

An Analysis of Mathematics Education Students Errors in Solving PISA Adaptation Test

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ABSTRACT

The objectives of this research are to determine the errors of mathematics education students in solving the PISA adaptation test. This research is an exploratory study with a qualitative approach that will produce descriptive data in the form of a description of the types and locations of student errors in solving PISA 2022. The subjects in this study were six students of the Program Studi Pendidikan Matematika Program Studi Diluar Kampus Utama (PSDKU) at Pattimura University in Maluku Barat Daya. They were in the second, fourth, and sixth semesters. Five students from each semester were asked to solve a question on the PISA adaptation test level 6, the highest level of the PISA test, as the method for selecting the subject. Six subjects were selected as research subjects out of the 15 who took the test. The conclusions in this study are that the ability of subjects to solve the PISA adaptation test is still very low. Only 3 out of 15 students can answer and provide the right solution for the test, and only 6 out of 15 students can figure out what to do to solve PISA adaptation test level 6. However, among the six students who gave their answers to this problem, there are some who have conceptual errors in the topic of SPLDV (System of Linear Equations with Two Variables). Besides conceptual errors, researchers also found that there is a subject who is incorrect in solving basic arithmetic operations involving parentheses.

Keywords: Conceptual Errors, Mathematics Education Students, PISA Adaptation Test.

ABSTRAK

Penelitian ini bertujuan untuk mengetahui kesalahan mahasiswa pendidikan matematika dalam menyelesaikan soal-soal adaptasi PISA. Penelitian ini merupakan penelitian eksploratif dengan pendekatan kualitatif yang akan menghasilkan data deskriptif berupa gambaran mengenai jenis dan letak kesalahan mahasiswa dalam menyelesaikan soal PISA 2022. Subjek dalam penelitian ini adalah 6 orang mahasiswa Program Studi Pendidikan Matematika Program Studi Diluar Kampus Utama (PSDKU) Universitas Pattimura Kab. Maluku Barat Daya yang berada di semester dua, empat dan enam. Metode pemilihan subjek dilakukan dengan meminta 5 orang mahasiswa dari masing-masing semester untuk menyelesaikan soal tes adaptasi PISA level 6 sebagai instrumen utama, yang merupakan level tertinggi dari tes PISA. 6 dari 15 subjek yang diberi tes, kemudian dipilih sebagai subjek penelitian. Kesimpulan dalam penelitian ini adalah kemampuan subjek dalam menyelesaikan tes adaptasi PISA masih sangat rendah. Hanya 3 dari 15 siswa yang menjawab dan memberikan solusi yang tepat untuk tes tersebut dan hanya 6 dari 15 siswa yang dapat mengetahui apa yang harus dilakukan untuk menyelesaikan tes adaptasi PISA level 6 ini. Namun, diantara 6 siswa yang memberikan jawaban pada soal, terdapat beberapa siswa yang memiliki kesalahan konseptual pada topik SPLDV (Sistem Persamaan Linier Dua Variabel). Selain kesalahan konseptual, peneliti juga menemukan bahwa ada subjek yang salah dalam menyelesaikan operasi hitung dasar yang melibatkan tanda kurung.

Kata kunci: Kesalahan Konseptual, Mahasiswa Pendidikan Matematika, Tes Adaptasi PISA.

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Introduction

The Programme for International Student Assessment (*PISA*) is an assessment tool in many regions around the world that was launched by the Organisation for Economic Co-operation and Development (OECD) to answer the need for internationally comparable evidence on student performance (OECD, 2023). This program is important both to compare and evaluate the education standards of each country. The achievement levels of the countries will be used as indicators of the education systems of the countries. The study will help governments and policymakers make changes in their country's education systems (Özer, 2020; Pons, 2017).

PISA is a triennial survey of 15-year-old students that assesses students' performance, especially in mathematics, reading, and science. It assesses not only students' ability to solve their daily tasks in school but also their ability to apply their knowledge in unfamiliar settings, both in and outside of school (OECD, 2023). The first PISA assessment was conducted in 2000 and has continued since then. It was implemented in 2003, 2006, 2009, 2012, 2015, 2018, and 2022 (Elisabeth et al., 2022; Pitsia et al., 2022). The number of countries participating in PISA has increased over the years. In 2022, 81 countries participated, including Indonesia. (OECD, 2023).

