ISSN 2087-8885
E-ISSN 2407-0610

Journal on Mathematics Education
Volume 12, No. 2, May 2021, pp. 349-364

DESIGNING PISA-LIKE MATHEMATICS TASK USING A COVID-19 CONTEXT (PISACOMAT)

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Abstract

New changes to the school curriculum by enacting a minimum competency assessment (MCA) with PISA criteria in 2021 have led to confusion over the form of MCA questions among teachers and students due to limited learning resources at schools. This study aimed to produce valid and practical PISA COVID-19 mathematics tasks (PISAComat) potentially affecting mathematics literacy. This study involved 27 secondary-level students aged 15 years old with different levels of mathematics skills. Design research in the form of development studies was chosen as the core framework of this research assisted with the online learning platform. Data were analyzed descriptively through observations, tests, interviews, and document reviews. A set of PISAComat on quantity and change & relationship at the level of reasoning was gained after a formative evaluation. The formative process was conducted through zoom meetings and intensive communication at WhatsApp Group (WAG) to produce valid and practical PISAComat. After being tested in the classroom, the resulting PISAComat had been potentially effective in promoting students' mathematics literacy and life skills during the COVID-19 pandemic.

Keywords: PISA Task, Numeracy Task, COVID-19 Context, Design Research

Abstrak

Perubahan baru pada kurikulum sekolah dengan memberlakukan asesmen kompetensi minimum (AKM) dengan kriteria PISA pada tahun 2021 telah menyebabkan kebingungan terkait bentuk soal AKM di kalangan guru dan siswa karena keterbatasan sumber belajar di sekolah. Penelitian ini menghasilkan PISAComat yang valid, praktis dan memilik efek potensial terhadap literasi matematis. Penelitian ini melibatkan 27 siswa menengah yang berusia 15 tahun dengan kemampuan matematika beragam. Desain riset dengan tipe *development studies* dipilih sebagai kerangka utama penelitian berbantuan platform pembelajaran online. Data dianalisis secara deskriptif dengan mengumpulkan pengamatan, tes, wawancara, dan analisis dokumen. Satu set PISAComat pada konten bilangan dan aljabar di level penalaran telah dihasilkan setelah evaluasi formatif. Proses formatif dilakukan melalui *zoom meetings* dan komunikasi intensif di *WhatsApp Group* (WAG) dengan menghasilkan PISAComat yang valid dan praktis. Setelah diujicobakan di kelas, PISAComat yang telah dihasilkan memiliki efek potensial terhadap kemampuan literasi matematika siswa dan kecakapan hidup selama Pandemik COVID-19.

Kata kunci: Soal PISA, Soal Numerasi, Konteks COVID-19, *Design Research*

How to Cite: Nusantara, D.S., Zulkardi, & Putri, R.I.I. (2021). Designing PISA-like Mathematics Task Using A COVID-19 Context (PISAComat). *Journal on Mathematics Education, 12*(2), 349-364. http://doi.org/10.22342/jme.12.2.13181.349-364

A growing international movement in mathematics focusing on skills requires students to utilize mathematical reasoning in every aspect of life. Thus, the students can successfully overcome the rapid change of the 21-st century and be engaged in being computerized (Hesse et al., 2015; Gravemeijer et al., 2017; Battelle for Kids, 2019). Similarly, some progress in terms of a new assessment system, such as a massive educational change through four reformations known as Freedom of Learning, has been established (MoEC, 2019; 2020a). One of them is the elimination of national examination.

The Ministry of Education and Culture (MoEC) of the Republic of Indonesia scrapped the national examination dreaded by students across the country and substitute it with a very different kind of educational assessment commonly known as “minimum competency assessment (MCA)” (MoEC,

2019; 2020a). The MCA will not examine students' subjects taught at school but assess their numerical competence related to real-life situations and valid for students of grades 5, 8, 11 (MoEC, 2019; 2020a; 2020b). The MCA was inspired by the PISA concept and the manifestation of MoEC's commitment to globalize Indonesia's educational standard and create a benchmark for the effectiveness and success of Indonesia's education reform.

