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COVID-19 Context in PISA - Like Mathematics Problems

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Abstract

The aim of this developmental study is to design PISA-style quantitative mathematics tasks using a valid and practical COVID-19 context and to investigate the potential impact of these problems on mathematical literacy. This study used a two-phase developmental research design: baseline and formative evaluation. This study also used the Lesson Study Learning Community (LSLC) system in the development and implementation process. Eighth-grade students of SMP Negeri aged 13-15 participated in this study 19 Palembang. Data collection was carried out through walking, documentation, observation, interview and testing techniques. This study produced 6 units and 12 units of PISA-like mathematics tasks with multiple content features in the context of COVID-19, including work, personal and social contexts, and levels consistent with the 2018 PISA framework. and competency processes such as mathematical literacy and standardized language skills that students can apply and interpret. In conclusion, the developed PISA-type math tasks are valid and practical and can influence math and life skills during the COVID-19 pandemic.

Keywords: Development Research, PISA, LSLC, COVID-19 Context

Abstrak

Penelitian ini merupakan penelitian pengembangan yang bertujuan untuk mengembangkan soal matematika kuantitatif tipe PISA dalam konteks COVID-19 yang valid dan praktis serta dapat mempengaruhi literasi matematika. Metode yang digunakan dalam penelitian ini adalah studi pengembangan dua fase, studi desain dengan evaluasi pendahuluan dan formatif. Studi ini juga menggunakan sistem Lesson Study Learning Community (LSLC) dalam proses pengembangan dan implementasinya. Siswa kelas delapan SMP Negeri 19 Palembang berusia 13-15 berpartisipasi dalam penelitian ini. Walk-through, dokumen, observasi, wawancara dan tes digunakan sebagai teknik pengumpulan data. Penelitian ini menghasilkan 6 unit dan 12 unit soal matematika berjenis PISA konteks COVID-19 yang meliputi konteks pekerjaan, personal dan sosial, level sesuai kerangka PISA 2018, keterampilan proses yaitu. literasi matematika. , dengan standar bahasa yang sesuai, siswa dapat menerapkan dan menginterpretasi dengan benar. Dengan demikian, dapat disimpulkan bahwa soal matematika berjenis PISA yang dikembangkan valid dan praktis serta dapat mempengaruhi literasi matematika dan kecakapan hidup untuk menghadapi pandemi COVID-19.

Kata kunci: Penelitian Pengembangan, PISA, LSLC, Konteks COVID-19

INTRODUCTION

Mathematical literacy is a pivotal ability in the globalization era because it can help students understand the role or benefits of mathematics in life (Syawahid & Putrawangsa, 2017; OECD, 2019a; Zulkardi, Putri, & Wijaya, 2020). In addition, in 2019, the Ministry of Education and Culture established a new policy called independent learning which discusses the 2021 minimum competency assessment (MCA) as a national assessment for mathematical domains; one of which is mathematical literacy skills. However, Indonesian students still have relatively low mathematical literacy skills because the results of the 2018 PISA survey show that Indonesia ranks the 72nd of 78 countries with a score of 379 (OECD, 2019b). One of the difficult contents in mathematical literacy at PISA is the quantity, the students show that they still have relatively low competence in it and have difficulties in solving PISA questions in quantity content, especially at levels 4, 5, and 6. These difficulties occur because they could not understand the problem and change real situations into mathematical situations Students could not solve problems because they do not have good reasoning abilities (Wulandari & Jailani, 2018; Noviana & Murtiyasa, 2020).