Based on the latest PISA's results in Table 1, the mathematics mean score of Indonesia is 366, which is below the mathematics mean score among OECD countries, which is 472 (OECD, 2023). Table 1 provides the proficiency scores of students in ASEAN countries in PISA 2023. It shows that, compared to other ASEAN countries, Indonesian students' mathematics skills are relatively poor. This is supported by previous research that states that students' mathematics skills in various regions of Indonesia are relatively low (Kurniati et al., 2018; Lestari et al., 2023; Nur'Aini et al., 2022; Putrawangsa & Hasanah, 2022; Sugiarto et al., 2023a). Whereas the results of PISA affect many factors of international relations between countries, such as the investment considerations of foreign investors (Özer, 2020; Pons, 2017).

Table 1. The Mean Score of ASEAN Students based on PISA 2022 Results

No	Countries	Mathematical Ability
1	Singapura	575
2	Viet Nam	469
3	Brunei Darussalam	442
4	Malaysia	409
5	Thailand	394

No	Countries	Mathematical Ability
6	Indonesia	366
7	Philippines	355
8	Cambodia	336

Source: OECD (2023)

The PISA ranking of a country is strongly influenced by the education system in that country, including teacher resources (Ambussaidi & Yang, 2019; Özer, 2020; Tonga et al., 2022; Yudhi Anggoro et al., 2019). Teacher resources, both in developed and underdeveloped areas, are very important. In Indonesia, the underdeveloped areas are also categorized as 3T regions. 3T in this context means underdeveloped, frontmost, and outermost regions (or, in Indonesian, the acronyms Tertinggal, Terdepan, and Terluar). Kabupaten Maluku Barat Daya is one of the underdeveloped areas that is located close enough to another country, Timor Leste (Kennedy et al., 2019; Sugiarto et al., 2023).

Just like the other 3T regions, the number of informal learning institutions in Kab. Maluku Barat Daya is very limited. This is also compounded by the low interest in self-learning among students in this area (Unpapar et al., 2022). These limitations make teachers one of the main learning resources for students at various levels of education. Therefore, the quality of teachers will have a significant impact on students' abilities, especially in mathematics. For this reason, we can improve the PISA scores of Indonesian students by improving the quality of teachers and prospective teachers, including those who teach or will teach in the 3T areas. This improvement can be implemented by finding out the ability of prospective teachers to solve the PISA questions and identifying their mistakes.

Because of the reasons described so far, it is very important to determine the errors of students in solving the PISA adaptation test, especially the students in Program Studi Pendidikan Matematika Program Studi Diluar Kampus Utama (PSDKU) at Pattimura University in Kab. Maluku Barat Daya. Besides the fact that this campus is the only school of teachers in Kab. Maluku Barat Daya, this campus is also one of the universities located in the 3T area. Knowledge of prospective teachers' errors can be a useful resource for lecturers to measure the extent of students' ability to solve the PISA adaptation test. In the future, this knowledge will improve the quality of education in Indonesia, especially in the 3T areas.

Research Methods

This research is an exploratory study with a qualitative approach that will produce descriptive data in the form of a description of the types and locations of student errors

in solving PISA 2022. In this study, researchers act as observers and interviewers to determine students' mistakes in solving the PISA adaptation test. The subjects in this study were six students of the Program Studi Pendidikan Matematika Program Studi Diluar Kampus Utama (PSDKU) at Pattimura University in Maluku Barat Daya. They were in the second, fourth, and sixth semesters. Five students from each semester were asked to solve a question on the PISA adaptation test level 6, the highest level of the PISA test, as the method for selecting the subject. These five selected students from each semester are the ones who qualified as the top 10 students at their respective levels. Six subjects were selected as research subjects out of the 15 who took the test. They are two subjects with correct answers, two subjects with incorrect answers, and two subjects who gave unique or different answers (without considering the accuracy of the answers).

This test consists of 1 question of PISA adaptation test level 6, which is the highest level of the PISA test (Figure 1). At this level, students conceptualize and generalize based on modeling and reviewing information in a complex situation and can make flexible connections between different sources of information and interpret them (Dewantara, 2018).

Ira and Ati each have candies. Here is a conversation between Ira and Ati

Ira : Ati, will you give me 5 candies of yours so my candies as much with your own candies.

Ati : (*Laughter*) No Ira. Why don't you give me 5 candies so my candies as much twice of your candies.

