Students' mathematical reasoning ability in solving PISA-like mathematics problem COVID-19 context

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Abstract

This study aims to use the Pendidikan Matematika Realistik Indonesia (PMRI) approach to measure the mathematical reasoning ability of grade VII students in answering PISA-like mathematics problems on number content in the context of COVID-19. This study employs descriptive research with 34 participants from a junior high school in Palembang, Indonesia. Tests, interviews, and observations were utilized to collect data. The method of analysis adopted is descriptive. Google Meet is used to facilitate learning. Learning the PMRI technique was accomplished in this study by assigning sharing and jumping tasks. That is, assignments for students to discuss with each other have different levels of difficulty, followed by two exam questions. In the context of COVID-19, the test questions are PISA-like maths problems. The results show that students' average mathematical reasoning skill is 63,037, with mathematical manipulation a common indicator. Most students have exhibited indications for presenting conjectures. However, only a few students have put down indicators for drawing logical conclusions, so drawing logical conclusions is an indicator that students rarely see. Overall, grade VII students' mathematical reasoning skills in answering PISA-like mathematics questions on number material in the context of COVID-19 utilizing the PMRI approach is good since students are used to modeling contextual problems such that mathematical manipulation indicators occur.

Keywords: COVID-19; mathematical reasoning ability; PISA; PMRI; number

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Introduction

The reasoning is a crucial skill that may be used to learn, understand, and solve issues in math and real life (Sofyana & Kusuma, 2018). Students' reasoning ability is defined as their ability to think in terms of connecting statements or premises whose truth has been established to conclude (Akuba et al., 2020; Asdarina & Ridha, 2020). The mathematical literacy ability tested in PISA includes reasoning mathematically (OECD, 2019). One of the materials that involve mathematical reasoning abilities in studying is number material (NCTM, 2000). Additionally, students should master the number material because it is a vital component of life. So the number is an essential material to learn. Numbers, especially integers, are taught in 7th-grade so that students' mathematical reasoning abilities in number material can be used to define students' reasoning abilities in more challenging subjects (Purwanti et al., 2020).

However, as seen by the results of the 2018 PISA, Indonesian students' mathematical reasoning ability is still relatively low; the mathematics score of Indonesian students is 379. It is a lower result than in 2015 when Indonesia received a 386 in maths (OECD, 2019). One of the materials tested in PISA is number (OECD, 2109). However, because teachers frequently ask low-level routine questions, students are not used to addressing contextual problems such as PISA (Nusantara et al., 2020a). Students' low thinking ability is also caused by a lack of ability to comprehend or study topics thoroughly and errors in computations (Amalia & Hadi, 2020; Sofyana & Kusuma, 2018).

Students need to be familiar with PISA-like mathematics problems (Nusantara et al., 2020b). Giving students a PISA-like mathematics problem will acquaint them with working on PISA questions, which will help them enhance their reasoning skills (Azizah et al., 2017). Students' mathematical literacy, which means their reasoning, can be improved by asking questions with valid and practical PISA-like maths problems (Zulkardi & Kohar, 2018).

The context that is close to students and is a hot topic currently being discussed is the context of COVID-19 (Saputri et al., 2020). Situations like the number of deaths and incidents of spread are frequently reported in the media. This environment is ideal for learning mathematics (Nusantara et al., 2021). It's believed that through learning about the current COVID issue, students will be able to grasp conflict, what COVID-19 is, how it is disseminated, and how students can tell if it's fact or hoax. There are already a plethora of materials relating to COVID-19, such as the proliferation of cases across Indonesia (Prabowo & Dahlan, 2020). As a result, the teacher can use that context to present PISA-like maths problems during the learning process.

The applied learning method or strategy impacts students' thinking abilities (Zulkardi, 2002). PMRI is a teaching method based on real-life situations that students have encountered (Zulkardi & Putri, 2010). In this instance, PMRI may be a viable option for improving the learning process and outcomes since students will be able to expand their knowledge and understand the concepts in that content (Manik, 2021).

