

Error Solving PISA-Oriented Math Problem Content Quantity Junior High School Students

Budi Murtiyasa¹, Asiyah²

¹ Universitas Muhammadiyah Surakarta, Indonesia; Budi.murtiyasa@ums.ac.id

² Universitas Muhammadiyah Surakarta, Indonesia; asiyahsajaaa@gmail.com

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ABSTRACT

The low mathematical literacy of students causes students to find it challenging to solve PISA-type questions, so they make mistakes. This study examines errors in solving PISA-oriented mathematical problems based on Newman's error analysis. This research involved 14 subjects of class VII A Junior High School Batik Special Program Surakarta. This research data results from error data analyzed from students' answers to solve PISA math problems. Data collection techniques used are written tests, interviews, and documentation. This research instrument uses three items of mathematical problems described from PISA in 2012 on quantity content. After the questions are ready, the next step is consulting the instrument with the supervisor. Before being tested, the questions went through a validation process by one lecturer and one mathematics teacher. The validity of the data in this study uses triangulation techniques. Data analysis techniques are data reduction, data presentation, and conclusions. Based on the results of writing tests and interviews obtained that 1) comprehension errors with a percentage of 23.68% of the cause because students do not understand the meaning of the question, 2) transformation errors with a percentage of 13.16% of the cause due to students confused filtering information and using relevant mathematical procedures, 3) errors of process skills with a percentage of 23.68% of the cause due to lack of skilled running the calculation operation, 4) writing errors of final answers with a percentage of 39.48% The reason is that students are not used to writing conclusions on the answer sheet.

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Corresponding Author:

Budi Murtiyasa

Universitas Muhammadiyah Surakarta, Indonesia; Budi.murtiyasa@ums.ac.id

1. INTRODUCTION

In the current era of globalization, Indonesian students must be able to compete with students in other countries. Competing for that is intended in this case is the world of education. Taking studies or tests on an international scale is one way. PISA is one of a wide variety of international-scale tests held. The Programme for International Student Assessment (PISA) is an ongoing program that monitors trends in the knowledge and skills students have acquired worldwide and in demographic subgroups in each country. This assessment every three years focuses on core subjects in the school, namely reading, mathematics and science.

The PISA problem is developed based on four content: change and relationships, space and shape, quantity, and uncertainty and data (OECD, 2019). The PISA content is by Permendikbud Attachment Number 21 of 2016 concerning High School Content Standards, which contains the content of numbers, algebra, geometry, statistics, opportunities, and sets. Quantity content will be the focus of this research. Many involve quantity content issues in everyday life, such as calculating taxes, measuring time, distance, etc (Bidasari, 2017). Noviana & Murtiyasa research (2020) said that if students' ability is low in several materials, it will affect other PISA content sub-materials.

Indonesia has been participating in PISA since 2000. The participation is to determine the development and progress of Indonesian education compared to other countries. In line with PISA, results can be used to benchmark education and learning outcomes and understand their education systems' relative strengths and weaknesses. Based on the latest PISA data in 2018 announced by the Organization for Economic Cooperation and Development (OECD), there was a decrease in results from the previous year by 7 points. The average score became 379 mathematics fields and was ranked 7th from the bottom (73) in 2018. The score is still far from the international average of 489 (Tohir, 2019). The results show that students' mathematical literacy skills are still low (Fadhilah & Rosyidi, 2020; Turner, 2016).

Students' low mathematical literacy can cause problem-solving errors, so they have difficulty solving PISA-type questions. Students in Indonesia do not know how to solve problems with PISA characteristics (Asdarina & Ridha, 2019; Usnul, Johar, & Sofyan, 2019). Another cause is the learning process that takes place in schools. Where the learning approach is still dominated by teachers (Husna & Burais, 2019). In addition, students are not used to solving questions with real context characteristics and only do the questions exemplified by the teacher without knowing the benefits in everyday life (Wati & Murtiyasa, 2016). Students also still have difficulty converting contextually based problems into mathematical sentences (Ahyar, Turmudi, & Prabawanto, 2019; Wijaya, van den Heuvel-Panhuizen, & Doorman, 2014). As a result, there are many errors in solving PISA-type math problems.

As many as 66.25% of students made mistakes in solving PISA questions for change and relationships content. Only 33.75% of students can solve the problem appropriately. In the space and shape content, 17.5% of students can solve the problem correctly. As many as 78.75% of students could not understand the problem exactly. As many as 81.25% of students make mistakes on uncertainty and data content and data. 18.75% of students can solve the problem correctly in the content. Meanwhile, in the quantity content, only 31.25% of students can solve the problem correctly. As many as 68.75% of students made mistakes on this content (Y. I. Oktaviana & Rosyidi, 2019). Of the four contents, the percentage of errors occurred more than the percentage of correct answers. The study did not focus on any of the content and did not use analysis according to Newman's theory. The purpose of future research can use one focus of the content to be researched in depth. In addition, it can also use error analysis according to different theories.