Question Problem

How many candies do Ira and Ati have? Write down how the calculations.

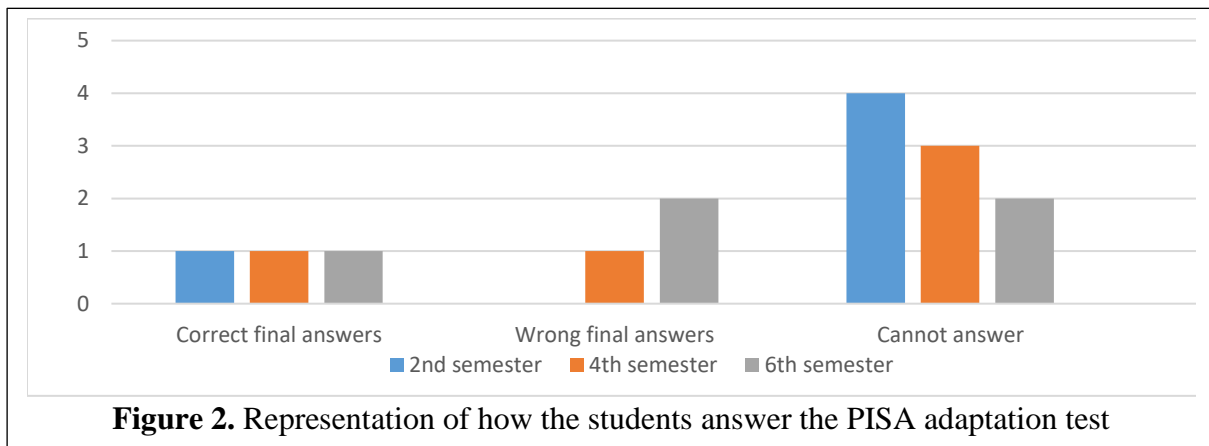
Figure 1. PISA Adaptation Test Level 6 (Lanya et al., 2021)

Students' answers then guided the researchers in conducting structured interviews. Students' problem-solving skills were identified in this interview based on Polya's four stages, namely, understanding the problem, devising a plan, carrying out the plan, and looking back (Triana et al., 2021).

Result and Discussions

Only four of the fifteen students were able to give accurate answers in the given twenty minutes. The remaining eleven students, however, claimed they needed more time and were unable to respond to the question because they did not understand its

purpose. Figure 2 provides a graphic representation of how the students answer the PISA adaptation test.



Based on the students' work, the researcher selected six subjects to conduct interviews with. The six subjects consisted of two students who answered correctly (S1 and S2), two students who answered incorrectly (S3 and S4), and two students who gave unique or different answers without considering the accuracy of the answer (S5 and S6).

Polya's First Principle: Understand the Problem

In this stage, S1 and S2 are able to re-explain the given problem using their own language. Both S1 and S2 were able to transform the given conversation into a mathematical model. Although S2 needed some extra explanation about the meaning of the question and left his paper blank for almost half the time.

