HOW STUDENTS WORK WITH PISA-LIKE MATHEMATICAL TASKS USING COVID-19 CONTEXT

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Abstract

School students can use a sequence of contextual tasks to learn mathematics. We can use Covid-19 as a phenomenon or context to exploit in learning mathematics. This article describes how students learn with mathematical problems that adapted PISA tasks and used the Covid-19 context. This study involved 29 secondary-level students, 15 years old, and each has different levels of mathematical skills. We use three phases of design research as the research method. Data were collected using observation, interviews, and documents. Then, they were analyzed descriptively. The result showed there were ten problems developed, and students were asked to work with those problems. We found that there are steps in how students understand and solve the problem. First, if students find a picture in the task, then they observe at the picture, read the question, and then start working to solve the problem. Second, if students find a table with less data, students refer to all data in solving the problem. Third if students find a table which has a lot of data, then some students calculate all of the data and other only compared among them. We'd like to encourage students to understand the problem before solving the problem. They do this by observing the pictures, comprehending the tables and also the questions.

Keywords: Students' work, Mathematical task, PISA task, Covid-19 context, Design research

Abstrak

Soal matematika yang menggunakan konteks dapat digunakan untuk merangsang siswa dalam belajar matematika. Covid-19 sebagai suatu fenomena merupakan salah satu konteks yang dapat dimanfaatkan. Artikel ini mendeskripsikan bagaimana siswa belajar dengan soal yang telah diadaptasi dari soal PISA dengan menggunakan konteks Covid-19. Penelitian ini melibatkan 9 siswa sekolah menengah, usia 15 tahun, dan kemampuan matematika mereka berbeda. Penelitian desain dipilih sebagai metode penelitian. Pengumpulan data dilakukan melalui observasi, wawancara, dan dokumen serta dianalisis secara deskriptif. Hasil penelitian menunjukkan ada 10 soal yang dirancang dan siswa diminta untuk mengerjakan soal tersebut. Jika soal melibatkan gambar maka siswa melihat gambar tersebut, melihat soal, dan mulai menyelesaikan soal; Jika soal memuat tabel dengan data yang tidak terlalu banyak, maka siswa mengacu pada semua data dalam menyelesaikan masalah; Jika tabel berisi banyak data, maka sebagian siswa menghitung semua data dan yang lainnya hanya membandingkannya. Sebelum siswa mulai memecahkan masalah, mereka mencoba memahami apa yang dimaksud dengan masalah tersebut dengan membaca atau melihat gambar, tabel, dan pertanyaan.

Kata kunci: Pekerjaan siswa, Soal matematika, Soal PISA, Konteks Covid-19, Penelitian desain

Higher order thinking, is the skill needed by students to face challenges in the future (Ahonen & Kinnunen, 2015; Hesse, Care, Buder, Sassenberg, & Griffin, 2015). These skills include the ability to analyze, evaluate, and be creative (Brookhart, 2010; Stacey et al., 2015). Meanwhile, to cope with the 21st century, students need to master the ability to think critically, be creative, collaborate, and communicate (Ahonen & Kinnunen, 2015; Hesse et al., 2015). Learning mathematics in schools has an important role in constructing these skills. Through mathematics learning, students have opportunities to construct abilities such as problem solving, reasoning, and communicating mathematically (Ahonen

& Kinnunen, 2015).

The fact is, that the skills of Indonesian students are still dominant in lower order thinking skills (Stacey et al., 2015; OECD, 2015; 2019). We can see this from examining the PISA results of Indonesian students (OECD, 2015; 2019). Students still have difficulty in solving math problems that require higher order thinking skills. This is because Indonesian students are accustomed to solving problems whose level of thinking is limited to knowledge and application (OECD, 2015; 2019; Putri & Zulkardi, 2018)

Efforts are needed to support students in developing their higher order thinking skills. One of the efforts that teachers can do, is by designing mathematics learning using teaching materials that are oriented towards higher order thinking skills. Giving math problems that function as learning material is an alternative way that can be considered. Giving mathematical problems is believed to stimulate students in learning mathematics (Watson & Ohtani, 2015; van Galen & van Eerde, 2018). Furthermore, math problems, using context in students' daily lives, help students to start learning mathematics. By applying context in the math problem, students will be interested to analyze through this context (van Galen & van Eerde, 2018; Rahayu, Putri, & Darmawijoyo, 2018; Meryansumayeka, Zulkardi, & Putri, 2019). Students' understanding of the context in the given math problems will lead students to think mathematically.