Analysis of mistakes made by students needs to be studied to minimize errors so that student achievement can improve. This is in accordance with (Dewi, 2014; Suharti, Nur, & Alim, 2021) that mistakes experienced by students in learning mathematics must be traced and resolved so that preventive measures can be taken in learning. Making a mistake can be fatal to other material errors (Safriani, Munzir, Duskri, & Maulidi, 2019). Performing an analysis of student answer errors can use Newman's theory. Newman error analysis is a framework with simple diagnostic procedures that include five processes,

namely, reading, comprehension, transformation, process skills, and encoding (Fitriani, Turmudi, & Prabawanto, 2018).

Several studies related to errors in solving PISA-type math problems have been conducted (Fazzilah, Effendi, & Marlina, 2020; Murtiyasa, Rejeki, & Ishartono, 2020; Pranitasari & Ratu, 2020; Rahmawati & Retnawati, 2019; Sumule, Amin, & Fuad, 2018). Research conducted by Sumule et al. (2018) concluded that the types of mistakes that students make are comprehension and transformational errors. Comprehension errors occur because students cannot interpret and understand the keywords in the problem and do not read the problem carefully and carefully. Transformation errors occur because students cannot determine formulas or plans to solve problems. Rahmawati & Retnawati research (2019) on the statement that students did not get any significant difficulties in solving Pisa-like multiple-choice problems, but the results of the analysis of incorrect and partially correct answers in solving similar essay problems PISA. However, the result showed 21.29% reading errors, 25.54% errors of comprehension errors, 34.38% of transformation errors, 19.14% of process skill errors, and 7.49% of encoding errors.

Pranitasari & Ratu research (2020) states that some of the factors that cause student error is considered problematic by students and require high reasoning, lack of interest and motivation, and confusion in filtering information. The other side of students is wrong in using formulas, lacking understanding of prerequisite materials, and are less thorough and hasty in solving the given problems (Fazzilah et al., 2020). Another factor that may cause is mathematics textbooks that still lack problems such as PISA and teaching practices that still place mathematics as an exact and abstract subject. Students are not used to solving problems that require reasoning and creativity (Murtiyasa et al., 2020). However, this previous study did not address students' errors in quantity content. Therefore, it is necessary to research student errors in solving quantity problems of PISA-type mathematical content.

Fazzilah et al., (2020) conducted a study entitled "Analysis of Student Errors in Solving PISA Problems uncertainty and data content." This study involved 20 students of class VIII MIPA 2, one of the State Junior High Schools in Telukjambe District. Furthermore, four students were taken as the subject of his research. Based on the study results, the type of error that more students make is transformation errors. In line with Sumule et al., (2018) research, the kinds of mistakes that students make are transformation and comprehension errors. This study examines the mistakes of junior high school students in solving PISA questions in space content and forms using Newman procedures. In his research, he also discussed the efforts made to overcome student mistakes by providing scaffolding.

Pranitasari & Ratu, (2020) has also conducted research that aims to discover the types of mistakes made by senior high school students in solving PISA math problems in change and relationship content. The study subjects consisted of 3 students of class XI MIPA 3 State Senior High School 1 Tuntang with the most errors. In general, the results showed that the three subjects in solving PISA mathematical problems in the 3 test questions were errors in understanding the questions, transformation errors, and encoding errors. Rahmawati & Retnawati, (2019) in her research examined students' difficulties in solving mathematical problems such as PISA. The test questions were given to 70 class XI students from three junior high schools in Yogyakarta Province. There are 30 questions given where nine multiple-choice questions and 21 essay questions. Multiple-choice questions are analyzed by detecting which distractor the student chooses, while the essay questions use an analytical framework developed by Newman. The results showed that students made reading, comprehension, transformation, process skills, and encoding mistakes.

Murtiyasa et al., (2020) research analyzes students' mistakes in solving mathematics problems based on the PISA framework. This study involved 63 students with low, medium, and high mathematics achievements from 2 schools in Surakarta. The results showed that based on the content, most students gave incorrect answers to the category of space and form; based on context, most students gave incorrect answers to job categories; and based on the process, most students gave incorrect answers to the interpreting category. Previous studies have not examined PISA mathematics on quantity content. Therefore, it is still necessary to study research on student errors in solving PISA-type math problems. It

is essential to find out the type and magnitude of the percentage of errors made by students in solving PISA content quantity questions.

Based on the description above, this study aims to describe the error of solving PISA-oriented math problems in the quantity content of Junior High School students based on Newman's error analysis. The limitation of this study is that the research is only limited to the PISA content quantity. The instrument of the questions given is only three questions. The subject of this study was only grade VII students of the Junior High School Batik Special Program Surakarta. This research can contribute to efforts to improve students' ability to learn mathematics, especially in solving PISA problems. The results and discussions can certainly be considered in the teaching and learning process.