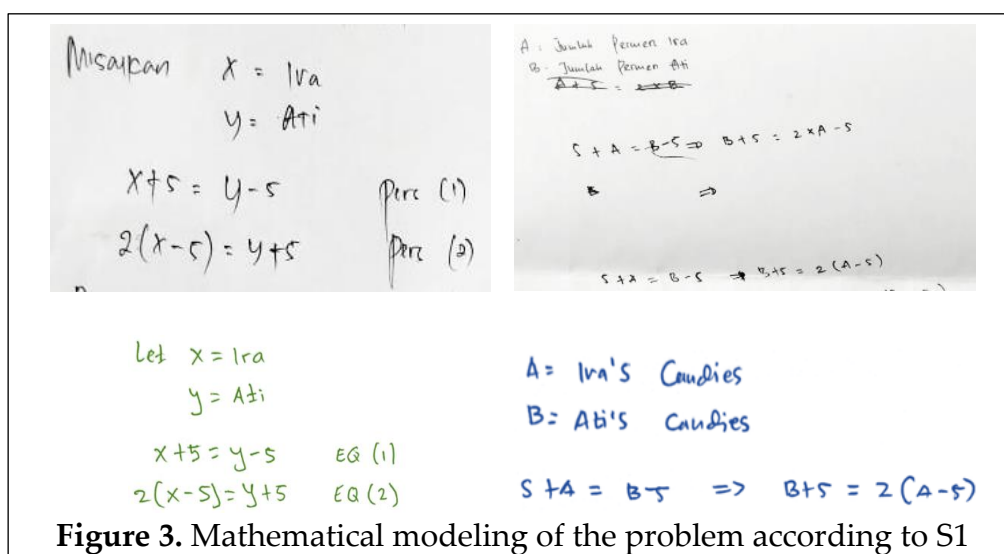


Figure 3 shows that S2 uses variables A and B to generalize the amount of candies that Ira and Ati have, whereas S1 employs variables x and y to create a mathematical model of the problem. According to Figure 3, the mathematical modeling they did looked similar. The only difference is in the writing sequence arrangement and variable assignment. Contrary to S1 and S2, subjects S3 and S4 had errors in understanding the problem. Both were wrong when it came to transforming the given problem into a mathematical model, as shown in Figure 4.

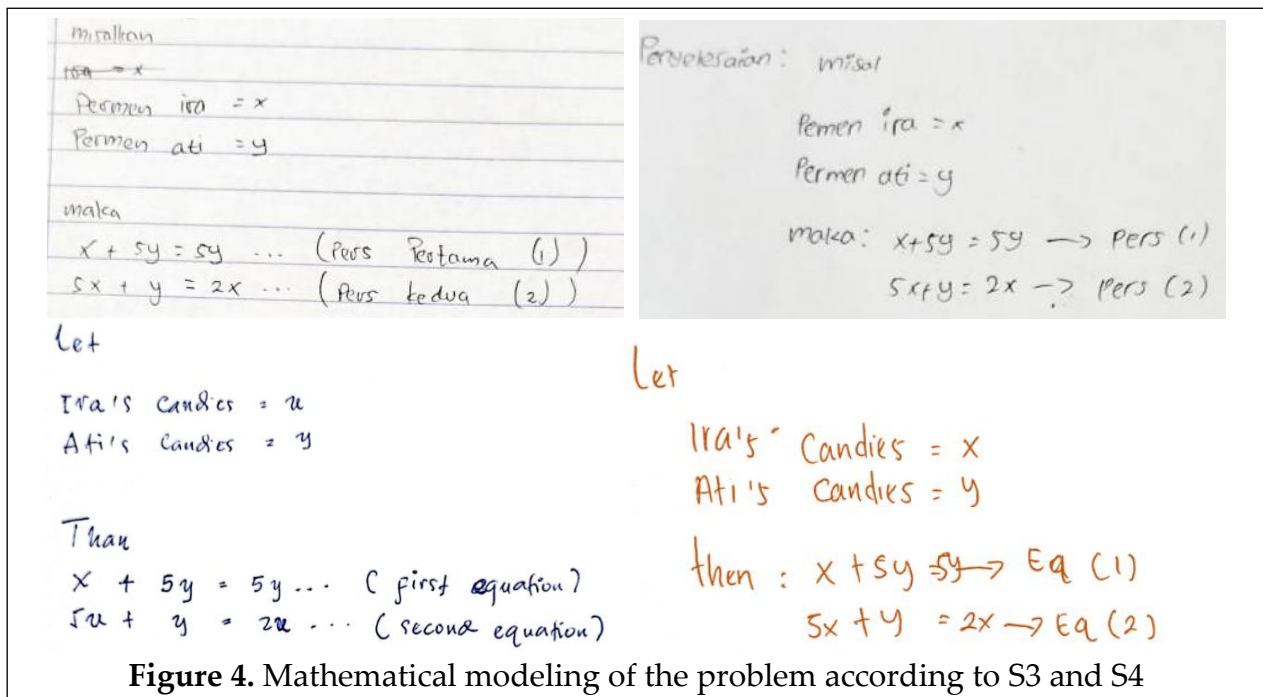


Figure 4. Mathematical modeling of the problem according to S3 and S4

S3 and S4 write the equation $x + 5y = 5y$ because the first statement in the problem is "Ira: Ati, will you give me 5 candies of yours so my candies as much with your own candies". In their opinion, the addition of 5 candies for Ira (which in the equation is written as $x + 5y$), is equal to Ati's candies (which in the equation is written as $5y$), therefore in the first equations S3 and S4 writes $x + 5y = 5y$. Moreover, in the second equation, they wrote $5x + y = 2x$ because of the second statement in the problem, "Ati: (Laughter) No Ira. Why don't you give me 5 candies so my candies as much twice of your candies". According to them, the addition of 5 candies for Ati (which in the equation is written as $5x + y$), is equal to twice Ira's candies (which in the equation is written as $2x$). Hence, in the second equation, they wrote $5x + y = 2x$. Furthermore, S5 and S6, who were categorized as gave unique or different answers stated that they solve the problem with logic and modeling, as shown in Figure 5.