There are a lot of studies related to the development of PISA-like mathematical problems (Zulkardi & Kohar, 2018). Several studies have used the development of these questions to describe students' problem-solving abilities (Novita, Zulkardi, & Hartono, 2012), mathematical literacy (Oktiningrum, Zulkardi, & Hartono, 2016), creativity (Novita & Putra, 2016), and higher order thinking skills (Meryansumayeka, Zulkardi, Putri, & Hiltrimartin, 2020). Some have developed questions using local context (Kamaliyah, Zulkardi, & Darmawijoyo, 2013; Charmila, Zulkardi, & Darmawijoyo, 2016; Jannah & Putri, 2019). According to Freudenthal (Sembiring, Hadi, & Dolk, 2008), a phenomenon in everyday life can be used to attract students to learn mathematics. One phenomenon that is currently happening is the Covid-19 pandemic. This pandemic is a problem and affects all aspects of human life including the student learning process (Bakker & Wagner, 2020). However, we can use this phenomenon to attract students to think about this, and come up with solution to this pandemic.

To be able to help students in forming their higher order thinking skills, it is necessary to understand how students work on these math problems. Thus, this study was carried out with the aim of designing PISA-like mathematical problems using Covid-19 context and describing how students work with those problems.

METHOD

This research used design research as a research method. This research consists of three stages, namely the preparation stage, the design stage and the evaluation stage. The evaluation stage includes self-evaluation, expert review, one-to-one, small group, and field test (van den Akker, 2013).

There were 29 high school students in Palembang city were involved. The students are 15 years old and have different level mathematical skills. Data were collected through tests, observations, interviews, and documentations. The test used was in the form of 10 math questions using the context of Covid-19 which were adapted from PISA questions. We used observation to determine students' behavior when they solve questions. We document the students' work to see how students think in solving questions. Meanwhile, we used interviews to clarify students' answers and explore their understanding. All data were analyzed descriptively.

RESULTS AND DISCUSSION

In the preparation stage, researchers analyzed the PISA framework, mathematical topics, and the context of Covid-19. In the next stage, researchers developed10 PISA math problems using the Covid-19 context. In addition, researchers prepare observation and interview sheets to be used during trials.

After finishing the design of the questions and research instruments, researchers evaluated the mathematical problems designed. In the self-evaluation stage, the mathematical problems design was validated through a Focus Group Discussion. It was attended by several teachers as practitioners of learning mathematics in classrooms and lecturers who had extensive experience in development research. After that, the mathematical problems were corrected based on the input obtained in FGD. Then, the mathematical problems were tried out to students in the one-to-one stage, small groups stage, and field test.
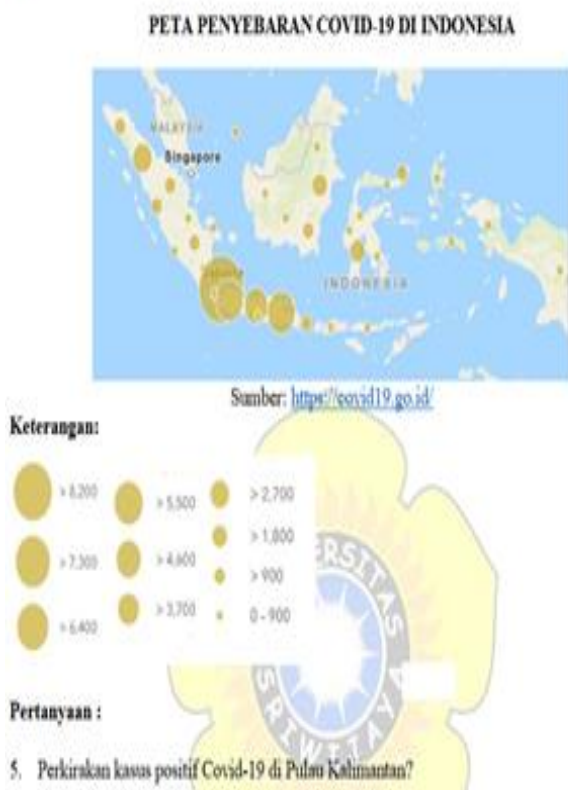
Figure 1. A shape and space task using Covid-19 contexts

Figure 1 shows one mathematical-like PISA task designed. This task used the spread of covid-

19 context in Indonesia. The content was about space and shape. In this problem, students were asked to estimate the number of Covid-19 cases happened in Kalimantan. In solving it, the students needed to estimate the total number of positive cases by examining the size of the circles.