Indonesian students inadequately achieve content knowledge of mathematics according to the last three PISA assessments (OECD, 2014; 2016; 2019). Students are not familiar with solving contextual issues like PISA tasks (Novita, Zulkardi, & Hartono, 2012; Wijaya, Panhuizen, Doorman, & Robitzsch, 2014) and have limited high-level skills (OECD, 2019; Putri & Zulkardi, 2018). Moreover, the learning resources containing PISA problems at school and in bookstores are insufficient (Wijaya, Panhuizen, & Doorman, 2015).

These findings forge an urgency in addressing problems that meet PISA criteria by adapting closer context to Indonesian students (Zulkardi & Kohar, 2018). Utilizing context in a mathematical problem can attract and stimulate students to initiate learning (Van Galen & Van Eerde, 2018; Nusantara & Putri, 2018; Zulkardi & Putri, 2019). Context is a phenomenon or situation in real life where mathematics problems are embedded and lead students to think mathematically (Kohar, Wardani, & Fachrudin, 2019; Zulkardi et al., 2020). An example of an ongoing prevalent situation impacting all aspects of global life and students' academic activities is the COVID-19 pandemic (Bakker & Wagner, 2020). This situation is continuously reported and published in various media every day to remind and raise awareness of the importance of health protocols. The current COVID-19 situation, officially confirmed cases, death counts, and transmission classification worldwide are reported daily in a map, epidemic curve, and table that invite readers to mathematically think about the latest number and trends at global, national, and regional levels. Hence, this unwanted situation can be utilized as a learning material for mathematics. According to the decree of MoEC number 719/P/2020, teachers must exploit an opportunity from this pandemic to improve the students' competence and life skills to face the COVID-19 situation.

Many studies on PISA items continuously developed, used multiple contexts such as Asian Games 2018 (Putri & Zulkardi, 2020), the COVID-19 context, i.e. focused on students' working process (Zulkardi et al., 2020), reasoning and argumentation processes (Nusantara, Zulkardi, & Putri, 2020a), mathematization process (Nusantara, Zulkardi, & Putri, 2020b). Other studies focused on difficulty levels (Ahyan, Zulkardi, & Darmawijoyo, 2014; Meryansumayeka, Zulkardi, Putri, & Hiltrimartin, 2020). Meanwhile, some previous studies explored potential effects on students' mathematical literacy, such as reasoning and argumentation (Rawani, Putri, & Hapizah, 2019), representation (Efriani, Putri, & Hapizah, 2019), and communication (Nizar, Putri, & Zulkardi, 2018). However, no study has employed PISAComat to investigate quantity and change & relationship content at the reasoning level that discusses the context of large-scale social restriction (LSSR) and panic buying. Furthermore, before designing a digital learning environment that provides PISAComat, a content development process and

students' strategies to learning from a developed content must be investigated. This study aimed to produce a valid and practical PISAComat that potentially affects mathematical literacy.

METHOD

Due to the COVID-19 pandemic, the framework employed design research in the type of development studies assisted with the online learning platform such as Zoom meeting and WAG. This framework consisted of two stages: preliminary and formative evaluations. There are three activities in the preliminary stage carried out in this research. The first activity is analyzing the PISA framework through PISA items from 2000 - 2018 and reviewing the 2022 PISA criteria consisting of contents, contexts, and cognitive competencies pointed to the level of reasoning. The second activity is analyzing the curriculum linked to the PISA items developed. The third activity is implementing the analysis results to design the initial draft of PISAComat and equipping the PISAComat with other instruments such as scoring rubrics, problem grids, interview questions lists, and question validation sheets. Then, the PISAComat design process continued with the task experiment using a focus group discussion (FGD). In the end, the PISAComat resulted after conducting a prototyping/formative evaluation (Bakker, 2018; Zulkardi, 2002).

