in 5 PISA-Like math questions with quantity content with social context. However, this article only discusses one PISA-Like math problem. The stages of the research carried out are described in more detail as follows.

1. The Results of PISA-Like Questions Development

a. Preliminary Stage

At this stage, the researcher determines the place of research on September 13, 2021 for 3 days. Researchers determines and analyzes the students who are used as research subjects, analyzes the curriculum used by the school and designs a draft of the developed assessment instrument. The researchers also interviewed the tecaher and the head of the student affairs department regarding whether a similar research had been conducted out and whether they had previously carried out mathematical literacy test such as PISA, and the results were not. At the research site was used as a place and 30 students of class IX-4 were used as research subjects. Next, the researchers conducted an analysis of the PISA mathematical problems and the 2018 framework as the basis for making a draft of the assessment instrument that was developed, followed by the preparation of a draft from 16 September-1 October.

b. Self-Evaluation

On 2-3 October, the draft that has been designed is then reviewed and evaluated by researchers by checking the suitability of the PISA problem and the PISA 2018 framework. Researchers also review whether there are errors or deficiencies by paying attention to the content, construct and language of the grid, question cards, and rubric scoring. The results of the review are used to improve the draft and the results are called prototype 1 and can be continued to the expert review and one-to-one stage.

c. Expert Review and One-to-One

On 4-13 October, prototype 1 is carried out simultaneously to the expert review stage which is carried out to the validator and to the one-to-one stage which is carried out to students. An expert review was conducted on three validators, namely V1 (validator 1); V2 (validator 2; and V3 (validator 3). In addition, a group discussion forum (FGD) was conducted on prototype 1 with lecturers and master students of mathematics education. Validation and FGD were carried out by evaluating, reviewing and by checking the suitability of the PISA 2018 framework and based on content, construct and language criteria.

Simultaneously, on 5 October prototype 1 was also continued to the one-to-one stage for 3 students apart from research subjects who had different mathematical abilities. The three students were asked to look at the clarity of language, investigate why students are confused or have difficulty and ease of use of the questions presented. Interviews were also conducted with students to obtain student responses and comments on the problems presented. The feedback given by expert reviewers, FGDs and students is presented as shown in Table 1.

Table 1. Feedback from The Result of The Expert Review and One-to-One

Validation	Feedback
FGD	• The decorative design section gives a more contrasting colour, for example red • Replace the word "umbul-umbul". The meaning of the word "umbul-umbul" in some areas may have different meanings • Do not use exclamation points (!)
Validators	• Give a picture of the road with the banners in question • The illustration is clarified by providing a description of the length of the road • In question 1 to be more communicative, present it using a table • The meaning of question 2 is still not clear. Can be slightly changed to "estimate the number of decorations requires on a 100 meter long road?"
Students	• The word "umbul-umbul" is different from what is meant • Confusing images between each road size • Still have typing mistakes

All feedback and responses obtained are used as consideration for revising prototype 1. The results of the improvement are called prototype 2 and can be continued at the small group stage.

d. Small Group

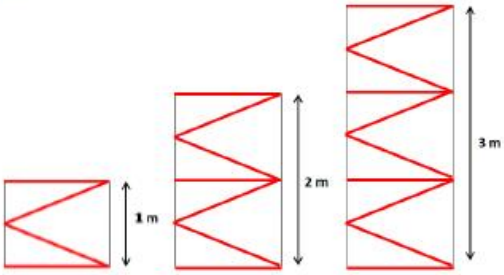
On 15 October, prototype 2 was tested on 6 students apart from research subjects with low, medium and high mathematical abilities. This is known from the data obtained by the mathematics class teacher. Students are asked to solve the problems given, then students are asked to provide suggestions and comments about the problems given. The result of this stage is that students have clearly understood the purpose of the questions being tested, students have also been able to solve problems with various strategies. At this stage, it is stated that the questions developed are practical, this is supported by Zulkardi (2002) that the product is said to be practical when it meets several criteria, including expert statements about the development of items that can be used and student abilities significant for solving and interpreting problems using various strategies. Improvements to prototype 2 are called prototype 3 and can be continued at the field test stage.

The PISA-Like math problem was developed to reflect the 2009 PISA math problem "Apples". In the problem of "Apples" questions about the number of conifers that surround an apple tree, and when there are more apple trees, there will also be more conifers. From this problem, the researcher designed the "Decorate the Road" problem by asking the number of plastic glass decorations needed when the road was getting longer. More clearly, the developed questions can be seen in Figure 1.

Decorate the Road

Dian will decorate Jalan Rasmi Jaya with plastic glasses that are assembled and hung.

Before the decorations were assembled, Dian illustrated the decorations in several sizes of roads in red as shown below.



Question 1.

From the picture above, on a 1 meter road it takes 4 decorations, on a 2 meter road or takes 7 decorations, and so on. Complete the table below.

Road length (meter)	Number of Decoration
1	4
2	7
3	...
4	...
5	...

Question 2.