This study is linked to a previous study that looked at the relationship between using the PMRI approach to improve students' mathematical reasoning abilities in number patterns (Octriana, 2019) and students' reasoning abilities in solving PISA equivalent questions with

geometric content (Octriana, 2019). (Asdarina & Ridha, 2020). However, there has been no research on student's mathematical reasoning abilities in solving PISA-like mathematics problems in the context of COVID-19 using the PMRI approach. In this regard, the researchers are interested in researching to gain an overview of students' mathematical reasoning abilities in solving PISA-like mathematics problems in the context of COVID-19 using the PMRI approach on class VII number material.

Methods

This descriptive study uses the PMRI approach to determine students' mathematical reasoning abilities in solving PISA-like mathematics problems on the COVID-19 context number material. The participants in this study were 34 students consisting of 20 male students and 14 female students from SMP Srijaya Negara Palembang's class VII.B in the odd semester of the 2021/2022 academic year. Data was gathered using essay test questions as many as two items, observations, and interviews with three students with different abilities, namely high, medium, and low. The test consists of two items in the form of a description of the test question. Number one has a level of difficulty, namely level two equivalent to C3, while question number two is level three equivalent to C4. The lecturer of Sriwijaya University, the doctoral student of Sriwijaya University, and the teacher of SMP Srijaya Negara Palembang all validated the research instrument. Validation results for the three validators The images chosen must be real data, problem-solving must include at least two strategies, and the question sentence editor must be adjusted to the level of difficulty, among other things. Following that, the researcher conducted one-on-one and small group trials, with the results for question number two being changed from "amount" to "total."

The results of student answer will be analyzed using the following scoring guidelines.

Table 1. Scoring guidlines

Score	Reasoning Indicator
4	Perfect answer, completion is given completely and correctly
3	The answer are correct, but the solution given contains one significant error
2	The answer is almost correct, but solution given contains more than one significant error or deficit
1	The answer is wrong, the solution is not completely resolved but contains at least one valid argument
0	The answer is wrong, the solution is based on process or argument that is wrong or contains no response at all

The observation data were descriptively analyzed, and researchers saw which students were active in the learning process and then presented them in the table. The interviews data were analyzed descriptively, and researchers listened to the student's answers about how they answered the questions.

The test's purpose was to determine which category of students' mathematical reasoning abilities in problem-solving fell into. Using the PMRI approach, observations were made to see what indicators emerged and students did while learning (Anggraini & Zulkardi, 2020). Learning using the PMRI approach begins by giving sharing tasks that enable students to

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discuss with each other to solve the problem with tiered questions. Then, students are given jumping tasks to use their knowledge and discuss with friends how to solve questions that have a higher level of difficulty than sharing tasks. From the results of students' answers, students begin to see whether their reasoning abilities are approximately good or not. The next step is to test student's mathematical reasoning abilities. While interviews were conducted to confirm answers to student test results and provide data to support test results, they were also conducted to confirm the answers to student test results (Saputri et al., 2017; Anggraini & Zulkardi, 2020). The type of data analysis that was used was descriptive. In this study, the following are indicators and descriptors of mathematical reasoning abilities adopted from Dikdasmen Depdiknas No 506/C/PP/2004 date November 11, 2004, regarding the development of junior high school students.
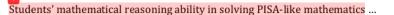
Table 2. Mathematical reasoning ability indicator

Indicator	Descriptor
Submit a conjecture	• Able to write what is known and asked from pictures and questions
Mathematical Manipulation	• Able to translate problems in sentence form into mathematical form • Able to solve problems based on assumptions
Drawing Logical Conclusion	• Able to write logical conclusion in accordance with the problem

Table 2 contains indicators and descriptors of mathematical reasoning ability used in this study and has been adapted to the number material.

Results

Starting with the problem of sharing tasks and jumping tasks, the learning is carried out using the PMRI approach, and the test questions are as in Figure 1. Figure 1 depicts the number one test question, which has a difficulty level of level two equal to C3. As of June 28, 2021, the data in the image represents death data for Indonesian health workers as a result of COVID-19. Between March 2020 and June 2021, students must calculate the number of deaths caused by COVID-19 among health practitioners.
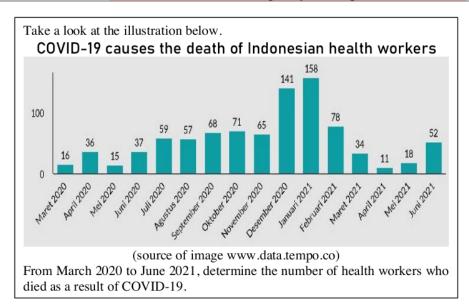
Take a look at the illustration below.