The FGD was conducted by inviting a research team or validators consisting of three mathematics teachers as reflective practitioners in the classroom, two graduate students, four Ph.D. students interested in PISA investigation, and four lecturers with sustained PISA research qualifications and experiences. The mechanisms were as follows. First, the researcher created a WAG for validators; Second, the PISAComat and other instruments were distributed to be reviewed by the validators for several days. Third, the reviewed results were discussed and presented orally in the Zoom meeting. In parallel, three students with various abilities engaged in a 1-1 activity. Students were given 10 minutes for each problem. The model teacher monitored the students' behavior during the problem-solving process until the final session to discover their difficulties in understanding the problems given. The inputs and suggestions during the FGD and 1-1 activity were considered to allow changes before being assessed in small groups.

The development process continued in a small group involving six students who worked collaboratively. The learning process in small groups was conducted on Zoom and used the breakout room feature. Each student had their answers in their small groups. Then, the model teacher was transferred to different groups to monitor the students' work. Along with the model teacher, a group of students had a research team serving as an observer. Upon completion of the small group work, the students returned to the main room to voluntarily present their work. At the same time, the model teacher interviewed the students to figure out their PISAComat comprehension. The results of the implementing small group were then revised before applying them in the field test.

The field test phase was participated by 27 secondary school students (under) aged 15 years old with different skills. They were gathered in a WAG of mathematics subject. Due to the online learning,

communication-related to the mechanisms and technical implementations of the test were informed on the WAG. Then, a set of PISAComat was sent to WAG or Zoom chat room. The students were asked to solve the PISAComat individually for two hours of the lesson. During the work process, they were required to turn on the camera. In addition, the model teacher accompanied by observers supervised the test process.

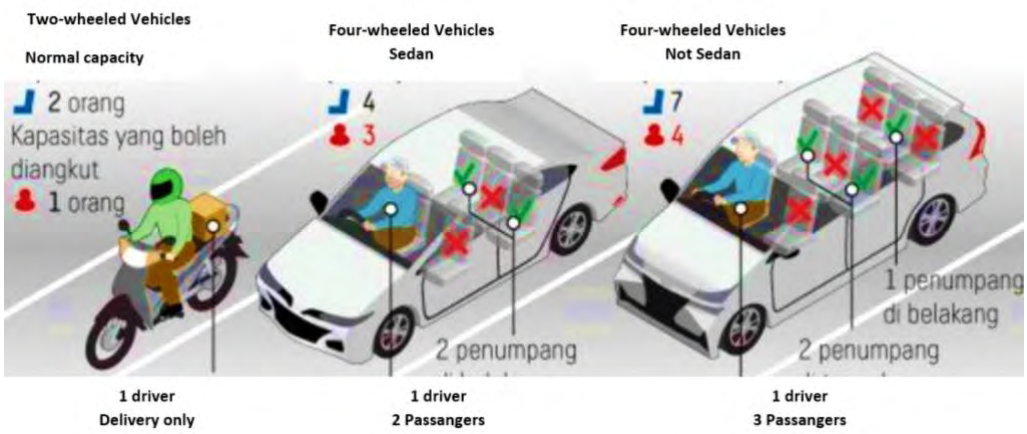
Data were collected through observations, tests, interviews, and document reviews. The validity of PISAComat was assessed by referring to the inputs and suggestions from FGD and 1-1 activity through document reviews. The practicality of PISAComat was discovered through observations, interviews, and document reviews in a small group. Furthermore, the students' test answers, observations, and interviews during the field test signified that PISAComat had a potential effect on mathematics literacy. The collected data were then analyzed descriptively.

RESULTS AND DISCUSSION

This research produced knowledge contents supporting a learning environment and provided ten PISAComat developed formatively. This research focused on quantity and change & relationship of the content. The COVID-19 contexts employed were public and private transportation restriction regulation during the large-scale social restrictions (LSSR) and panic buying in Palembang (as in Figure 1).