Translate in English:

Therefore, the estimate of Covid-19 positive cases on the Kalimantan island is 4500 < the number of positive cases < 5500

The answer is d. 4500 < positif case numbers < 5500

Figure 2. Student's answer in solving a mathematical problem using Covid-19 spread context in Kalimantan

Student's answer in Figure 2 shows that there were circles drawing by the student as representation of Covid-19 spread area in Kalimantan. The student also tried to calculate the number of Covid-29 cases in Kalimantan by multiplying 3 same little circles that have range between 0 and 900. It looks like the student used the biggest number that is 900 and multiply it with 3 (3 circles). Then, the student estimated that the number of the biggest circle was 1800 and the number of medium one was 900. All numbers were added up together and the results was 5400. Then, the student referred to the option which 5400 is found within the range, that is between 4500 and 5500. The way students answered was recorded in transcript below.

> R : "How did you answer this problem?"
> S :" At first, I saw the question. Then I understand that, the question is asking about the number of Covid-19 spread cases in Kalimantan."
> R : "Then?"
> S : "Then I saw Kalimantan and I observed that there were 5 circles. There were 3 small circles, 1 medium, and 1 big one. "
> R : "Ok"
> S : "Then I estimated that the small one is around 900, the biggest one is around 1800, and

the medium is more than 900.”

R   : *“So, you observed the number of small circles, medium circles and big circles?”*

S   : *“Yes”*

R   : *“And then?”*

S   : *“And I added all numbers, and it was 5400”*

R   : *“So, at what range it was?”*

S   : *“D, between 4500 and 5500”*

Based on the transcription, student started solving the problem by reading the question directly. Then she looked at the picture. She estimated the values of all circles by referring to information about each circle given. She added up all estimated numbers and chose an answer, in which the number was included in the range.

Translate in English:

HAND SANITIZER

Look at the picture below

To make one bottle of WHO standard hand sanitizer, the following ingredients are needed

Ingredient	Amount
Alcohol	840 ml
Hydrogen Peroxide	40 ml
Glycerol	15 ml
Aquadest	60 ml

The question is:

Suppose that one wants to make a WHO standard hand sanitizer. He has 5040 ml of alcohol, 124 ml of Hydrogen Peroxide, 64 ml of Glycerol, and 320 ml of Aquadest. How many bottles can he make?

Figure 3. Quantity task using Covid-19 contexts

The mathematical task in Figure 3 was about quantity. The context is about making hand sanitizer based on WHO standard. The ingredient information is given in the table. The task asks students to calculate the number of hand sanitizer bottles to produce, using the given ingredients.

Figure 4. Student's answer in whole numbers

Figure 4 shows that the student used all information given for his calculation. From the information given, there are 4 ingredients of hand sanitizer. The student tried to determine the number of bottles to produce. He divided the number of each ingredient available with the amount of each ingredient needed to make 1 bottle of hand sanitizer. He did not really count the exact number, but he only estimated the nearest whole number.

R   : *How did you find the answer?*
S   : *I divide the amount of ingredients available by the number of ingredients needed.*
R   : *How did you get 3?*
S   : *124 divided by 40 is 3 something*
R   : *Do you think the answer is 3? Why not 6?*
S   : *If we make 6 bottles then we cannot use Hydrogen Peroxide. That's not enough. It is just enough for 3 bottles.*

From the transcription, the student use estimation in determining the result of division of the number. In answering the question, he had to find the smallest number of the results obtained from his calculation. He had a reason in finding the answer. He argued that the other ingredient was not enough to produce more than 3 bottles of hand sanitizer.

Translate in English:
Therefore, the number of hand sanitizers that can be made is 3 bottles

Figure 5. Student's answer in decimal numbers

Different from Figure 4, the result of student's calculation in Figure 5 was more precise. She used

division and found the result in decimal numbers. However, both student's answer in Figure 4 and Figure 5 have the same conclusion, that the maximum number of hand sanitizer bottles to produce was 3 bottles.

