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ANALYSIS OF STUDENT ERRORS RELATED TO THE ASPECTS OF COMMUNICATION, MATHEMATISING, AND REPRESENTATION IN THE COMPONENTS OF THE PISA MATHEMATICAL LITERACY PROCESS

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Abstract

Project Based Learning (PjBL) is a learning model with an inquiry approach that adopts student-centered learning. This research was apre-experimental quantitative research with a one group pretest-posttest design which aims to analyze the effectiveness of learning through the implementation of PjBL. This research involved a class of students at a Junior High School in South Sulawei Province. Data collection included: 1) the test consists of 5 essay questions with cognitive level C5; 2) an attitude assessment observation sheet that measures the attitude of mutual cooperation, critical reasoning, conscientiousness and responsibility; 3) skills assessment sheet that measures the ability to observe, ask questions, explore, process data and communicate; 4) project assessment sheet, measuring the project implementation stage, results stage, and presentation stage. The data analysis technique used descriptive analysis and inferential analysis using paired-sample t-test with Shapiro Wilk normality test requirements. The research results concluded that PJBL is effectively implemented to improve the quality of research processes and results. The effectiveness indicators are described as follows: 1) Learning outcomes after implementing PjBL reach the very high category, there is a significant difference between the Pre-test and post test, the average student learning outcomes after implementing PjBL are higher than student learning outcomes before the action; 2) a series of learning activities carried out by students in PjBL such as observing skills, asking questions, exploring, processing data, and communicating are able to empower students' skills so that students' skills meet the very good category; and 3) students' attitudes in the learning process which include mutual cooperation, critical reasoning, thoroughness and responsibility meet the very good category.

Keywords: project based learning (PjBL); learning effectiveness; learning outcomes, skills and attitudes

1. Introduction

PISA (*Program for International Student Assessment*) measures how well students, at age 15, are equipped to deal with problems they may face in the future [1], [2]. Participants include OECD member countries as well as more than 30 non-member economic partner countries [3]. PISA consists of several literacies, one of which is mathematical literacy [3].

The ability to articulate, apply and interpret mathematics in a variety of situations, and the capacity to use concepts, processes and facts to describe, explain or anticipate phenomena or events, are all part of what the OECD defines as mathematical literacy [4]. Understanding the function or application of mathematics in everyday life and using it for decision-making as a responsible, wise and constructive citizen are both made possible by mathematical literacy[5].

The PISA process involves seven important things as follows: (1) Communication; (2) Mathematishing; (3) Representation; (4) Reasoning and Argument; (5) Devising Strategies for Solving Problems; (6) Using Symbolic, Formal and Technical Language and Operation; and (7) Using Mathematics Tools [2]. This study focuses on the ability of the Using Symbolic, Formal and Technical Language and Operation process.

Your ability*sing Symbolic, Formal and Technical Language and Operation* Mathematical literacy involves the ability to use symbolic language, formal language and technical language and mathematical operation skills [4]. After seeing a problem, someone is asked to name and understand it. An important stage in understanding, describing and defining problems is modeling. It may be necessary to summarize and report interim results to find answers. In addition, if a solution is established, the findings must be communicated to others along with justification and explanation. Presenting the results of problem solving requires communication skills (OECD, 2019). Communication is a routine in interacting between two or more people. Speaking and writing mathematical concepts to friends, teachers and others in a way that can be understood while providing arguments and explanations is known as mathematical communication [6], [7]. According to Sumarmo Students' mathematical communication skills include: 1) Integrating mathematical concepts with real-world objects, images, and diagrams; 2) Using real-world examples, images, graphs, and algebra to explain mathematical concepts, situations, and relationships orally or in writing; 3) Putting ordinary events into mathematical words or symbols; 4) Making conjectures, gathering evidence, developing definitions and generalizations, and writing about mathematics are important skills to develop; 5) You should also be able to explain and ask questions about mathematics that has already occurred [8].