The lack of PISA-type math tasks in textbooks and specially designed questions that match the potential and character of the students did not make them used to solve PISA-type math tasks (Nizar, Putri and Zulkardi, 2018; Murtiyasa, Rejeki and Setyaningsih, 2018). whereas PISA-style math problems are very necessary for classroom teaching to train students to solve PISA-like math problems;

thus, they can improve their literacy in learning activities such as the mathematization process (Nusantara, Zulkardi, & Putri, 2020a), reasoning, argumentation (Nusantara, Zulkardi, & Putri, 2020b), presentation (Efriani, Putri, & Hapizah, 2019).) and communication (Nizar et al., 2018). In this regard, Pratiwi, Effendi, and Ummah (2020) argue that designing and implementing PISA-type mathematical problems in learning activities is central because the designed tasks adopt familiar contexts so that students can easily understand them. This shows that PISA-style math tasks in familiar contexts train students to solve problems.

The Context-Based Realistic Approach to Mathematics Education (PMRI Bahasa) specifies that mathematics tasks such as PISA are used appropriately for learning (Jannah, Putri, & Zulkardi, 2019; Zulkardi et al., 2020). One of the characteristics of PMRI is the contribution of students, which enables them to actively develop their knowledge in solving a problem (Dewi, Putri, & Hartono, 2018). Student input is very important to the collaborative strategy that will become the 21st-century skills framework (Batelle for Kids, 2019). This collaborative strategy can be applied to the Lesson Study Learning Community (LSLC) (Sato, 2014; Octriana, Putri and Nurjannah, 2019; Estrella, Zakaryan, Olfos, and Espinoza, 2020). In addition, this collaborative strategy can be integrated with the effective use of information and communication technology in appropriate learning, which consists of synchronous and asynchronous learning and is in line with the government's policy, namely distance learning, to fight against the COVID-19- pandemic.

Several studies have investigated the development of PISA-type mathematical problems in different contexts, such as the context of Jambi (Charmila, Zulkardi, & Darmawijoyo, 2016), the context of sailing (Efriani et al., 2019), the context of the Asian Games (Putri). and Zulkardi, 2020), the context of the COVID-19 pandemic (Nusantara, Zulkardi, & Putri, 2021), the context of physical distance (Nusantara et al., 2020b), and the Arab context (Turidho, Putri, Susanti, & Johan, 2021). Freudenthal (Bakker and Wagner, 2020) claims that a popular phenomenon and a hot issue in life can be used to arouse students' interest in learning mathematics.

The researchers are interested in developing PISA problems using the COVID- 19 context. Therefore, research employed the COVID-19 contexts due to 3 reasons. First, moststudents have experienced the COVID-19 pandemic. Second, the COVID-19 pandemic is currently popular and a hot issue. Third, students could understand important things to deal with the pandemic, such as knowing the rules for social distancing, making hand sanitizers, and producing masks. This research aims to develop valid and practical PISA-like mathematics problems on quantity content using COVID-19 contexts that potentially affect students' mathematical literacy skills.

METHODS

This research employed the development research design to create quantity content of PISA problem using the valid and practical context of COVID-19 affecting students' mathematical literacy. Eighth-grade students of SMP Negeri 19 Palembang between the ages of 13 and 15 were included in this study. This study consists of two phases of item development: preliminary evaluation and formative evaluation (Bakker, 2018).

In the preliminary, the researcher examined the literature used in the preparation of PISA-type mathematical tasks, the amount of content in the context of COVID-19, and all the necessary instruments. In addition, the researchers discussed PISA-style math problems that were created with their peers. In addition, validity and reliability tests were conducted to empirically examine the validity and consistency of the questions developed using SPSS. Students from grade VIII.4-VIII.7 at SMP Negeri 19 Palembang participated in this validity and reliability test. The developmental assessment phase included self-assessment, expert assessment, individual, small group, and field tests. First, in the self-evaluation phase, the researchers evaluated and revised all the proposed instruments, taking into account the results of peer-to-peer and post-evaluation. The researchers then revised the evaluation results to produce Prototype I. Second, the modified results of Prototype 1 are validated concurrently with peer reviews and individually. In this phase, three aspects of Prototype I were validated: content, structures and language. Three experts participated in this validation: Universitas Ahmad Dahlan Mathematics Education Lecturer, Universitas Singaperbangsa Karawang Mathematics Education Lecturer and Universitas Sriwijaya Mathematics Education Doctorate Alumni. Meanwhile, a personal assessment was carried out to evaluate prototype I, involving three students of high, medium and low ability in class VIII.3. The peer review and one-by-one phase results were combined and used to revise prototype I and produce prototype II. Third, in a small group phase, eight VIII.1-grade students participated in evaluating the practicality of the developed PISA-type mathematical tasks and checking prototype II for the production of prototype III. Finally, 27 students participated in the field test phase, during which the possible effects of the developed PISA-type math tasks on students' math literacy were investigated.