As with S3 and S4, S5 was wrong in writing the mathematical modeling of the problem, as shown in Figure 5. S5 writes the equation $x + 5 = y$ because the first statement in

the problem, "Ira: Ati, will you give me 5 candies of yours so my candies as much with your own candies". In her opinion, the addition of 5 candies for Ira (which in the equation is written as $x + 5$) is equal to Ati's candies (which in the equation is written as y). Therefore in the first equation S5 writes $x + 5 = y$. Moreover, in the second equation, S5 wrote $5 + y = 2x$ because of the second statement in the problem, "Ati: (Laughter) No Ira. Why don't you give me 5 candies so my candies as much twice of your candies". According to her, the addition of 5 candies for Ati (which in the equation is written as $5 + y$), is equal to twice Ira's candies (which in the equation is written as $2x$), Hence, in the second equation, S5 wrote $5 + y = 2x$.

Ati = y
Ira = $2x$
Mencari nilai x dan y .
 $\rightarrow x + 5 = y$
 $\rightarrow 5 + y = 2x \rightarrow y = 2x - 5$

Ati = y
Ira = u
To find u and y
 $\rightarrow u + 5 = y$
 $5 + y = 2u \rightarrow y = 2u - 5$

Figure 5. Mathematical modeling of the problem according to

S3, S4, and S5 responses, which are half of the subjects, show that students' ability to transform real-life problems into mathematical form is extremely low. This statement is similar to the findings of (Hoiriyah, 2019) and (Oktaviana, 2018) that more than half of the students or subjects in their research have trouble understanding real-life problems and transforming them into mathematical form.

Ira dan Ati memiliki permen
permen Ati > permen Ira

- * Ati memberikan 5 permennya agar permen Ira sebanyak permennya
- * Ira memberi Ati 5 permennya agar permen Ati 2x permen Ira

Ira and Ati have candies
Ati's candies > Ira's candies

First statement : Ati give 5 of her candies to Ira so that the candies of both of them are the same.

Second statement : Ira give 5 of her candies to Ati so that Ati's candies is equals to 2x Ira's candies.

Figure 6. Mathematical modeling of the problem according

In Figure 6, S6 solved the problem by using logic without mathematical modeling. S6 made a new statement by simplifying the conversation in the problem, so that according to him, there are two statements that must be fulfilled. S6 thought the problem could be solved by supposing the number of candies belonging to Ira and Ati. Based on the student's work to this point, it was found that S6's numeracy literacy skills were good because he had applied all indicators of numeracy literacy skills, which included being able to use the numbers presented in the problem, analyze the information provided, and interpret the results to predict and make decisions (Putri et al., 2021). Furthermore, students' numeracy literacy skills greatly affect their ability to solve problems (Alfiah et al., 2020; Firdausy et al., 2023).

Polya's Second Principle: Devise a Plan

Based on the interview results, S1, S2, S3, S4, and S5 realized that the problem given was related to the subject of the system of linear equations with two variables. The five subjects have a good idea of what they need to do. Although in the process, S3, S4, and S5 made some errors in making mathematical models, which resulted in the incorrect results obtained. This is because they were confused about understanding the problem and unfamiliar with solving non-routine problems. Similar findings were also written in (Simatupang et al., 2019) who stated that the low ability of students in devise a plan is caused by their behavior who do not like to read long texts and do not like to solve non-routine problems. Furthermore, S6 devised a plan by taking advantage of its numeracy literacy capabilities, which was very helpful (Alfiah et al., 2020; Firdausy et al., 2023; Putri et al., 2021).