Unit 1

Context: LSSR in Palembang



Question 1.1

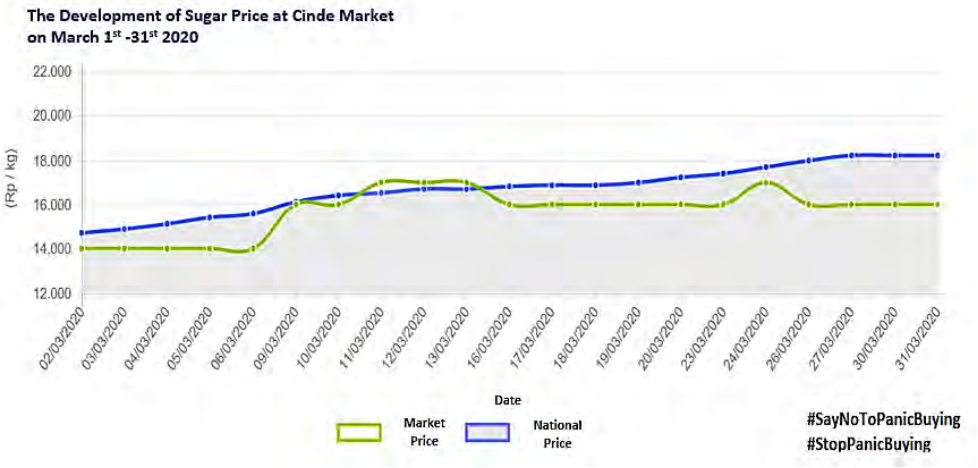
What is the minimum number of vehicles required to carry eight people?

Question 1.2

Riza is taking his friend around the city by private motorbike. Is he breaking the LSSR regulations in Palembang City? Explain your reasons.

Unit 2

Context: Panic Buying at Cinde Market



Question 2.1

Explain how the graph shows the fluctuation of sugar prices in Cinde Market compared to the national market?

Question 2.2

Based on the graphic, when did the conditions of people's panic buying occur in Palembang City? Tell your reasons.

Figure 1. LSSR and Panic Buying Context on PISAComat (Before Revision)

PISAComat was developed by adapting the PISA items with the context "LSSR is similar to skateboard (the 2000 and 2003 PISA items) or sauce (the 2006 and 2012 PISA items)" and "panic buying is similar to growing up (the 2000 and 2003 PISA items) or car drive (the 2006 and 2012 PISA items)". Based on the PISA content knowledge, "Quantity" as well as "Change and Relationship" are associated with the 2013 curriculum contents, such as integers, slopes, coordinate systems, and data presentation. Besides, the contents are related to other areas, such as the law of demand and market equilibrium. The cognitive level of thinking in PISAComat is in level 3 based on MoEC level and level 4,5 based on the PISA framework.

PISAComat (as in Figure 1) was processed through FGD, 1-1 activity, small groups, and field tests in the formative phase. This formative process was supported by combining online learning platforms, such as WAG and Zoom.

Some inputs and suggestions (in Table 1) were determined in the development process of the FGD and 1-1 activity. The development process found that the PISAComat was necessarily revised considering comprehensive and easier-to-read picture changes, additional data sources, shorter-term explanations, and avoidable ambiguity. The formerly developed PISAComat was then modified by considering the inputs and suggestions from the FGD and 1-1 activity. Theoretically, a series of activities resulted in valid PISAComat, regarding contents, constructs, and language. Likewise, the initial prototype was declared valid qualitatively in the experts' comments and suggestions as well as students' understanding of the problems (Zulkardi, 2002).

Table 1. Inputs and suggestions from FGD and 1-1 Activity on PISAComat

Validators	Inputs/Suggestions	Revision
	LSSR Context	
FGD (Lecturers, Ph.D. students, Graduate students, and Teachers) 1-1 (Students)	• The pictures and captions should be displayed in table form • The word "minimum" narrows the students' answers and makes it ambiguous • Add the word "passenger" to the question to clarify the question • The image is low quality and the captions are not clear • Do 8 people include the driver?	• The picture and its caption have been changed • The word "minimum" has been changed to "many" in the question • The word "passenger" has been added to the question • The picture and its caption have been changed • Clarify the question and add the word "passenger"
	Panic Buying Context	
FGD (Lecturers, Ph.D. students, Graduate students, and Teachers) 1-1 (Students)	• Add a graphic data source • There were too many sentences on the explanation of panic buying • Is it market price or national price or national market? • The word "fluctuation" is difficult to understand	• Source has been added • Sentences were shortened • The word "market price" is replaced with "national price" • The word "fluctuation" is replaced with "the instability"