The data collection techniques of this study were examination, observation, interview and test. The collected data were then qualitatively analyzed. The item was considered valid based on the actual assessment of content, structure and language as well as the results of the student's individual work phase. However, the practicality of the questions was defined by the unfortunate things that were easy for students to use, check and possibly interpret. These things were the results of small group experiments. At the same time, analyzing the results of the field tests revealed the possible effects of PISA-type math tasks.

RESULTS AND DISCUSSION

This study resulted in six units and 12 items of PISA focused on quantity content within the COVID-19 context. However, the researcher made hand sanitizer unit as representations of the development process. This research developed the questions using a research design with a development study type. The stages of implementation are as follows

Preliminary

In the preliminary stage, the researcher conducted a literature study, reviewed the flow of problem development, and analyzed several articles developing PISA-like mathematics problems. Based on this literature, this research has a different focus from the previous research focus because this study has trained students to work on PISA-like mathematics problems in classroom learning.

In this study, the learning process was conducted to train and c students with solving PISA-like mathematics problems by applying the Lesson Study for Learning Community (LSLC) system and the PMRI approach in the learning process. The research subjects were selected based on these two criteria.

At the curriculum analysis stage, the researcher analyzed learning materials based on the curriculum which included quantity content, such as topics of integer operations and comparisons. Furthermore, the researchers analyzed the PISA problems released by the OECD as the basis for developing PISA-like mathematics problems using quantity content in the COVID-19 context. The reference questions and developed questions of this study are summarized in Figure 1.

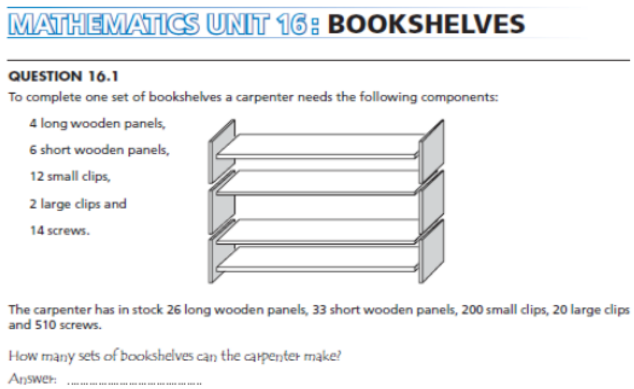
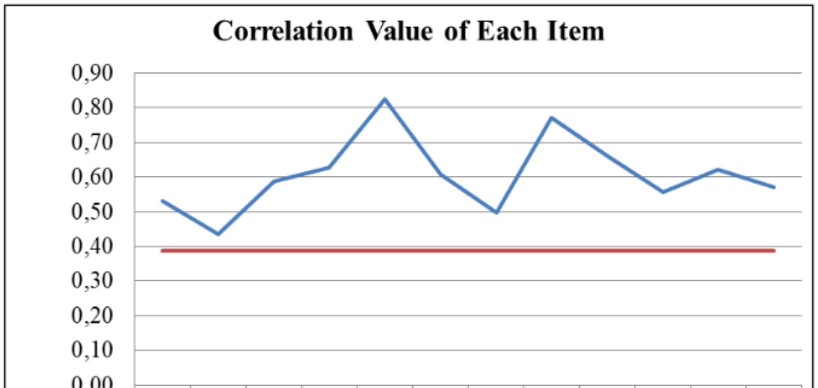
<table>
<tr><td>Original
PISA</td><td>
MATHEMATICS UNIT 16: BOOKSHELVES
QUESTION 16.1
To complete one set of bookshelves a carpenter needs the following components:
4 long wooden panels,
6 short wooden panels,
12 small clips,
2 large clips and
14 screws.
The carpenter has in stock 26 long wooden panels, 33 short wooden panels, 200 small clips, 20 large clips and 510 screws.
How many sets of bookshelves can the carpenter make?
Answer: ……………………………</td></tr>
<tr><td>Developed
PISA</td><td>Hand sanitizers are currently an important ingredient in the Covid-19 virus outbreak, making them scarce and their prices skyrocketing. This hand sanitizer functions as an antiseptic that can kill viruses or bacteria that stick to our hands. To make hand sanitizer based on WHO standards, one 1 liter bottle requires the following ingredients:
Alcohol 96% as much as 840 ml
H_2O_2 3% as much as 40 ml
Glycerol 98% as much as 15 ml
Aquadest as much as 60 ml
Question :
A person has a stock of 6,000 ml of Alcohol, H_2O_2 300 ml, 120 ml Glycerol and 430 ml Aquadest.
How many bottles of Handsanitiser can he make?</td></tr>
</table>