The ability to communicate mathematically is a very important talent for students to have. However, the problem that often arises is that students' responses to the information they receive are often not as expected. Because mathematics is full of terms, symbols, and symbols, it is natural that students are good at solving mathematical problems but are unable to explain their solutions to others [9]. In addition, according to Ningtyas, certain students tend to be less confident when expressing their mathematical concepts [10]. Both orally and in writing, the ability to describe and communicate mathematical concepts is very important. A key element of the mathematical communication standards that students must have is the ability to express mathematical ideas from a text both orally and in writing. Students' mathematical communication skills are influenced by their mathematical abilities.[9]–[11].

In addition to communication skills, mathematical skillsis also very important. To understand a mathematical result or model into its original problem, or to transform a problem from the real world into a mathematical form or vice versa, one must have mathematical literacy, this is called "mathematising"[4], [12]. This is in line with the opinion Kholifasari et al. which states that because students' ability to use mathematics to solve problems in their daily lives cannot be separated, mathematical literacy skills are very important for learning mathematics [13]. This is what connects the mathematics that students learn in class with the application of mathematics in the real world.

Next is representational ability. The capacity of students to convey mathematical concepts or ideas in a certain way is known as representational ability [14]. Students' mathematical concept representation is an effort to overcome the problems faced. Mathematical concepts can be represented in various ways while dealing with problems, including images, tables, graphs, numbers, letters, and other symbol [15]. This is in line with the statement Hardianti & Effendi which states that representation ability is the capacity to select, interpret, translate, and use graphs, tables, images, diagrams, formulas, equations, or concrete objects to depict problems in a way that makes them easier to understand [16].

However, the importance of these abilities is inversely proportional to the results of PISA. PISA statistics show that the achievements of Indonesian students are still far behind

other countries. Based on the results of the 2006 PISA ranking, Indonesia's mathematical literacy ability was ranked 50th out of 57 participating countries, ranked 61st out of 65 participating countries in 2009, and ranked 64th out of 65 participating countries in 2012 [4]. The latest PISA results in 2018 also show that Indonesia's mathematical literacy score is still below the international average score, which is 379 out of 489 [2].

By analyzing the results of the PISA exam which consistently places Indonesia in the bottom 10, it is clear that Indonesian students often make mistakes and have difficulty in solving PISA mathematical literacy questions of the story type. This problem is in line with the statement Parnitasari & Ratu which states that students experience difficulties in completing PISA questions which causes students to make mistakes and obtain low results [17]. Novferma said that less than optimal learning outcomes were caused by students experiencing difficulties so that mistakes occurred [18]. In addition Trapsilo said that the mistakes made by students occurred because students had difficulty in interpreting real context problems into algebraic forms [19]. Another cause was that students were not careful in doing calculations [20].

Based on this background, it will be analyzed students' errors related to the process elements in solving PISA Mathematics literacy questions. Where this research will be conducted on 9th grade students of SMPN 21 Bengkulu City.

2. Method

This study aims to analyze student errors related to the elements of the PISA mathematical literacy process. Therefore, the research used is qualitative descriptive research. SMPN 21 Bengkulu City became the location of the research. Grade 9 students of SMPN 21 Bengkulu City were used as research subjects.. The data of this study are students' errors in solving PISA questions. The data collection method used is the semi-structured test and interview method. Test and interview instruments are the instruments of this research. Essay and multiple choice questions are the test formats in this research. The test findings are expanded by using an interview guide. Data analysis was conducted descriptively and analytically, with the criteria, namely if students make mistakes related to the elements of the PISA mathematical literacy process, then the student is declared to have made mistakes in the elements of the PISA mathematical literacy process, this can be seen in table 1, as follows:

Table 1 List of Student Process Element Error Assessments in Completing PISA Mathematical Literacy

Process Elements	Category Students Make Mistakes
Communication	1. Students write their answers in an unstructured/unorganized manner, which confuses the corrector/teacher. 2. Unable to explain the answer verbally during the interview. 3. For multiple-choice questions without descriptions, students are said to have made an error if they answer incorrectly, which means that the student is unable to read/understand the question properly. 4. Did not answer the question.
Mathematising	1. Students are wrong in making a mathematical model of the problem correctly. 2. Did not answer the question.
Representation	1. Students make mistakes in creating images to represent their explanations. 2. Did not answer the question.