2. METHODS

The research conducted at Junior High School Batik Special Program Surakarta is qualitative research with a qualitative descriptive approach. This qualitative research is used to obtain more in-depth information and data to describe errors in solving PISA math problems in quantity content in students. The subjects in this study were 14 students of class VII Junior High School Batik Special Program Surakarta. After testing and anorexia of the answers of 14 students of class VII-A. Furthermore, four research subjects with the most errors were selected according to the category of mistakes according to Newman's theory to be interviewed in-depth.

This research data is the result of error data obtained from students' answers to solve PISA math problems that have been analyzed. Error analysis in this study is the analysis of errors according to Newman's theory, including comprehension, transformations, process skills, and encoding. In PISA studies' modeling process, reading errors are not appropriate, so they are not used (Wati & Murtiyasa, 2016:200). The indicators used in this study are presented in Table 1.

Table 1. Newman error indicator

Error Type	Error Indicator
Comprehension Errors	-If students can't write what is known -If students can't what is being asked of the problem
Transformation Errors	If students can't select and determine of mathematical formulae, its operation and procedure
Process Skills Errors	If students can't correctly perform mathematical processing
Encoding Errors	If students can't represent answer appropriately right

(Suyitno & Suyitno, 2015)

The data collection technique used, namely 1) written tests, is carried out to collect data on students' answers to solve PISA math problems with quantity content which is then analyzed to get student error information with Newman's theory. 2) Interviews are used to get more information from students regarding the process of working on written test questions and measuring students' abilities. 3) documentation, in the form of questions taken from PISA, data on student work results, and some photos as evidence of having conducted actual research at Junior High School Batik Special Program Surakarta.

This research instrument uses three items of mathematical problems taken from PISA in 2012 on quantity content with the theme of climbing Mount Fuji, sauces, and mp3 players. The tested problem is in the form of a description that has been adjusted to the indicator according to Newman's theory. The questions that have been prepared are then consulted with the supervisor. Before use, the question was validated by one lecturer of the Mathematics Education Study Program of the Muhammadiyah University of Surakarta and one teacher of mathematics subjects of Junior High School Batik Special Program Surakarta. This validation test is done to correct the problem to match the indicator before being tested on students. The validation test uses the validation of the contents provided to the validator.

The validity of the data in this study uses triangulation techniques. The triangulation technique used is to compare the results of the analysis of the student's test and continue the interview. Data analysis techniques were carried out 1) data reduction, 2) data presentation, and 3) conclusions. The data reduction

step in this study is to examine the answers students have collected, determine which students can represent each category of Newman errors to be subjected to in the interview, and summarize the data obtained to select the essential parts needed in the study. The presentation of data is done to make it easier to describe student errors. The inference is intended to look for the meaning of the data collected by looking for relationships, similarities, or differences.

3. FINDINGS AND DISCUSSION

Based on the results of the analysis of student work according to Newman's theory obtained several findings of student errors in solving PISA-based mathematics problems content quantity, namely students make 23.68% comprehension errors, transformation errors by 13.16%, process skill errors by 23.68%, and encoding errors 39.48% (see Table 2). The results showed that students made the encoding error more than other errors.

Table 2. Description of Each Type of Error

Question Number	Error Type			
	K1	K2	K3	K4
1	5	2	0	7
2	3	1	4	9
3	10	7	14	14
Total	18	10	18	30
%	23,68	13,16	23,68	39,48

Information:

K1 = comprehension errors

K2 = transformation errors

K3 = process skills errors

K4 = encoding errors

Based on the results of the analysis of test data and interviews, will ben describe the type of error and the factors that cause student errors in solving PISA math problems in quantity content.

Comprehension Errors

The comprehension errors made by students occurred a lot in question number 3 of 55.56%, as many as ten students. Student error for question number 1 amounted to 27.78%, as many as five students. Student error for question number 2 amounted to 16.67% for as many as three students. Here is table 3 description of the comprehension errors.

Table 3. Comprehension Errors

Question Number	Error Description	n	%
1	Not writing down what is known and asked	2	11,11
	Not writing down what was asked	3	16,67
2	Not writing down what is known and asked	1	5,56
	Not writing down what was asked	2	11,11
3	Not writing down what is known and asked	10	55,56

$$2. \quad \frac{100}{60} = \frac{150}{x}$$

$$x = 90$$

Figure 1. S14 Answer Results Number 2

1. diketahui ~~.....~~
 langkah = 9 km
 berjalan = 22.500

Figure 2. S8 Answer Results Number 1

Figure 1 shows that S14 made a mistake in understanding that is not writing down what information was known and asked in the question. The subject simply writes $100/60 = 150/x$ so that $x = 90$ is obtained. Based on the results of the S14 interview, it was obtained that the subject was not accustomed to writing down known elements and was asked to solve mathematical problems. Figure 2 shows that the subject made a mistake of comprehension errors by not writing down the information completely. The subject only writes known: step 9 km and road 22,500, while the information asked about it is not written. Based on the results of the S8 interview, where the subject knows the known data, but the subject cannot understand the meaning of the question asked in the question. S8 understanding of question number 1 is still not intact because S8 is less thorough and careful in reading the question thoroughly.