COVID-19 causes the death of Indonesian health workers

(source of image www.data.tempo.co)
From March 2020 to June 2021, determine the number of health workers who died as a result of COVID-19.

Figure 1. Test question number 1

INDONESIA IS A CORONA EMERGENCY
6 Areas With The Largest Cases

No	8 June 2020	5 June 2021
1	**DKI Jakarta** Case: 8.121, Healed: 3.206, Die: 529	**DKI Jakarta** Case: 434.116, Healed: 415.246, Die: 7.273
2	**Jawa Barat** Case: 2.424, Healed: 952, Die: 161	**Jawa Tengah** Case: 204.342, Healed: 181.994, Die: 9.348
3	**Sulawesi Selatan** Case: 2.014, Healed: 673, Die: 94	**Kalimantan Timur** Case: 72.039, Healed: 69.236, Die: 1.731
4	**Jawa Timur** Case: 6.313, Healed: 1.499, Die: 502	**Jawa Barat** Case: 318.892, Helaed: 294.870, Die: 4.297
5	**Jawa Tengah** Case: 1.642, Healed: 428, Die: 98	**Jawa Timur** Case: 156.050, Healed: 142.713, Die: 11.458
6	**Kalimantan Selatan** Case: 1.347, Healed: 117, Die: 100	**Sulawesi Selatan** Case: 62.321, Healed: 60.964, Die: 948

(Source of image www.cnbcindonesia.com)
Check whether the total rise in death cases in the DKI Jakarta and West Java provinces from June 2020 to June 2021 was 10.000 instances?

Figure 2. Test question number 2

Figure 2 depicts the number two test question, which has a difficulty level of level three, equivalent to C4. In June 2020 and June 2021, the picture of Indonesia's corona emergency indicates six regions with the most incidents. Students must verify whether the cumulative rise in mortality cases in DKI Jakarta and West Java Provinces from June 2020 to June 2021 reached 10,000. Here are some of the students' responses.

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AA's answers (high ability student)

Submit a conjecture

Mathematical Manipulation

Drawing Logical Conclusion

Translated
Known:
March 2020: 16   December: 141
April 2020: 36   January 2021: 158
May 2020: 15   February 2021: 78
July 2020: 59   June 2020: 37
August 2020: 57   March 2021: 34
September 2020: 68   April 2021: 11
Oktober 2020: 71   May 2021: 18
November 2020: 65   June 2021: 52
Asked: find out how many people died
Answer:
16+36+15+37+59+57+68+71+65+141=565
158+78+34+11+18+52=351
So, 565+351=916
So, from March 2020 to June 2021, 916 persons died as a result of covid-19 in health workers.

Figure 3. AA's answer for the question number 1

Figure 3 shows that students comprehend the information in the image and the meaning of the problem, resulting in indicators making assumptions, manipulating mathematics, and drawing logical conclusions. Students receive a score of 12 on question number 1. AA is one of the students who pay attention and is not afraid to ask questions even during learning.

Submit a conjecture

Mathematical Manipulation

Drawing Logical Conclusion

Translated
Known:
Case of death in DKI Jakarta
8 june 2020: 529
5 june 2021: 7.273
Case death in West Java:
8 june 2020: 161
5 june 2021: 4.297
Increase in death case in DKI Jakarta
7.273-529 = 6.744
Increase in death case in West Java
4.297-161 = 4.136
Asked: Total increase in death case
Answer: 67.44 + 4.136 = 10.880
Because the total increase in death cases is 10.880, the conclusion is incorrect.

Figure 4. AA's Answer for the question number 2

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Figure 4 shows that students comprehend the question's content and can write down everything known and asked in its entirety. As a result, he receives a score of 4. The final step, checking for increases in the two provinces, adding them together, and receiving a score of 4, is likewise right. The conclusion is also correct, earning a score of four. As a result, the overall score is 12.