3. Result and Discussion

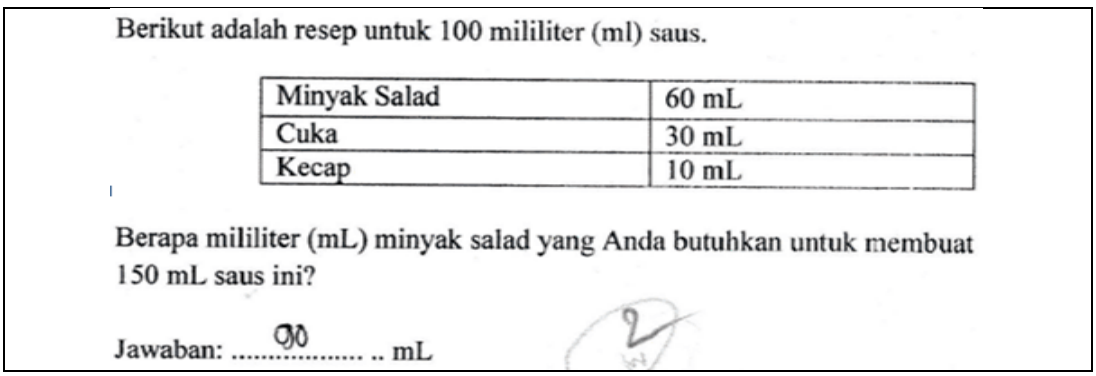
The test for this study was conducted at SMPN 21 Bengkulu City with samples of classes 9.1 and 9.2, each consisting of 32 and 34 students. Class 9.1 is a superior class while class 9.2 is a bilingual/independent class. This sample was chosen because according to the teacher, this class is more talented than other classes. However, 10 children in class 9.1 showed below average mathematics abilities, as shown by interviews with their teachers. So this class is quite representative of classes with low and medium ability students. To determine students' abilities and errors in answering PISA mathematical literacy questions, this study used two types of instruments, namely tests and interviews.

Table 2 shows the results of students' ability tests on the PISA mathematical literacy process elements.

Table 2 Summary of Student Errors in the Elements of the 2012 PISA Mathematical Literacy Process

No	Process Components		Class	Many Students Master Process Skills															Percentage
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
	Using Symbolic, Formal and Technical Language and Operation	*Symbolic*	9 2	20		28	11	11	19	31	33	11	21	19	16	26	26	15	16	49.82%
			9 1	26		32	7	3	2	24	17	8	12	14	10	14	14	8	23	
		Operation	9 2	33	21	16	8	6	7	31	25	11	21	21	10	23	26	15	16	
			9 1	26	2	32	7	3	2	24	17	8	12	14	10	14	14	8	23	

Based on the analysis of table 2 of student errors on PISA mathematical literacy questions, it can be seen that the first process error is communication. Communication process errors are related to students' errors in explaining their answers in writing. In question number 2, there were 24 students in class 9.2 and 31 students in class 9.1 who were unable to explain their answers properly. This shows that there are still many students who make communication errors. However, in question number 10, there were only 8 students in class 9.1 and 5 students in class 9.2. Likewise for questions 4 and 22, there were no students in class 9.1 and 1 student in class 9.2 who made communication errors. Figure 1 is an example of a student's answer that made a communication process error. The student only wrote a direct answer of 90, he should have written in detail the process of getting the answer.


Berikut adalah resep untuk 100 mililiter (ml) saus.

Minyak Salad	60 mL
Cuka	30 mL
Kecap	10 mL

Berapa mililiter (mL) minyak salad yang Anda butuhkan untuk membuat 150 mL saus ini?