Figure 1 shows that the reference question refers to the 2009 PISA problem. The question asks how many bookshelves can a carpenter make. Furthermore, the researchers blindly paraphrase the question by changing the picture and reformulating the problem into different aspects adopted from the Bairac method. This change results in a PISA-like mathematics problem within the COVID-19 context. This question asks how many bottles of hand sanitizer can be made from available materials based on the WHO standards. The purpose of developing this question is to inform students about the importance of hand sanitizers which are easily made by utilizing available materials. At the same time, the purpose of the reliability test is to examine the reliability of the developed PISA task analyzed using SPSS to determine the validity of the quantitatively constructed questions. The correlation of the 12 items in the validity test is shown in Figure 2.



	Unit1. Soal1	Unit2. Soal1	Unit2. Soal2	Unit3. Soal1	Unit3. Soal2	Unit4. Soal1	Unit5. Soal1	Unit5. Soal2	Unit5. Soal3	Unit6. Soal1	Unit6. Soal2	Unit6. Soal3
r hitung	0,53	0,44	0,59	0,63	0,83	0,61	0,50	0,77	0,66	0,56	0,62	0,57
r tabel	0,388	0,388	0,388	0,388	0,388	0,388	0,388	0,388	0,388	0,388	0,388	0,388

Figure 2. Validity test results of developed PISA item

Figure 2 shows that items 1-6 are declared quantitatively valid, because all items have higher correlations than in the table (0.388). In addition, the reliability test using SPSS with the Cronbach's alpha value of 0.75. This score is greater than 0.6. Therefore, the developed PISA-type math tasks are considered reliable. Validity and reliability tests are not part of the formative assessment phase. However, the tests provide additional empirical information to investigate the validity, consistency and quality of quantitatively developed PISA-type mathematics tasks. At the same time, in the form assessment section, a factual assessment and a one-on-one phase were carried out qualitatively to confirm the content, constructs and language and to improve the developed questions.

Self Evaluation

The researchers then reassessed the PISA - like math problems and rechecked them to identify gaps. As a result, Prototype I is produced, consisting of six units and 12 pieces. The prototype of the PISA-type math tasks I for the hand sanitizer is shown in the following Figure 3.

Hand sanitizers are currently an important ingredient in the Covid-19 virus outbreak, making them scarce and their prices skyrocketing. This hand sanitizer functions as an antiseptic that can kill viruses or bacteria that stick to our hands. To make hand sanitizer based on WHO standards, one 1 liter bottle requires the following ingredients:
Alcohol 96% as much as 833 ml
H_2O_2 3% as much as 41,7 ml
Glycerol 98% as much as 14,5 ml
Aquadest as much as 1000 ml

Question :
A person has a stock of 6,000 ml of Alcohol, H_2O_2 300 ml, 120 ml Glycerol and 430 ml Aquadest.
How many bottles of Handsanitiser can he make?