Polya's Third Principle: Carry Out the Plan

$$\begin{aligned} \text{Pers (1)} & \text{ dikalikan } x \text{ dan } y \text{ dan } z = x - y - 5 = 5 \\ \text{Pers (2)} & \text{ dikalikan } x \text{ dan } y \text{ dan } z = x - y - 10 = 10 \end{aligned}$$

$$\begin{aligned} \text{Substitusi Pers (1) dan Pers (2)} \\ 2(x - y - 5) = 10 & \rightarrow 2x - 2y - 10 = 10 \\ 2(x - y - 10) = 20 & \rightarrow 2x - 2y - 20 = 20 \\ 2y - 20 = 10 & \rightarrow 2y = 30 \\ y = 15 & \end{aligned}$$

$$\begin{aligned} \text{Eliminasi Substitusi } y = 35 \text{ ke Pers 3} \\ x = y - 10 \\ x = 35 - 10 \\ x = 25 \end{aligned}$$

Jadi dapat disimpulkan bahwa Ira memiliki 25 dan Ati memiliki 35

$$\begin{aligned} \text{Eliminasi} \\ \text{Pers (1)} & \text{ dikalikan } x = 35 \\ \text{Pers (2)} & \text{ dikalikan } x = 25 \end{aligned}$$

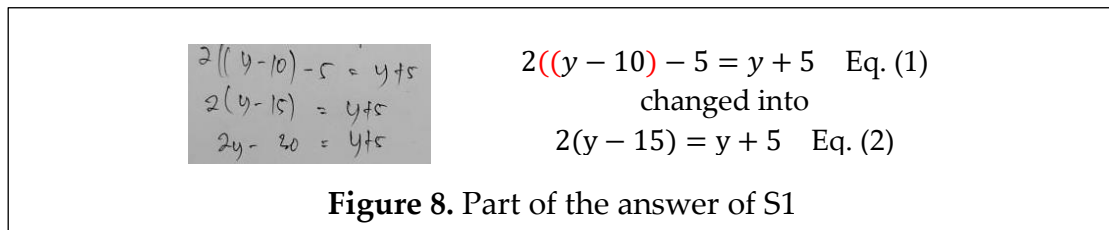
$$\begin{aligned} 2(35 - y - 5) = 10 & \rightarrow 70 - 2y - 10 = 10 \\ 2(25 - y - 10) = 20 & \rightarrow 50 - 2y - 20 = 20 \\ 2y - 20 = 10 & \rightarrow 2y = 30 \\ y = 15 & \end{aligned}$$

$$\begin{aligned} \text{Substitusi } y = 35 \text{ ke Pers (1)} \\ x = y - 10 \\ x = 35 - 10 \\ x = 25 \end{aligned}$$

Jadi dapat disimpulkan bahwa Ira memiliki 25 dan Ati memiliki 35

Figure 7. The answer of S1

At this stage, both S1 and S2 can solve the problem independently without anyone's help. Although both subjects gave the exact same result, there were significant differences in the way they solved the problem. The work of S1, shown in [Figure 7](#), shows a conceptual error because there are two values for the y variable. Based on his answer, it was recognized that S1's concept error occurred in operations that have parentheses. In his solution, S1 wrote:



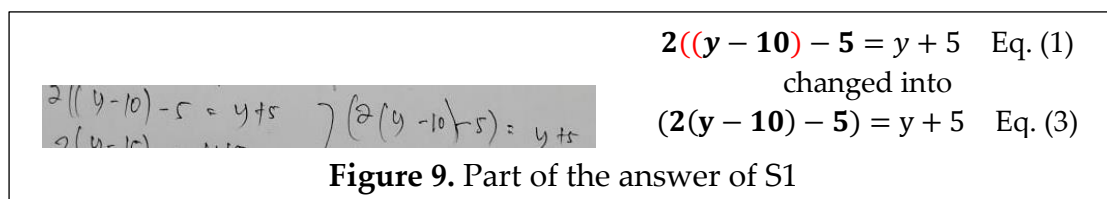
$$2((y-10)-5 = y+5 \quad 2((y-10) - 5 = y+5 \quad \text{Eq. (1)}$$

$$2(y-15) = y+5 \quad \text{changed into}$$

$$2y-20 = y+5 \quad 2(y-15) = y+5 \quad \text{Eq. (2)}$$

Figure 8. Part of the answer of S1

The transformation of equation (1) to equation (2) in [Figure 8](#) is not correct because there are only three parentheses in equation (1), with two open parentheses and one close parenthesis. Which means that one parenthesis is not closed. The second mistake S1 made was when changing equation (1) to equation (3).