The development process continued in a small group phase involving six students who worked collaboratively. The results of the small group phase indicated that students comprehended the tested problems because they could provide various answers. However, several crucial points were still necessarily illustrated in the instructions. Meanwhile, another finding during the presentation of students' work discovered the technical constraints because some students had difficulties using the share screen feature. Besides the technical constraints, the developed PISAComat items were declared practical. This finding is relevant to Zulkardi (2002) and Nieveen (2007), who assert that the PISA items become practical when meeting some criteria, including experts' statements about usable item development and students' significant ability to solve and interpret the item using various strategies.

The field test was also conducted on Zoom. During the online test, the technical constraints could be anticipated, especially when the students presented their work and the model teacher collected students' answers in one file. Then, the model teacher displayed some interesting answers and discussed them in the virtual classroom. The revised PISAComat is presented in Figure 2 and 5.

Perhatikan informasi pada gambar berikut.

Sumber : www.guguscovidpalembang.com

Pertanyaan 1.1

Berapa banyak kendaraan yang dibutuhkan untuk mengangkut 8 orang penumpang? Kemukakan alasanmu.

Pertanyaan 1.2

Riza mengajak temannya berkeliling kota menggunakan motor pribadi. Apakah Riza melanggar aturan berkendara selama PSBB di Kota Palembang? Kemukakan alasanmu.

Translated into English:

Look at the information from the picture below

Type of Vehicles	*Number of people transported*	*Description*
Two-seated car	*3*	*1 driver* *2 (passengers) at the back*
Three-seated car	*4*	*1 driver* *2 (passengers) at the middle* *1 passenger at the back*
Owned motorcycle	*2*	*1 driver* *1 (passenger) at the back* *(having the same address)*
Online transportation (motorcyle)	*1*	*Hitchhiking prohibited*

Question 1.1

How many vehicles needed to carry 8 passengers? Give your reasonings.

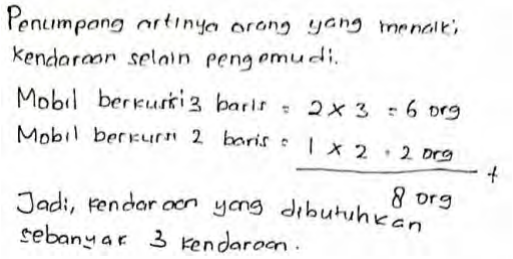
Question 1.2

Riza takes his friend on a ride around the town on an owned motorcycle. Do you think Riza break the driving rules during LSSR in Palembang? Give your reasonings.

Figure 2. LSSR Context on PISAComat after Revision

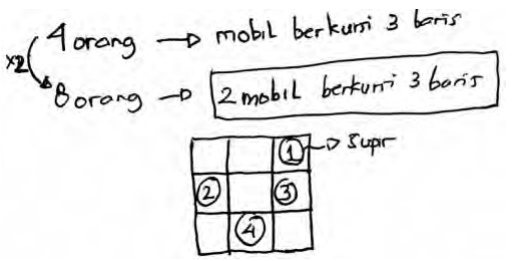
Figure 2 shows one of the generated PISAComat relating to quantity content using LSSR context. There were two questions using the LSSR context. The first question asked the students to estimate the number of vehicles needed to transport eight passengers. In contrast, the second question asked the students to make decisions based on problem stated in the provided picture.

The students' solutions on PISAComat for number 1.1 are presented in Figure 3.



(a)

Translated into English:
The passenger means a traveler who rides a vehicle, but not a driver.
Three-seated car = 2 x 3 = 6 people
Two-seated car = 1 x 2 = 2 people +
So, there are three vehicles needed.