Translate in English:

Look at the data in the following table to answer questions 6 – 7

| COVID -19 DATA IN INDONESIA |
| Last Update: September 12, 2020, 3.53 PM |

The following are data on the 10 highest provinces of Covid-19 cases in Indonesia

No	Province	Confirmed	Died	Recovered
1	Jakarta	52840	1386	39793
2	East Java	37839	2746	29924
3	Central Java	17460	1139	10969
4	West Java	14231	294	7493
5	South Sulawesi	13235	376	10103
6	South Kalimantan	9249	386	7319
7	North Sumatra	8362	355	5042
8	Bali	7113	168	5593
9	East Kalimantan	5752	238	3445
10	South Sumatra	5018	297	3601

Questions:

6. Based on the table, which province has the highest number of Covid-19 patients in care? Give your reasons!

7. Circle yes or no for each of the following statements, based on the information above!

Statement	Is the statement true?
South Sumatra is the province with the highest recovery percentage	Yes/ No
Central Java Province can adapt the handling of Covid-19 from the DKI Jakarta province	Yes/No

Figure 6. Uncertainty and data task using Covid-19 context

Figure 6 shows a mathematical task with data provided in a table. One problem was analyzing

which province has the biggest recovery percentage. The other problems were evaluating the statements whether it's True/False.

Translate in English:

$$\text{recovered} = \frac{3601}{5018} \times 100 = 70\% \text{ South Sumatra}$$

$= \frac{3145}{5752} \times \quad = 59\%$ West Kalimantan

$= \frac{5593}{7113} \times \quad = 78\%$ Bali

$= \frac{5042}{8362} \times \quad = 60\%$ North Sumatra

$= \frac{7319}{9249} \times \quad = 79\%$ South Kalimantan

$= \frac{10103}{13235} \times \quad = 76\%$ South Sulawesi

$= \frac{7493}{14231} \times \quad = 52\%$ West Java

Central Java $= \frac{10469}{17460} \times \quad = 62\%$

East Java $= \frac{29924}{37839} \times \quad = 79\%$ ⎫ Yes

Jakarta $= \frac{39793}{52240} \times \quad = 65\%$ ⎭

7a. No
7b. Yes
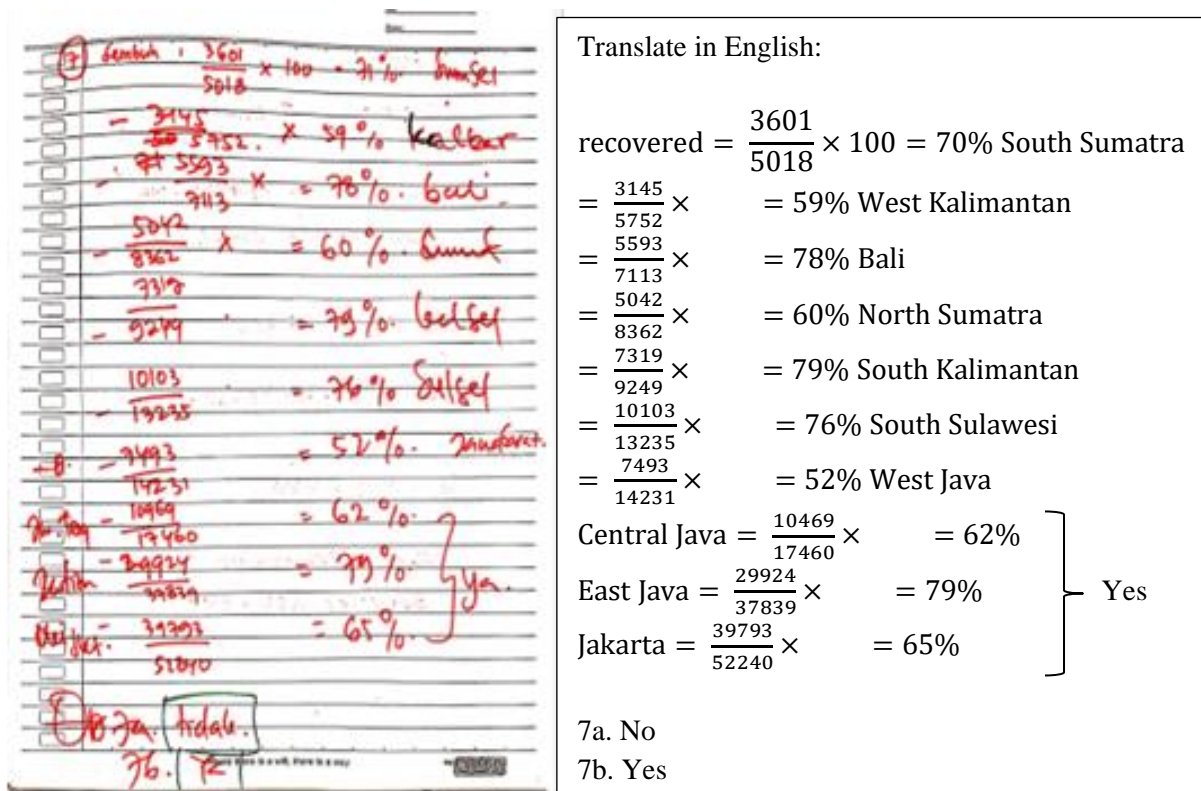
Figure 7. The student calculated all data