$$2((y-10)-5 = y+5 \quad 2((y-10) - 5 = y+5 \quad \text{Eq. (1)}$$

$$2(y-10) - 5 = y+5 \quad \text{changed into}$$

$$2(y-10) - 5 = y+5 \quad \text{Eq. (3)}$$

Figure 9. Part of the answer of S1

As shown in [Figure 9](#), although the only difference is the placement of parentheses, mathematical models of equations 1 and 3 have very different meanings. This inaccuracy in the placement of parentheses caused S1 to obtain two different values for the y variable. However, based on the results of the interview, there are other misconceptions that S1 understands. According to him, if two values are found for the same variable, the correct value is the highest one. That's why S1 concluded that the correct value for variable y is 35. This number is then substituted into another equation to obtain the value of x . Based on this statement, it was recognized that the subject understood the problem very well and knew how to solve it. However, the error occurred due to the subject's inaccuracy in writing parentheses. Because of this inaccuracy, the subject may answer incorrectly. The final correct answer is also just a matter of luck, not purely the result of the subject's thoughts. Similar findings were also reported in the research of (Rafiepour et al., 2023) who found that when students simplify algebraic expressions with parenthesis, they make more mistakes.

Contrary to S1, as shown in Figure 10, the S2 subject was able to write and explain the answer and the flow of working on the question coherently. Although he did not write the conclusion on the answer sheet, S2 was able to explain the answer to the given problem.

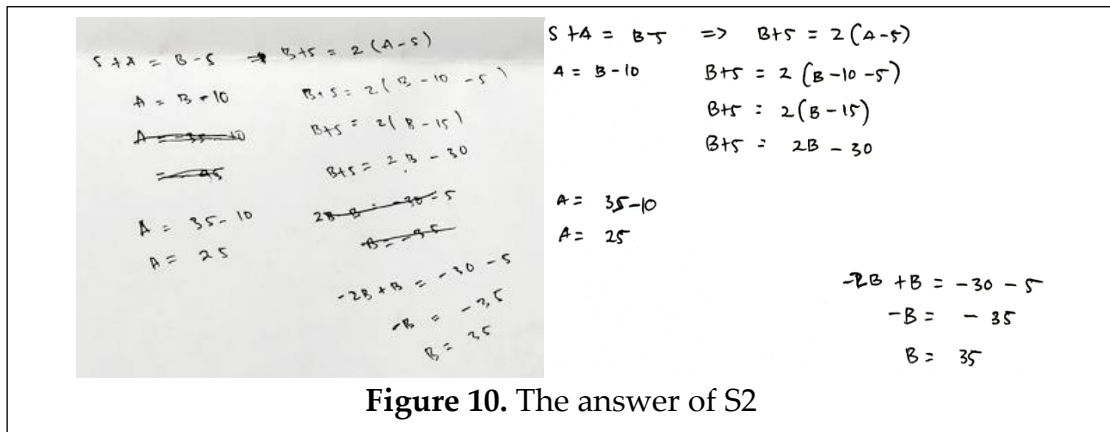


Figure 10. The answer of S2

Unlike S1 and S2, who answered correctly on the mathematical modeling of the problem, subjects S3 and S4 were wrong in determining the model, so the next solution was also wrong, as shown in Figure 11. Based on Figure 11, it is seen that S3 and S4 understand the procedure for solving the problem. But they make errors in the completion stage because of mistakes in the first step. According to them, neither Ira nor Ati have candy.