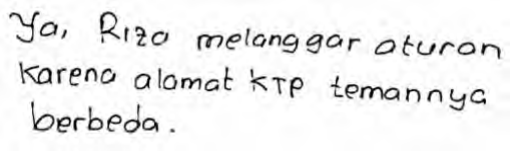
(b)

Translated into English:
x2 ↓ *4 People → Three-seated car*
8 People → 2 Three-seated cars

		1 → *Driver*
2		3
	4	

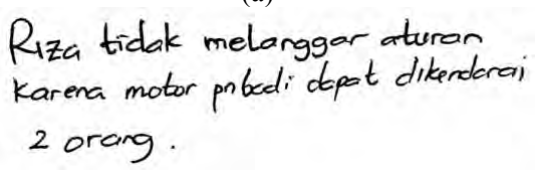
Figure 3. Students' Solutions on PISAComat for Number 1.1

Figure 3 (a) illustrates that the student described the passenger traveling in any vehicle and excluded drivers from the concept of "passenger". As a result, three cars were used to accommodate eight passengers with the following details. Every three passengers needed a car with a three-rows seating, and the remaining two passengers needed a car with a two-rows seating. Meanwhile, Figure 3 (b) denotes that the students solved the problem by counting the driver listed as a passenger. Thus, the eight passengers covered two vehicles, consisting of two car types with three-rows seating. The students' solutions on PISAComat for number 1.2 are presented in Figure 4.



(a)

Translated into English:
Yes, Riza had broken the rules because their address on the IDs card are not the same.



(b)

Translated into English:
Riza did not break the rules because an owned motorcycle can be ridden by two people.

Figure 4. Students' Solutions on PISAComat for Number 1.2

Figure 4 illustrates two opposite views of the problem. Figure 4 (a) shows a violation of the law because two people were riding a private motorcycle and had different IDs. Meanwhile, Figure 4 (b)

confirms no offenses committed. This result was affected by the imprecise interpretation of the captions on the image associated with the problem. The problem insisted mainly on the terminology of the rules but did not interpret the statements carefully. The interview also confirmed this condition.

(*Note: R: Researcher; S1: Student A; S2: Student B*)

R: Do you think three cars are enough to fit eight people?

S1: Yes, I am sure, because the "passengers" do not include the driver, so it takes three passengers (3 + 3 + 2) per car.

R: Why did Riza break the rules?

S1: Riza and his friend do not live together, so their address must not be the same.

R: How did you solve this problem?

S1: I read the information in the picture at first sight, understood the statement, then reidentified the relevant information of the picture. Finally, I answered the question.

R: How did you get the two vehicles you needed?

S2: A car with three-rows seating can accommodate four people. Thus, eight is divided by four equals two

R: Is the driver also count as passengers?

S2: Oh yaa, I was wrong. I was only focusing on the description of the image. I did not read the word "passenger" in the question carefully.

The transcript denotes that S1 tended to solve problems by understanding problems and find the solutions by identifying relevant information on images. Meanwhile, S2 less thoroughly found solutions because she(he) focused more on the information on images than answering the questions.

The Panic Buying phenomenon is an act of purchasing many products excessively due to fears of product scarcity or a high price increase against certain situations (considered an emergency).

Question 2.1

Explain how the graph shows the instability of sugar price at Cinde Market compared to that at the national price?

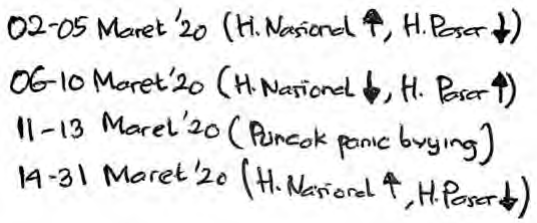
Question 2.2

According to this graph, what period did indicate the condition of panic buying in Palembang? Explain your reasons.