Jawaban: 90 .... mL

Figure 1 Example of Student Answers that Made Communication Process Errors in Number 10

Based on the interview results, students are confused about how to write the correct solution to the problem. This can be seen from the following interview results.

ICE	*: Now pay attention to question number 10. How can you answer 90 mL?*
RJ	*: It is known that 100 mL of sauce requires 60 mL of salad oil, sir. So if 150 mL of sauce means you still need 50 mL more sauce, sir. Because 100 mL of sauce requires 60 mL of salad oil, so 50 mL of sauce requires 30 mL of salad oil. So if 150 mL of sauce requires 60+30=90 mL of salad oil, sir.*
ICE	*: You can answer that. Why don't you write the answer?*
RJ	*: Yes sir, I understand what you mean.**But I'm confused about how to write it, sir.**.*

Figure 2 Interview Results Showing Communication Errors

Based on the students' answers to question number 10 and the results of the student interviews, the students were unable to explain their answers in good and correct written form, and did not read the questions carefully. This shows that students have poor communication process skills. Based on the results of this study, 40.85% of students were unable to understand the questions, did not read the questions carefully, and were unable to explain their answers in good and correct written form. This is in line with research conducted by Sholihah et al. which states that students are less careful and lazy to read long questions [21].

The second type of process error is mathematising. Mathematising process errors are related to students' errors in creating mathematical models of problems. The most common mathematising process errors made by students are in question number 9, with 30 students in class 9.1 and 25 students in class 9.2. In question number 8, there were 29 students in class 9.1 and 23 students in class 9.2 who still made mathematising process errors. This shows that in this question, students are still unable to create mathematical models of problems. The fewest mathematising process errors made by students were in question number 3, with 6 students in class 9.2 and 2 students in class 9.1 who made mathematising process errors. This shows that in this question, only a few students were unable to create mathematical models of problems. Figure 3 is an example of a student's answer that made a mathematising process error. The mathematical model created is not quite right, students wrote Rope/90o when the correct answer should be Rope/45o.

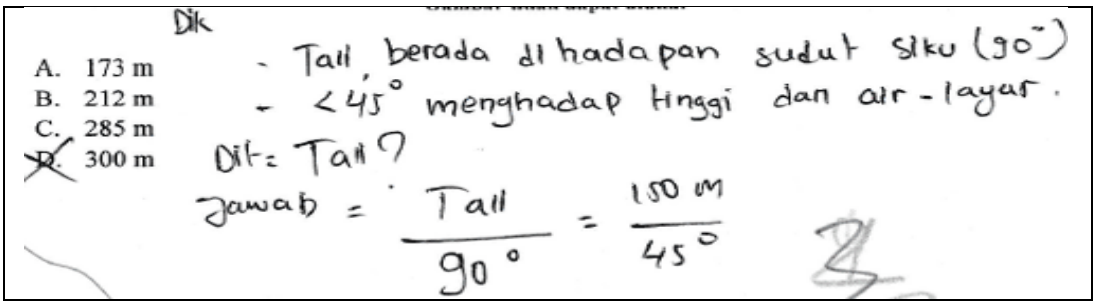


Figure 3 Example of Student Answers that Made Mathematising Process Errors in Question Number 8

This is supported by the results of interviews with students who made the mistakes. Students are still unable to create mathematical models correctly. The following are the results of interviews with students.

ICE	*: Now pay attention to your answer to number 8. Try to explain it to me.*
PM	*:**It is known that the rope is facing a right angle (90o), and 45o facing the height (150 m). Then asked about the length of the rope. So, we can make a ratio rope/90o = 150m/45o**, so length of rope= (150 m/ 45o)x 90o = 300m.*
ICE	*:**PM is not like that. What we should see is a triangle with angles of 90o and 45o so the other angle is 45o, so the image of the triangle is an isosceles right triangle. If the height is 150m then the length of the base side is also 150m.**So to find the length of the kite string we use Pythagoras.*

Figure 4 Interview Results Showing Mathematising Errors

Based on the students' answers to question number 8 and the results of the student's interview, the students were unable to create a mathematical model of the existing problem. This shows that students make mistakes in the mathematising process. This is in line with research conducted by Trapsilo which states that many students have difficulty in changing real context questions or problems into mathematical or algebraic models [19]. Based on the results of this study, 48.59% of students made the wrong mathematical model from the existing questions.