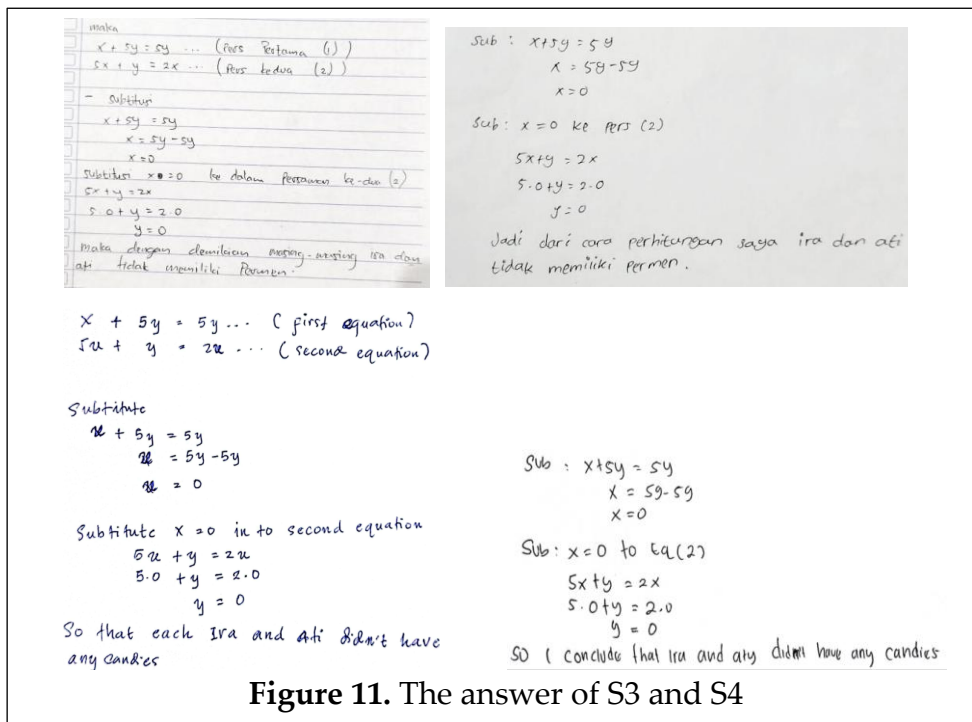


Figure 11. The answer of S3 and S4

Similar to S3 and S4, as shown in Figure 12, S5 also knew the procedure to solve the problem properly but had made mistakes in the first step of solving the problem. Her misinterpretation of the mathematical model led to an incorrect final result. Furthermore, the interview also showed that S5 was able to explain well the steps in finding the values of x and y .

Figure 12. The answer of S5

Meanwhile, S6, by optimizing his numeracy literacy skills as shown in Figure 13, started by supposing that Ati's candies were 15 and Ira's candies were 10 as simulation 1 (*Misal 1*). However, because the calculation did not fulfill the first statement in the problem, S6 changed the combination to Ati 20 candies and Ira 10 as simulation 2 (*Misal 2*). In the second simulation, it appears that the answer fulfills the first statement, but when tried for the second, it does not fulfill the value. She continued on to the third case by modeling Ati's candy as 35 and Ira's candy as 25 in simulation 3. In this case, when both statements are tested, the results are always fulfilled. Therefore, S6 concluded that the correct answer is that Ati has 35 candies and Ira has 25 candies.

Figure 13. The answer of S6

Based on the interview, the assumption of S6 regarding the number of candies owned by Ati and Ira is more than that, but only 3 simulations were listed. In addition, S6

stated that there was no specific reason for him to choose the numbers in the simulation other than because they were relatively easy to calculate. This is supported by the findings of Firdausy et al. (2023) and Alfiah et al., (2020), who found that the relationship between numeracy literacy skills and problem solving skills is extremely strong.

Polya's Fourth Principle: Look Back

Only S1 and S6 carried out this final step. In this stage, S1 and S6 wrote their conclusion about the number of candies that Ira and Ati have at the end of the answer and verified the answer. In contrast to S2, who also had the correct answer, he did not try to check because he thought that it was not necessary. The same thing was also conducted by S3, S4, and S5. According to them, there was no need to verify their answers because they thought it was enough to determine the result. This statement is similar to the findings of Simatupang et al., (2019), who stated that the students' errors in solving mathematics problems at the looking-back stage were 86.8%, which is the highest percentage of the four stages in the study.

The description of students' problem-solving ability, based on Polya's four stages, suggests that their ability to solve non-routine problems remains very low. Numerous studies confirm this, indicating that students across all grades continue to struggle with solving non-routine problems (Maulana & Yuniawati, 2018; Ozrecberoglu et al., 2022; Tabun et al., 2020).

Conclusions

The research results described in this study indicate that the ability of students in the Mathematics Education Study Program at PSDKU Pattimura University in Maluku Barat Daya to solve the PISA adaptation test remains significantly low. Only 3 out of 15 students can answer and provide the right solution for the test, and only 6 out of 15 students can figure out what to do to solve PISA adaptation test level 6. However, among the six students who gave their answers to this problem, there are some who have conceptual errors in the topic of SPLDV (System of Linear Equations with Two Variables). Besides conceptual errors, researchers also found that there is a student who gets incorrect answers to basic arithmetic operations involving parentheses. This was a warning to the lecturer because the student was classified as one of the top 10 students in his class and would be a future math teacher.

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