Figure 5. Panic Buying Context on PISAComat after Revision

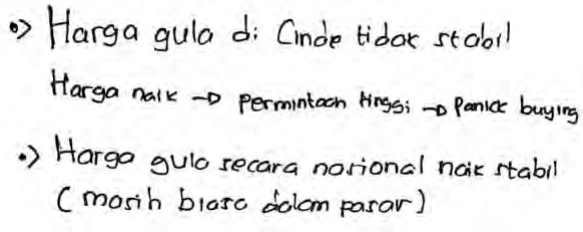
One of the PISAComat items related to change and relationship content using panic buying context is presented in Figure 5. There are two questions using the panic buying context. The first question asked the students to describe the panic buying phenomenon by comparing the market price and national prices. Meanwhile, the second question asked the students to predict panic buying by

observing the data on the graph. The students' solutions on PISAComat for number 2.1 are presented in Figure 6.



(a)

Translated into English:
02-05 March 2020 (National Price ↑, Market Price ↓)
06-10 March 2020 (National Price ↓, Market Price↑)
11-13 March 2020 (the peak of punic buying)
14-31 March 2020 (National Price ↑, Market Price ↓)

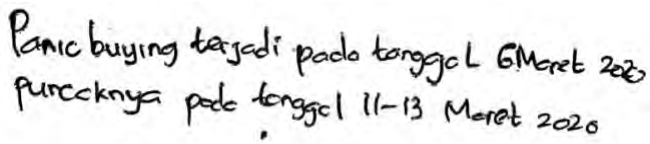


(b)

Translated into English:
The sugar price at Cinde Market is unstable.
Price goes up → Demand goes up = Panic buying
The national price has increased in stable (still common in the market)

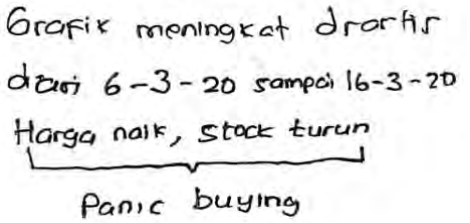
Figure 6. Student' Solutions on PISAComat for Number 2.1

Figure 6 shows how the students described the graph of panic buying conditions in Palembang differently. In Figure 6 (a), the students specifically explained the graph of market price and national price based on the date and the sugar prices. Meanwhile, in Figure 6 (b), the students generally described the graph and concluded some information from the graph. The students' solutions on PISAComat for number 2.2 are presented in Figure 7.



(a)

Translated into English:
Panic buying occurred on March 6th, 2020. The peak of (panic buying) on March 11th to March 13th, 2020.



(b)

Translated into English:
The graph increased dramatically from March 6, 2020 to March 16, 2020.
Prices goes up -> Quantity goes down
panic buying

Figure 7. Students' Solutions on PISAComat for Number 2.2

The students' solutions in Figure 7 signify that 7 (a) and 7 (b) understood how panic buying conditions occurred when the sugar prices began to increase on March 6, 2020. Based on Figure 7 (a) could indicate the peak of panic buying occurred on March 11, 2020, because the sugar price at the Cinde market was higher than that in the national price. On the other hand, Figure 7 (b) made a

mathematical logic relationship "when the sugar price increased suddenly, the stock in markets would be scarce" this relationship reflected panic buying in Palembang. The following transcription describes this situation.

(*Note: R = Researcher; S1 = Student A; S2= Student B*)

R: What do you think about the graph?

S1: This graph represents unstable the sugar price at the Cinde market and in the national price.

R: How do you describe this graph?

S: First, we must observe the crucial points of increasing or decreasing sugar price, then explained them in detail. After that, we can elaborate on the mentioned situation from the graph and compare it to what happens between the blue and the green lines.

R: How could you know the occurrence of panic buying just by looking at the data on the graph?

S1: From the graph, we can see that the first point to experience an increase is the beginning of panic buying. Furthermore, as the green line is above the blue line, it reflects the peak of panic buying in Palembang.

R: How did you describe the graph?

S2: In general, there is a significant difference between the increase in the sugar price at the Cinde market and the national price. The sugar price increases drastically at the Cinde market, while the price is commonly stable in the national price.

R: Why did panic buying happen on March 6? Not on March 11?

S2: Yes, that is interesting. On March 6 was the starting point of the increase sugar price and on March 11 was just a continuation of the rising price (peak increase). Then, the increasing sugar price on March 11 resulted in a scarcity of the product (sugar). That is a common situation in the economy field; when the price goes up, the products go down.