In solving the problems in Figure 7, a student tried to calculate the recovery percentage of all provinces. The student did not calculate in exact way, but only by estimating the results to the nearest whole numbers. Then, she looked at the biggest number of the percentage. There, she found that the highest percentage were in East java and South Kalimantan. For the first True/False problems, using her calculation of the data, she concluded that the recovery percentage of South Sumatra was not the highest one. Therefore, she concluded that the statement was false. For the second statement, she concluded that the statement was true since the recovery percentage in Jakarta was higher than in Central Java. However, there were also students did not calculate all data, but they only calculated for some data. The following transcription described the situation.

　　S : I thought the statement (the first statement of problem no. 7) was false

　　R: Why?

　　S : Because Bali's recovery percentage was higher than South Sumatra

　　R: How did you find that?

　　S : At first, I divided the number of recoveries with the number of confirmed cases in South Sumatra. Then, I multiplied by 100%. After that, I looked at data in Bali. I also did the same way in determining the recovery percentage in Bali. Evidently, the recovery percentage in Bali

is higher than the South Sumatra.

In the transcription, we see that after the student found the recovery percentage in South Sumatra, she looked at data of the other province and calculated its recovery percentage. When she found out that recovery percentage of the other province was higher than South Sumatra, she concluded that the recovery percentage in South Sumatra was not the highest one. Then, she marked the statement as false.

Based on the results, designing mathematical problems can provoke students thinking mathematically. Van Galen and van Eerde (2018) stated that mathematical problem can stimulate student in learning mathematics. Using context in mathematical problems is also a good way in attracting students to learn mathematics, since they understand the context and can explore mathematics in it from analyzing the problems given (Sembiring et al., 2008; van den Akker, 2013; Meryansumayeka et al., 2019).

Students are encouraged to use their analytical skills in solving PISA-like mathematical problems developed using Covid-19 context, like displaying in Figure 1, 3, and 6. Brookhart (2010) stated that analytical skill is one of higher-order thinking skills. In using this skill, students need to see the relation among information and find out the possible strategies that satisfy the condition.

In solving a PISA - like mathematical problem, students tried to understand it by reading the question. This is the first step of students in solving problems (Nurkaeti, 2018). By reading the question, student understand the problem. However, students did not read every part of the problem. Most of students start by reading the question first. This happened because the students were lazy in reading all of the sentences. This is in line with what Hoogland, Pepin, de Koning, Bakker, and Gravemeijer (2018) stated that a "word" problem, when a task is described in long words, it gives negative effect to students' performance. In understanding the problem, students also looked at the picture or the table given and refer some information from there. Hoogland, Pepin, de Koning, Bakker, and Gravemeijer (2018) and Hoogland, de Koning, Bakker, Pepin, and Gravemeijer (2018) also stated that using pictures in mathematical problems may help students in understanding the problems. A picture helps student to understand the problem as well as giving information visually (Hoogland, Pepin, de Koning, Bakker, & Gravemeijer, 2018; Hoogland, de Koning, Bakker, Pepin, & Gravemeijer, 2018)

When students saw a problem showing less data, most of them used all information in finding the answer. Since the numbers shown in data were not exactly the same as in the answer option, they referred to all data from the task and then estimate the answer. It also happened when the problem displaying a lot of data, students calculated all data and compared them to find the highest percentage as described in Figure 7. What students did was their strategy in finding the answer; finding the highest percentage, by calculating and comparing among data. After students understood the problem, they used strategy or procedure that they know (Nurkaeti, 2018).

Some students used estimation in finding the result of division, they did not count it in the exact number. The steps they made is shown in Figure 4 and Figure 7. This happened because the students

used multiplication in determining the result of division. They tried to find a number, which multiplication result in the nearest whole number to the solution. This is in line with Dubé and Robinson (2018) that, in determining the result of division of two numbers, students look at the relation to the multiplication that appropriate to those numbers.

CONCLUSION

This study has developed 10 PISA-like mathematical problems using Covid-19 context. In solving those problems, most of student read the question directly, observed and referred information on the picture or the table. For the problems showing less data, students looked at all data and used them to find the solution. It also happened for the problem displaying much data. Some students also used estimation in solving mathematical problems related to division of numbers

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