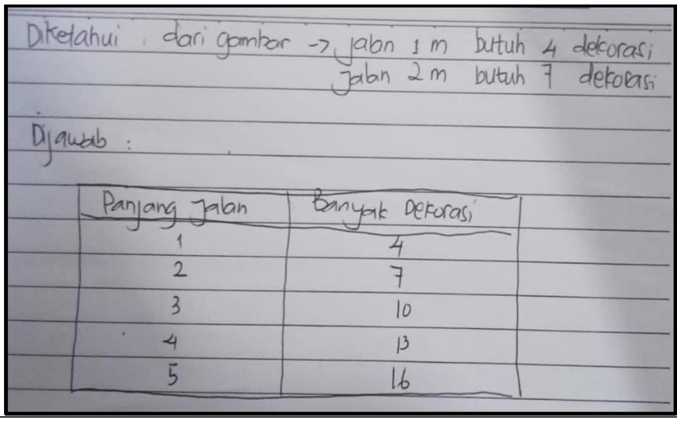
Based on table, it can be seen that for a road length of 1 meter it takes 4 decorations, for a road length of 2 meter it takes 7 decoration, and so on. Estimate the number of decorations needed on a 100 meters road length? Explain how your work!

Figure 2. Prototype 3

e. Field Test

At this stage on 25 October, 30 students of class in one of junior high school in Medan were tested by working on prototype 3. Researchers observed students when students worked on questions to find out the difficulties he faced. One of the objectives of this field test stage is to determine the potential effect on students' mathematical literacy based on the results of the analysis of students' answers. At this stage, questionnaires were also filled out regarding student responses regarding the questions that were solved. The results of the questionnaire, as many as 26 students gave positive responses to the questions given. Furthermore, interviews with 9 students were selected using simple random sampling on 3 categories of students' mathematical abilities. As a results, 7 out of 9 students stated that they were interested in solving problems because the questions presented used contexts that were easy to understand.

The results of the field test stage, in question 1, all students were able to answer correctly. From the results of student answers, one of them was chosen to be analyzed in depth so that the potential effect can be seen. The following are the results of students' answers to question 1 which are presented in Figure 2.



Diketahui : dari gambar -> jalan 1 m butuh 4 dekorasi
jalan 2 m butuh 7 dekorasi

Dijawab :

Panjang Jalan	Banyak Dekorasi
1	4
2	7
3	10
4	13
5	16

Translate in English:

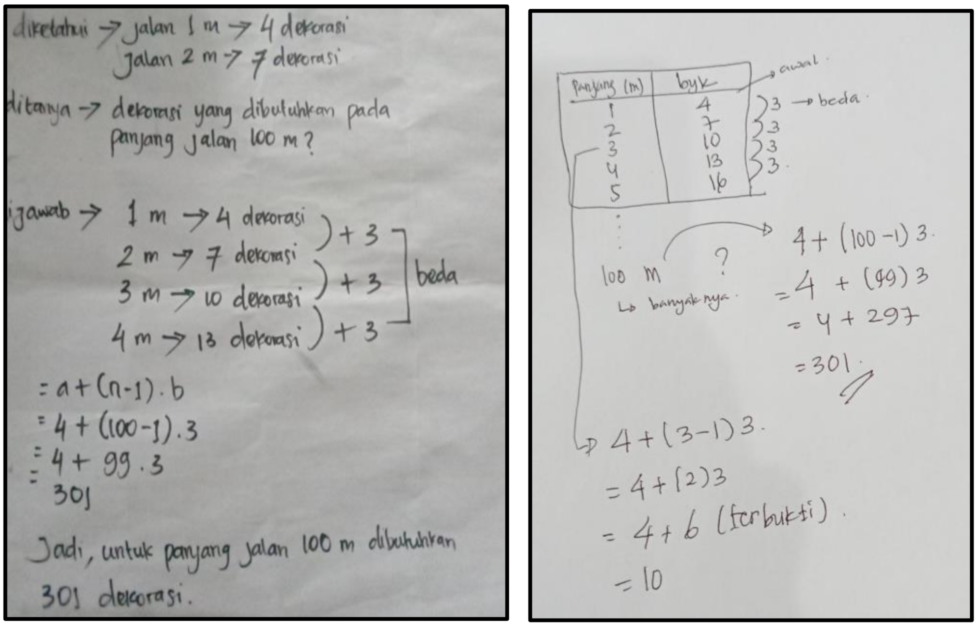
Known: form figure above → 1 m road need 4 decorations
→ 2 m road need 7 decorations

Answer:

Long road	Number of decorations
1	4
2	7
3	10
4	13
5	16

Figure 2. Student answer on question 1

From Figure 2, students are able to involve communication skills although not completely, this can be seen from how students are able to sort out the information need to solve problems. All students did not write down how the process of students getting answers on the answers sheet, students only wrote answers by filling in the black table. However, from the results of the student's scribble analysis and interviews conducted, students got the answer by involving the ability of representation, this is because students illustrate a lot of decorations in the 4 m and 5 m lengths. The results of the field test stage in question 2, 24 students have succeeded in completing the answers correctly. From the results of student answers, two student answers were selected for in-depth analysis so that the potential effect can be seen. The following are the results of students' answers to question 2 which are presented in Figure 3.