Figure 3. Prototype I of PISA-like mathematics problems developed for hand sanitizer unit

Figure 3 is the result of improving the self-evaluation of the question by correcting the errors in the information about Aquadest on the question and the solution to improve the answer keys. In addition, the writing hand sanitizer was improved to be skewed due to foreign languages and changes in editorial questions. Thus, the revision of the developed problem is called prototype I.

Expert Reviews and One-to-One Stages

To validate the qualitatively designed instrument, the competence and the personal phase were conducted simultaneously. In the actual evaluation, three experts confirm the content, structure and linguistic aspects of the proposed questions, giving comments and suggestions to improve the developed questions. The validation process of Prototype I with expert ratings was done by sending Prototype I files to each expert's email address. At the same time, in a one-on-one phase, 19-grade VIII.3 students of SMP Negeri Palembang with high, medium and low abilities were surveyed to evaluate prototype I and ask students to comment and answer freely. Comments and suggestions from the prototype I are summarized in Table 1.

Table 1. The experts' and students' comments on hand sanitizer units

Validator	Comments and Suggestions	Revision
Experts	• WHO standards to manufacture hand sanitizer are presented on a table or captured directly from the original WHO source. • Content and context in unit 1 are acceptable. • The content and context in unit 1 are good. However, the scoring rubric should carefully assess students' answers	• The rules of making hand sanitizers could be changed by referring to WHO standards and adding sources from WHO. • The grading rubrics and adding possible answers from some students could be improved
Students	• The information about the questions should be separated from the questions. • The calculation is difficult because it does not use integers	• Not using integers in the question is not accepted on the grounds because this information has been standardized by the WHO standards.

Table 1 shows the comments and suggestions of the experts on aspects of content, structure and language. In addition, Table 1 shows performance and comments one by one. This discovery will be used as material to test prototypes I and II. The peer review and one-to-one phase meant that questions would not be modified based on peer review and student suggestions not to use integers because this information is standardized by WHO. The following questions were modified and the result is Prototype II as shown in Figure 4.

Hand Sanitizer is currently an important part of the Covid-19 virus outbreak, so it has become rare and the price has skyrocketed. This Hand Sanitizer functions as an antiseptic that can kill viruses or bacteria that stick to our hands. Based on WHO standards, to make 1 bottle of Hand Sanitizer size 1 liter requires the following materials:

- Ethanol 96% as much as 833 ml
- Hydrogen Peroxide 3% as much as 41.7 ml
- Glycerol 98% as much as 14.5 ml
- Aquadest as much as 1000 ml

Source : www.who.int/gpsc/Smay/Guide_to_Local_Prodoction

If someone has a stock of 5,400 ml of Alcohol, 260 ml of Hydrogen, 90 ml of Glycerol and 6500 ml of Aquadest.

Question:

How many bottles of Hand Sanitizer can be made from the available materials?

Figure 4. Prototype II of PISA like mathematics problems developed for hand sanitizer unit

Small-Group

In the small group phase, the II prototype was tested with eight VIII.3 grade students. There were four students in each group. The PMRI approach, Lesson study and combined learning are used in the learning process. Synchronous learning was implemented with virtual meetings using Zoom and asynchronous learning with WhatsApp groups.

While working on the questions, most of the students understood the meaning of the questions. However, some still had problems solving the questions because they did not understand the questions and were confused about how to solve the questions. In addition, the researchers recorded the students' questions, interviewed their answers, comments and suggestions, and studied their difficulties. At this point, the researchers did not check the questions because the students fully understood the questions being tested. Therefore, the developed PISA-type math tasks are considered practical. The results used to control prototype II, which would produce prototype III.