The third type of process error is representation. Representation process errors are related to students' errors in making drawings. The most representation process errors made by students are in question number 8, as many as 29 students in class 9.1 and 24 students in class 9.2. This shows that in this question there are still many students who have not been able to make drawings that can help students explain their answers. The least representation process errors made by students in question number 1, as many as 6 students in class 9.2 and 13 students in class 9.1. In question number 23 there are 8 students in class 9.2 and 18 students in class 9.1 who made representation process errors. This shows that in this question only a few students are unable to make drawings that can help students explain their answers. Figure 5 is an example of a student's answer that made a representation process error. The student represents the width of the roof as 4 units, he should have used Pythagoras so that the width of the roof is 5 units.

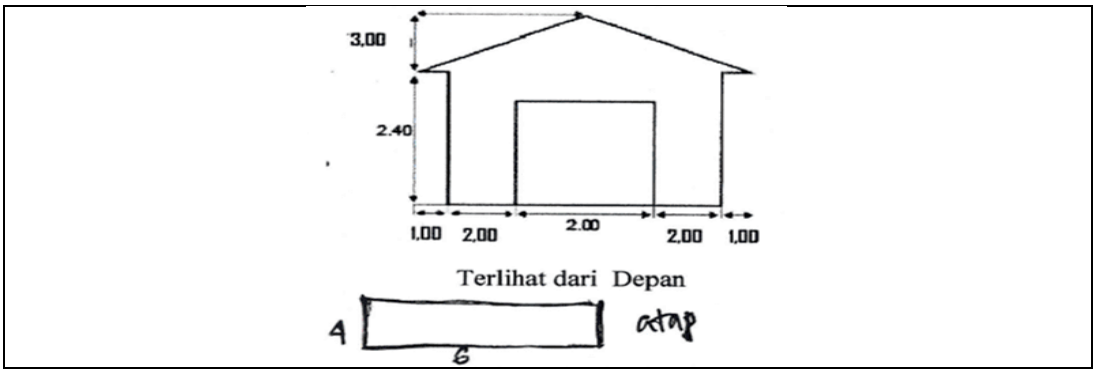


Figure 5 Example of Student Answers that Made Representation Process Errors in Number 23

This is supported by the results of interviews with students who made the mistake. Students are still not right in drawing the roof, namely in the size of the roof width. The following are the results of interviews with students.

ICE	*: Now pay attention to your answer to number 23. Explain your answer!*
PM	***: The roof is rectangular, with a length of 6 units and a width of 4 units.***
ICE	*: Look at the picture of the house, which part is the width of the roof?*
PM	*: This part, sir (Students point to the picture)*
ICE	*: That's right. Look at the picture, how wide should the roof be?*
PM	*: (Students think) Hmm, the width of the roof should be 5 units, sir, we should find it using Pythagoras.*
ICE	*: Yes, that's right. So,**the width of the roof is not 4 units as you wrote in the picture**.*

Figure 6 Interview Results Showing Representation Errors

Based on the students' answers to question number 23 and the results of the student interviews, the students were wrong in describing the width of the roof of the house. This shows that students made mistakes in the representation process. Based on the results of this study, as many as 53.41% of students made the wrong drawings. This is in line with the results of the study Kusumaningtyas which states that students make many mathematical representation errors [22].