Translate in English:

Known: 1 m road→ 4 decorations

1 m road→ 4 decorations

Asked: Decorations needed on a road length of 100 m?

Answer:

1 m → 4 decorations } +3

2 m → 7 decorations } +3

3 m → 10 decorations } +3 } different

4 m → 13 decorations

$= a + (n-1).b$

$= 4 + (100 - 1) \cdot 3$

$= 4 + 99 \cdot 3$

$= 301$

So, for a road length f 100 m it takes 301 decorations.

(a)

Long road (m)	Number of decorations	
1	4 (beginning)	3→different
2	7	3
3	10	3
4	13	3
5	16	

100 m? → $4 + (100 - 1) \cdot 3$

$= 4 + 99 \cdot 3$

$= 4 + 297$

$= 301$

$= 4 + (3 - 1) \cdot 3$

$= 4 + (2) \cdot 3$

$= 4 + 6$ (proven)

$= 10$

(b)

Figure 3. Students' answers on question 2

From Figure 3, both students (a) and students (b) have been able to solve problems with the correct answers and use their respective strategies. Even though both students used answer-solving strategies with their respective strategies, the final solution given was the same. From the results of the analysis of student answers (a), student (a) has involved several abilities in mathematical literacy. Students are able to involve communication skills, seen from students writing down what information is obtained and needed in the problem presented to be used in solving problems and being able to make conclusions from the mathematical solutions obtained. Students write information about the number of decorations needed on 1 meter long road and the number of decorations on a 2 meters long road. Students also write down what is asked in the problem, namely about the number of decorations if the length of the road is 100 m. Furthermore, students (a) also involve mathematical abilities, seen from how students translate the given context in the problem into mathematical form. Students are able to identify real-world context on problems and make assumptions so that they can be used to solve problems. Students write sequentially about the length of the road and the number of decorations, then the students analyse and then make the assumption that every time the length of the road increases by 1 meter the number of decorations will increase by 3 decorations. Students also involve the ability to use symbolic, formal and technical language and operations, seen from students using arithmetic sequence formulas that have been studied previously.

From the results of the analysis of student answers (b) students are able to involve the ability to develop strategies for solving problem, this can be seen from the students who sort out the important information obtained in the problem by reframing the problem which is contextualized mathematically by writing down important information in tabular form. Students also involve their mathematical ability, this can be seen from how students understand the context used in the problem to be translated unto mathematics so that students are able to make mathematical assumptions to solve problems. This can be seen from how students present a table containing the length of the road and the number of decorations in order, then assume that the difference in the number of decorations for each length of the road is a “different” and the number of decorations on 1 meter road is the “start”. This student assumption is used to solve the problem using an arithmetic sequence formula, although students do not write down the formula used, but from the results of the interview, the mathematical steps used refer to the arithmetic sequence formula that asks “S_n”. On the other hand, students involve reasoning and argument skills, this can be seen from students strengthening and defending their answers by proving many decorations on a 3 m long road using the formula used previously.

In general. from the results of the analysis of the answers of students who solve PISA-Like problems with Quantity content, students are able to involve their abilities in mathematical literacy. Students are able to involve communication skills, this is in line with research conducted by Putra, Zulkardi, & Hartono (Putra et al., 2016) when students solve PISA model questions Quantity content also involves communicating information obtained in problems. Furthermore, students involve reasoning and argument skills, this is in line with research conducted by Anisah, Zulkardi & Darnawijoyo (2011) when students solve PISA model question with Quantity content, students involve reasoning abilities, although only some students have very good reasoning abilities in solving a problem. Similarly, research conducted by Maharani, Putri & Hartono (2019) that when students solve PISA-Like math problems, students can involve reasoning and argumentation skills. Students who have good reasoning abilities can certainly solve problems correctly (Ahyan et al., 2014; Permatasari et al., 2018). Other abilities involved by students are mathematizing abilities, representation abilities, devising strategies for solving problems, and using symbolic, formal and technical language and operations.

In addition to the use of the content developed in this question, the use of context is also chosen so that student feel close to the problems presented. The results of the interviews were synthesized that the use of the context presented gave a positive response, because students felt familiar with the context of the questions give and made students feel challenged to solve them. This is supported by Kohar, Wardanu, Fachrudin (2019) and Zulkardi et al (2020) that the use of context can lead students to think mathematically because it invites students to think, brings up mathematical processes and makes learning more meaningful (Putri & Zulkardi, 2020).

D. CONCLUSION AND SUGGESTIONS

This research has produced valid and practical PISA-Like Quantity content math problems. Validity is seen from the results of expert reviews and one-to-one, while practical is seen from the results of testing on students at the small group stage. To see the potential effect on mathematical literacy skills, students answers at the field test stage were analyzed, the results of students generally involved communication skills, reasoning and argument skills, mathematical abilities, representation abilities, devising strategies for solving problems, and using symbolic, formal skills, and technical language and operations. Suggestion that can be given from the results of research that have been carried out are that further research can be carried out to develop more PISA-Like problems. Furthermore, teachers and students can take advantage of mathematical problems that have been developed to be used in learning.

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