ST's answer (medium ability student)

Submit a conjecture

Known: Number of death from healtg workers due to COVID-19

In 2020	In 2021
March = 16,	March = 34
April = 36,	April = 11
May = 15,	May = 18
June = 37	June = 52

Asked: determine the number of deaths from health workers due to COVID-19 from march 2020 untill june 2021

Mathematical Manipulation

Figure 5. ST's answer from the question number 1

Based on the responses of students and interviews, it appears that ST is misinterpreting the questions, resulting in incorrect solutions at the end. The question covers the period from March 2020 to June 2021, yet ST only writes from March 2020 to June 2020, then from March 2021 to June 2021 in the second part. Meanwhile, the period from July 2020 to February 2021 has not been written. The researcher came to the conclusion that ST did not read the questions carefully or could not properly analyze them. Her mathematical manipulation abilities are already strong, it's only that the outputs are incorrect due to the inadequate data. ST does not include a conclusion in the results section, only line two. Based on the foregoing analysis, the researcher assigns a 2 to the indicator of making claims, a 3 to the indicator of mathematical manipulation, and a 0 to the indicator of drawing logical conclusions. As a result, the ST score attained is 5.

Figure 6 and results of student interviews show that ST knows what they know and are asked about the questions. She meets the indicator of submitting an assumption with a score of four. However, he was inaccurate when it came to math because, rather than looking for an increase in death cases in each province, she added death cases to the two provinces every year. She got one for it. She determined that it was accurate even if the result he received was not 10,000 examples to draw a reasonable conclusion. She then receives a score of zero. She is awarded a total of 5 points.

Figure 6. ST's answer from the question number 2

RR's answer (low ability student)

Figure 7. RR's Answer from the question number 1

It indicates that students comprehend the meaning of the questions based on the images and the findings of interviews with students. It is only that he did not write down everything that was known and requested; instead, he answered the problem right away by writing down the facts in an addition operation. As a result, the student does not appear to be submitting his conjecture; instead, the student appears to be manipulating numbers. Because the signs for generating logical conclusions are also absent, they receive a 4 out of a possible 5.

Then, in response to question 2, RR simply wrote the word "yes" in the response. The signal in this example reveals that RR draws judgments, but she does so without supporting evidence. She seemed to be oblivious to the meaning of the inquiry. Indicators are not used to make conjectures, and mathematical manipulations are not used. Because the response is incorrect and is not supported by evidence, the score is 0, and she receives a score of 0 in question 2.

Only 14 of the 34 students collected responses to the tests. It is because many kids do not own cell phones and rely on their parents' property to complete their assignments, making it difficult to complete them. The indications' appearance can be seen in the accompanying table, which is based on the responses of 14 students.

Table 3. The origin of mathematical reasoning ability indicators

Indicator	Total student who meet	
	Question test number 1	Question test number 2
Submit a Conjecture	10	11
Mathematical Manipulation	13	12
Drawing Logical Conclusion	6	8

According to table 3, the indicator that emerges the most frequently from the two test questions is mathematical manipulation, which received responses from 13 people for question one and 12 people for question two. The scores of all students' replies were then calculated and arranged into table 4 below.

Table 4. The qualitative value of mathematical reasoning ability

Score	f_1	f_2	f_{tot}
81-100	5	7	12
61-80	3	1	4
41-60	1	2	3
21-40	5	0	5
0-20	1	2	3

Note:

f1: Number of students in question number 1

f2: Number of students in question number 2

ftot: f1 + f2

According to table 4, the top five students on question one have the highest score, while the top seven students have the highest score on question two. The most people are in question two, which has the lowest score, 2 people.

Table 5. Students' average mathematical reasoning abilities

Score	f_{tot}	x_i	$f_{tot} \cdot x_i$	Average
81-100	12	90,5	1086	63,037
61-80	4	70,5	282	
41-60	3	50,5	151,5	
21-40	5	30,5	152,5	
0-20	3	10	30	
Total	27		1702	

According to table 5, the average mathematical reasoning ability of 7th-grade students in solving PISA-like mathematics problems on the COVID-19 context number material after implementing the PMRI approach learning indicates that the students' mathematical reasoning abilities are classified as good.