Field Test

The field test stage is the final stage of question preparation. At this stage, prototype III trials were conducted at SMP Negeri 19 Palembang. At this stage, the goal of the research was 27 students of grade VIII.2. The students were divided into several groups, with four students in each group. At this stage, we tried to find out the possible effects of mathematical literacy on the points developed by analyzing the students' answer sheets and considering indicators of mathematical ability. Milhana Betty, a grade VIII teacher from SMP Negeri 19 Palembang, was the model teacher in the field test phase.

Learning was carried out using a blended learning method and a collaborative strategy. If the students have difficulties, they can ask for help from their colleagues who already understand the topic by applying the LSLC rule of saying "please teach me", the students who are asked must explain the questions until their friends really understand (Sato, 2014; Putri & Zulkardi, 2020). Octriana et al. (2019) state that the LSLC system requires students to discuss the questions collaboratively by forming the students' self-confidence. Thus, the students could understand and solve the problems, including mathematical literacy skills. The students' answers to question number 1 of the hand sanitizer are summarized in Figure 5.

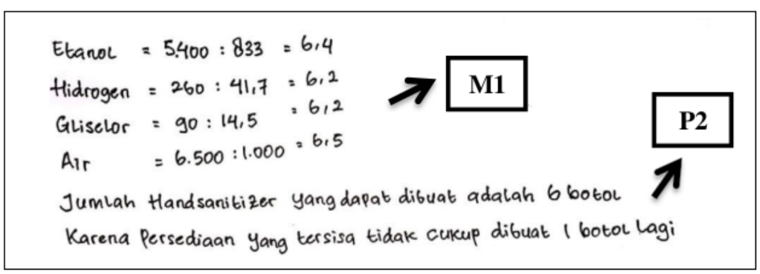


Figure 5. Answer of Student A of PISA-like mathematics problem for hand sanitizer unit

Figure 5 shows that the students could answer the questions using the mathematical ability of the M1 indicator. This indicator uses an understanding of the context to solve mathematical problems by linking the rules to produce hand sanitizer based on WHO standards and perform operations on the distribution of available materials with the materials needed. The students also involve the reasoning and argumentation skills of the P2 indicator. This indicator connects the obtained information to determine a mathematical solution by writing down the number of hand sanitizers and providing arguments for the answer. Afterward, the researchers investigated students' reasons for using the strategy and providing conclusions. The snippet of the interview is presented as follows

(R: Researcher; S: Student)

R : Why do you use the division operation to solve the problem?

S : Producing a bottle of hand sanitizer requires provisions for each ingredient. Thus, each available material can be divided by the manufacturing rules. The results in the minimum number of bottles are made from each material.

R : Why did you only make 6 bottles?

S : Because the rest of every available material is not enough.

The conversation above shows that the students could determine the minimum number of hand sanitizer bottles that they could make from the available materials. Moreover, the students' answers denote that they could determine the answers to the questions using the mathematical ability of the M1 indicator. This indicator uses an understanding of the context to solve mathematical problems by linking the WHO rules to make hand sanitizer by performing operations on the distribution of available materials with the materials needed. Then students involved their reasoning and argumentation abilities of the P2 indicator. This indicator connects the obtained information to determine a mathematical solution by writing down the number of hand sanitizers and providing arguments for the answer.

The answers and interview results show that the students have high mathematical and reasoning abilities so that they can answer logically. This finding is supported by Hidayat, Wahyudin, and Prabawanto (2018) who state that someone with argumentation and reasoning abilities could analyze, relate the information presented, and carry out procedures to find solutions used as justification (Mumu & Tanujaya, 2019). However, the researchers have found that although some students have different strategies, their solution is the same.

The above interview shows that the students significantly understand the meaning of the questions and solve the given tasks correctly and logically. This finding agrees with Nusantara et al. (2020a) who assume that a student good argumentation and complete mathematical tasks such as PISA as shown in the computational process. In terms of math literacy, students could link presentation skills to R2 indicators by making a towel-making worksheet. These indicators consist of inventory, requirements, remaining materials and the number of bottles. In addition, the students could use the tables to choose the best strategy to solve the tasks. These findings are consistent with Efrian et al. (2019).