The transcription denotes that S1 described the graph of the panic buying situation in March comprehensively. In contrast, S2 discussed the graph in general but could interpret the critical points. S1 and S2 have similarly perceived that the beginning of panic buying was at the first price rise. S2 also added the problem-solving process required logical thinking to intertwine with other fields.

In general, the use of COVID-19 context in PISAComat could invite students to learn and think mathematically and inadvertently and actively involve them in the learning. When mathematical content focuses on the situations closed to students, their mathematical thinking emerges naturally. In line with Kohar et al. (2019) and Zulkardi et al. (2020), the use of context directs students to think mathematically because their potentials for the mathematical thinking process occur from the given situation. Furthermore, using context will provoke students to be involved in collaborative learning, and thus, the learning is meaningful (Putri & Zulkardi, 2020).

When students were addressed with PISAComat in the form of pictures, as in Figures 2, they

started to understand the problem and then solved it by identifying the available information. Moreover, they would identify the relevant information on the question and adapt the situation to their experiences. Thus, the emerging mathematical process is strategies to integrate various information to get a solution. This process emerges because students with good reasoning skills can integrate the stage of understanding, formulating, and solving problems correctly (Kohar et al., 2019; Rawani et al., 2019). Besides, understanding real-world problems are important at the early stage for solving and interpreting PISA problems (Nusantara et al., 2020a).

However, some students only focused on supporting information, not answering the questions. They spent a much longer time understanding the question sentence than identify important information about the question. This condition affected them in making an error in the counting process. On the contrary, Efriani et al. (2019) state that students made mistakes in turning problems into counting processes because they do not read the problem correctly. They only focus on the question description, not understanding the main problem (Nizar et al., 2018; Zulkardi et al., 2020).

When the students worked with PISAComat in a graphic form, as in Figure 5, most of them explicitly presented the graph based on the situation using their language. They likely re-explained the graphs and used simple vocabulary to understand the graph easily. Other than that, not a few students used mathematical language to explain the graph implicitly. They employed mathematical symbols to make simplify the explanation of the phenomena on the graph. Zulkardi et al. (2020) and Nusantara et al. (2020b) discover the same results that when the students a table or graph, they will explain and compare all data, then they will solve the problem and interpret mathematical solution.

The developed PISAComat allowed students to integrate prior knowledge or knowledge on other topics with problem-solving. Moreover, using the COVID-19 context as a learning resource helped students combine other issues with problem-solving. Consequently, they could work mathematically on the COVID-19 situation and associate ideas from different subjects to solve the given problem. It is also supported by several researchers who said that phenomena or conditions could be used as starting point of learning and a solution to a problem (Zulkardi & Putri, 2019; Van Galen & Van Eerde, 2018).

CONCLUSIONS

This study achieved the success parameters in ten valid and practical PISAComats and potentially affected mathematical literacy. The developed PISAComat criteria included a focus on quantity, change & relationship of contents, the difficulty level of reasoning consisting of the LSSR, and panic buying contexts. Learning the effects of COVID-19 on PISAComat in the form of images enabled most high-reasoning students to understand the problem and find a solution by identifying the relevant information. Moreover, these learning enabled low-reasoning students interpret the supporting information more than address the problem. When students worked with PISAComat in graphic form, most of them explicitly present the graph based on the situation using their language. However, not a few students used mathematical language to explain the graphic implicitly. Using the COVID-19 context as a

learning resource helped the students integrate other topics with problem-solving. Moreover, they counted mathematically but also used their reasoning to express their perceptions and arguments about life skills towards COVID-19. Thus, the students learn how to survive amid the COVID-19 while mastering mathematical reasoning.

ACKNOWLEDGMENTS

This study was financially supported by the Deputy for Strengthening Research and Development, Directorate of Research and Community Service, the Ministry of Research and Technology or the National Research and Innovation Agency through "Master's Education towards a Superior Doctor of Bachelor (PMDSU)" with Contract Number: 212/SP2H/PMDSU/DRPM/2020. We thank the model teachers and the students for their collaboration and participation in this study.

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