4. Conclusions

Some process errors made by students in completing the 2012 PISA mathematical literacy are as follows:

a. The first type of process error is communication error. As many as 40.85% of students were wrong in explaining their answers. The most common student errors were due to students not being able to understand the questions, not reading the questions carefully, and not being able to explain their answers in a good and correct written form.
b. The second type of process error is mathematising error. As many as 48.59% of students made the wrong mathematical model of the existing problem. The most errors occurred because students were unable to model everyday life problems into mathematical language.
c. The third type of process error is representation error. As many as 53.41% of students made the wrong picture. The most student errors occurred because students were not precise in making pictures as a form of representation of the problem.

References

[1] N. Nurjannah, M. Mirna, N. Nurlili, and A. A. Ismunandar, "Analisis Kesalahan Siswa Dalam Memecahkan Masalah Pisa Ditinjau Dari Gender," *JTMT J. Tadris Mat.*, vol. 1, no. 2, pp. 1–8, 2021, doi: 10.47435/jtm.v1i2.466.

[2] OECD, *PISA 2018 Results : COMBINED EXECUTIVE SUMMARIES VOLUME I, II & III*, vol. I. 2019. doi: 10.1787/g222d18af-en.

[3] OECD, *PISA 2012 Results in Focus : What 15-year-olds know and what they can do with what they know*. 2014. [Online]. Available: https://www.oecd.org/pisa/keyfindings/pisa-2012-results-overview.pdf

[4] OECD, *PISA 2012 Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy*. 2013. doi: 10.4324/9781003090366.

[5] E. Stiadi, A. Putra, and R. Lestary, "Analisis Kemampuan Siswa Dalam Menguasai Komponen Content Ketika Menyelesaikan Soal Literasi Matematika Pisa Di Smpn 4 Kota Bengkulu," *J. Penelit. Pembelajaran Mat. Sekol.*, vol. 6, no. 3, pp. 440–449, 2022, doi: 10.33369/jp2ms.6.3.440-449.

[6] S. Tahmir, N. Nasrullah, and S. Nurwana, "Deskripsi Kemampuan Komunikasi Matematis Ditinjau dari Tingkat Kemampuan Matematika Siswa SMA," *Issues Math. Educ.*, vol. 4, no. 1, p. 30, 2020, doi: 10.35580/imed15289.

[7] M. Kholil and E. D. Putra, "Kemampuan Komunikasi Matematis Siswa Dalam Menyelesaikan Soal PISA Konten Space And Shape," *Indones. J. Math. Nat. Sci. Educ.*, vol. 1, no. 1, pp. 53–64, 2019, doi: 10.35719/mass.v1i1.6.

[8] A. Astuti and Leonard, "Peran Kemampuan Komunikasi Matematis," *J. Form.*, vol. 2, no. 2, pp. 102–110, 2015, doi: http://dx.doi.org/10.30998/formatif.v2i2.91.

[9] L. Lutfianannisak and U. Sholihah, "Kemampuan Komunikasi Matematis Siswa dalam Menyelesaikan Soal Materi Komposisi Fungsi Ditinjau dari Kemampuan Matematika," *J. Tadris Mat.*, vol. 1, no. 1, pp. 1–8, 2018, doi: 10.21274/jtm.2018.1.1.1-8.

[10] I. K. Ningtyas, "PROFIL KEMAMPUAN KOMUNIKASI MATEMATIKA SISWA KELAS VIII MTs SULTAN AGUNG JABALSARI DALAM MEMAHAMI POKOK BAHASAN GARIS SINGGUNG LINGKARAN BERDASARKAN KEMAMPUAN MATEMATIKA," 2015. [Online]. Available: http://repo.uinsatu.ac.id/2058/

[11] I. R. Wardhana and M. Lutfianto, "Analisis Kemampuan Komunikasi Matematis Siswa Ditinjau dari Gender," *UNION J. Pendidik. Mat.*, vol. 6, no. 2, pp. 173–184, 2018, doi: https://doi.org/10.30738/.v6i2.2213.

[12] S. Lindawati, "Literasi Matematika Dalam Proses Belajar Matematika Di Sekolah Menengah Atas," *J. Prinsip Pendidik. Mat.*, vol. 1, no. 1, pp. 28–33, 2018, doi: 10.33578/prinsip.v1i1.18.