Figures 5 and 6 show that students use different strategy patterns. The wording of these strategies corresponds to the knowledge or problems identified in mathematical tasks such as PISA and shows that each student can use different solution strategies mathematical problems such as PISA (Nusantara et al., 2020b). This study also found that students' ability to read information and analyze problems can help them determine problem-solving strategies (Franestian, Suyanta, & Wiyono, 2020)

Communication skills are involved in all problem-solving. This involvement can be seen when students could form models of the presented situation and present solutions for the work. The students are considered to have communication skills if they are able to express their ideas using pictures, tables, and diagrams and can state problems of daily life in symbols or mathematical models (Rusyda, Ahmad, Rusdinal, & Dwina, 2020).

Mathematical abilities in unit 1, unit 2 (2), unit 3, and unit 6 (3) require students' ability to identify variables and mathematical structures, use contextual understanding, and make assumptions to solve problems. This statement is supported by Nurzalena, Susanti, Hapizah, Meryansumayeka, & Miswanto (2019) who state that students are considered to have mathematical abilities if they are able to translate real context problems into mathematical symbols that can be interpreted in mathematical models to make assumptions.

Representation ability is used by students when completing units 1 and 4. This condition occurs when students are able to interpret mathematical results in various representations and compare or evaluate two or more related representations with situations by expressing their ideas in pictures, tables, and symbols (Franestian et al., 2020).

Argumentation and reasoning abilities can be seen when the students are able to explain, defend, and justify the process of reaching a mathematical solution in unit 1, unit 2 (1), unit 3 (1), unit 4, unit 5 (2 & 3), and unit 6 (1). Argumentation and reasoning abilities enable students to successfully analyze, relate the presented information, and carry out procedures to find solutions that serve as justification (Mumu & Tanujaya, 2019).

Meanwhile, problem solving abilities in unit 3 (2) and unit 5 (2 & 3) occur when students can solve a problem with various strategies and mindsets and compose the symbolic, formal, and technical language. The operations involved in unit 3 (1) can emerge when students could use symbols or mathematical variables and their understanding of mathematical concepts, principles, and procedures to express their ideas (Nurzalena et al., 2019). Unfortunately, not all students could use symbolic or formal language because they do not understand the meaning of symbols or variables due to a lack of understanding of definitions, rules, and algorithms.

The dominant abilities that rise from the developed problems are argumentation, reasoning, and communication. These abilities occur because the students have significantly understood the meaning of the problem and could connect the information of the problem in pictures, tables, and diagrams to solve the problems (Rusyda et al., 2020). However, the students' communication ability is still low because they only focus on finding the answers and are not accustomed to writing answers in detail. The students require training to solve problems properly because they potentially develop their mathematical literacy. However, since each student has a distinct ability to understand mathematics, the teacher must train students to optimize their ability. Consequently, their mathematical literacy ability can be extracted by giving them routine problems and asking them to solve these problems by writing down solutions in detail (Pratiwi et al., 2020).

CONCLUSION

This study developed PISA-like mathematics tasks on quantity content using the context of COVID-19. This series is considered competent and practical and can contribute to students' mathematical literacy. The developed PISA-style mathematics problem criteria focus on quantitative content, such as the topics of integer operations and comparisons. The problem is how to make a bottle of hand sanitizer. PISA-style math tasks allow students to use their math skills, such as communication, math, presentation, argumentation and reasoning, to solve problems while researching the COVID-19 pandemic. On the other hand, students can also apply their knowledge and logical thinking to deal with the COVID-19 pandemic. For example, students understand important information about the pandemic and know the rules for keeping a distance, making hand sanitizers and making masks. Therefore, they can learn how to deal with the ever-expanding COVID-19 pandemic using their math skills.

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