Discussion

According to the study's findings, the analysis of students' mathematical reasoning abilities that emerged after learning with PISA-like mathematics problems was applied to the COVID-

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19 context number material using the PMRI approach, according to the study's findings. The following is a more detailed explanation of the indications identified in this research.

Submit a conjecture

The indication that submitting a conjecture can be described as appearing in the second order. It is because most students displayed the indicator, with only a few students failing to write it down. When the indication presenting conjectures appears, students understand the question by putting down what they know and asking questions based on illustrations and questions. After that, the learner makes an educated assumption about the problem's solution, which leads to mathematical manipulation. Real data or graphics also influence students' responses to problems. According to Zulkardi et al. (2020), some students read the questions first, then look at illustrations, tables, or count all the data, and so on.

Mathematical manipulation

The indicator that occurs the most in this investigation is mathematical manipulation. Students can convert phrases into mathematical forms and then answer problems using assumptions or what is known and asked from the questions. Even if some students cannot write down what is known and asked, they can solve the problem using arithmetic procedures, even if the solution is not entirely correct. Wulandari et al. (2016) said that this means that students are used to transforming real-world situations into mathematical problems.

Drawing logical conclusion

Many students fail to write conclusions from the issues they have solved in this indicator. Line two in the answer section on mathematical manipulation is frequently used by students. As a result, after receiving an answer, students line up the two responses to signify that they have concluded. When the indicator should draw a logical conclusion, it appears if the student writes a new statement indicating that sentences are a conclusion from the calculation results (Afnadi, 2016). Some students perform their calculations accurately but come to the incorrect conclusion, which contradicts the data and the questions asked.

Because the teacher directed them, the students appeared to understand the context of COVID-19 when they were studying. Bidasari (2017), PISA-like mathematics problem quantity content, has a potential effect on junior high school students. Fauziah et al. (2017) discovered that using the PMRI approach to learning made it easier for students to understand and learn new things. Students can expand their knowledge and understand the principles in the content they are studying (Manik, 2021). PMRI, according to Octriana et al. (2019), can help students grow and improve their mathematical reasoning indirectly.

However, some students are less engaged in the learning process due to online learning. Due to quotas, networks, parents using cellphones, low batteries, and other factors, many children are passive and do not respond during learning and group discussions. Only 14 students collect test answers as a result of this. Sholichin et al. (2021) found that many students could not participate in learning because of unstable networks, low cellphone

batteries during class, and a lack of internet capacity.

Aside from the online learning issue, students still require a significant amount of time due to the constraints of researchers who only teach one meeting and immediately deliver test questions for the second meeting, causing students to be unfamiliar with learning to answer problems in the context of COVID-19. As a result, learning that leads to mathematical thinking requires a significant amount of time.

Despite the challenges, the findings of this study demonstrate that students' average mathematical reasoning ability is 63,037, which is considered good, with mathematical manipulation as an indicator that frequently arises. Students' reasoning abilities were likewise classified as good when using the PMRI technique, according to Nisa et al. (2019). In junior high schools, PMRI could be an alternative learning model (Kusumaningrum, 2016).

For future research, pay attention to the allocation of time used during learning. Then, for the researchers and the students to better prepare all the necessities for online learning, such as internet and network quotas.

Conclusion

The mathematical reasoning ability of grade VII students in solving PISA-like mathematics problems on the COVID-19 context number material using the PMRI approach is good, according to the research results, because students are used to modeling contextual problems so that indicators of mathematical manipulation appear. Students' understanding of cases of spread and the current situation of Indonesia can be increased by asking questions based on COVID-19 and taught utilizing the PMRI approach. However, this study has some drawbacks, including a lack of lesson hours due to online learning, and the questions used are of a pretty high difficulty level.

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Conflicts of Interest

The authors state that the publication of this work does not include any conflicts of interest. Furthermore, the writers have comprehensively addressed ethical issues such as plagiarism, misconduct, data fabrication and/or falsification, multiple publishing and/or submission, and redundancy.

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