[13] R. Kholifasari, C. Utami, and M. Mariyam, "Analisis Kemampuan Literasi Matematis Siswa Ditinjau Dari Karakter Kemandirian Belajar Materi Aljabar," *J. Deriv. J. Mat. dan Pendidik. Mat.*, vol. 7, no. 2, pp. 117–125, 2020, doi: 10.31316/j.derivat.v7i2.1057.

[14] K. Hutagaol, "Pembelajaran Kontekstual Untuk Meningkatkan Kemampuan Representasi Matematis Siswa Sekolah Menengah Pertama," *Infin. J.*, vol. 2, no. 1, pp. 85–99, 2013, doi: https://doi.org/10.22460/infinity.v2i1.p85-99.

[15] B. Fattah, I. Zawawi, and M. Midjan, "Representasi Matematis Peserta Didik Menurut Pandangan Bruner Dalam Menyelesaikan Soal Geometri Ditinjau Dari Kemampuan Matematika Dan Jenis Kelamin," *Didakt. J. Pemikir. Pendidik.*, vol. 24, no. 2, pp. 123–138, 2018, doi: http://dx.doi.org/10.30587/didaktika.v24i2.333.

[16] S. R. Hardianti and K. N. S. Effendi, "ANALISIS KEMAMPUAN REPRESENTASI MATEMATIS SISWA SMA KELAS XI," *JPMI J. Pembelajaran Mat. Inov.*, vol. 4, no. 5, pp. 1093–1104, 2021, doi: http://dx.doi.org/10.22460/jpmi.v4i5.p1093-1104.

[17] D. Pranitasari and N. Ratu, "Analisis Kesalahan Siswa Dalam Menyelesaikan Soal Matematika Pisa Pada Konten Change and Relationship," *AKSIOMA J. Progr. Stud. Pendidik. Mat.*, vol. 9, no. 4, pp. 1235–1248, 2020, doi: 10.24127/ajpm.v9i4.2685.

[18] N. Novferma, "Analisis kesulitan dan self-efficacy siswa SMP dalam pemecahan

masalah matematika berbentuk soal cerita," *J. Ris. Pendidik. Mat.*, vol. 3, no. 1, pp. 76–87, 2016, doi: 10.21831/jrpm.v3i1.10403.

[19] T. E. B. Trapsilo, "ANALISIS KESALAHAN SISWA MENURUT TEORI NEWMAN DALAM MENYELESAIKAN SOAL-SOAL CERITA MATERI PERSAMAAN LINIER DUA VARIABEL PADA SISWA KELAS IX SMP N 1 BANYUBIRU," 2016. [Online]. Available: https://repository.uksw.edu/bitstream/123456789/9775/2/T1_202010039_Full text.pdf

[20] M. N. Cahyanto, "Kesalahan Siswa Kelas VIII Dalam Memecahkan Soal Matematika Model Pisa Konten Space and Shape," UNIVERSITAS MUHAMMADIYAH SURAKARTA, Surakarta, 2017.

[21] D. Sholihah, E. A. Purnomo, A. Aziz, and D. Ampuni, "Analisis Kesalahan Siswa Mengerjakan Soal Pisa Konten Ruang Dan Bentuk Dengan Prosedur Newman Ditinjau Dari Kecerdasan …," in *Seminar Nasional Edusainstek*, 2019, pp. 221–230. [Online]. Available: file:///C:/Users/USSER/Downloads/235-388-1-SM.pdf

[22] A. A. S. Kusumaningtyas, Kartono, and T. S. N. Asih, "Analisis Kesalahan pada Representasi Matematis Melalui Model Think-Talk-Write dengan Verbal Feedback," *Prism. Pros. Semin. Nas. Mat.*, vol. 3, pp. 518–520, 2020, Accessed: Mar. 15, 2021. [Online]. Available: https://journal.unnes.ac.id/sju/index.php/prisma/article/view/37574/15534