Referring to the results of student interviews, the factors that cause comprehension errors of students in this study are:

- Students cannot understand the meaning of the problem.
- Students' reasoning skills are still low
- Students are not accustomed to using the process of solving as known, asked, answered, and concluded.
- Understanding of students in real context is still weak

Students make mistakes by not understanding the meaning of the problem. This is in accordance with Oktaviana research (2017) that students make mistakes because they do not know the importance of the problem. Students are not accustomed to using the process of solving as known, asked, answered, and concluded in solving problems. In line with Suyitno & Suyitno research (2015), comprehension errors occur if students cannot write down what is known, what is asked, or do not write down any information. In addition, the understanding of students in real context is still weak. Jha (2012) added a comprehension error because students' understanding is not intact to the problem not to write down

the important information contained in the issue. The results of research by Djadir et al. (2018) stated that the ability to understand is needed in solving mathematical problems, especially in the context of the story.

Transformation Errors

The total transformation errors made by students are 10, with a percentage of errors of 13.16%. This transformation error is the least or minimal mistake made by students. The minor error occurs in question number 2, which is one student with a percentage of 10%. The most errors occurred in question number 3, with a percentage of 70% in 7 students. Here is table 4 description of the transformation error.

Table 4. Transformation Error

Question Number	Error Description	n	%
1	Unable to select and specify formulas, operations, & procedures	2	20
2	Unable to select and specify formulas, operations, & procedures	1	10
3	Unable to select and specify formulas, operations, & procedures	7	70

1. $900.000 \div 22.500 = 40$
 22.500
 90000
 90000
 0

Jadi kerdus panjangnya 40 cm

2. $100 = \frac{x}{69} = 159 = 90 \text{ ml}$

Jadi minyuk esok yg dibutuhkan Niska adalah 90 ml

Figure 3. S13 Answer Results Number 1 and 2

Figure 3 shows that on question number 1 S13 directly writes $900,000 / 22,500 = 40$ cm. The subject did not specify the 900,000 obtained from where. As for the 9km issue. S13 should be able to write down the process to get 900,000. Problem number 2 subjects cannot determine the formula and mathematical operation correctly to solve the problem of the question. S13 only writes $100/60 = x/150$, obtaining a result of 90 mL. This comparison used S13 is less relevant. When the calculation process is continued, no proper results will be obtained. Based on the results of the S13 interview, it was obtained that the subject was able to determine the initial solution appropriately but did not write the information in the answer sheet. The other side of the subject of confusion filters information to solve problems using proper mathematical procedures.

The factors that cause transformation errors are:

- Students do not write down the initial solution obtained
- Students cannot apply well-used formulas
- Students are confused in sifting through information and using appropriate mathematical procedures.

Students make the transformation mistake of not writing down the initial solution obtained. Similar to Fadhillah & Rosyidi research (2020), the transformational error was made because students were incomplete in writing answers. Students cannot apply well-used formulas. In line with Sumule et al. (2018) analysis, students cannot determine a plan to solve the problem to be the cause of transformation errors. Referring to the interview results, students are confused about filtering information and using appropriate mathematical procedures. The results of the Pranitasari & Ratu (2020) study of students are not able to design the settlement well and are not able to use relevant mathematical procedures. Rohmah & Sutiarmo (2018) added that students do not understand the material thoroughly and are also the cause of transformation errors.

Process Skills Errors

Process skills errors occurred in question number 3 with as many as 14 students by 77.78%. From the total number of students, no one answers correctly on the indicator of process skills. Students cannot perform mathematical processing correctly, so they make mistakes. Here is table 5 description of process skill errors.

Table 5. Process Skills Errors

Question Number	Error Description	n	%
1	Unable to perform mathematical processing correctly	0	0
2	Unable to select and specify formulas, operations, & procedures	4	22,22
3	Unable to select and specify formulas, operations, & procedures	14	77,78

2. Diket: Minyak salad 60 ml
 Cuka 30 ml
 Kelap 10 ml
 100 ml Saus

Ditanya: Berp ml yg dibutuhkan Naura utk membuat 150 ml Saus

Jawab: $\frac{100 \text{ Saus}}{60 \text{ minyak salad}} = \frac{150 \text{ Saus}}{X}$

$X = 5$

$X =$

Figure 4. S10 Answer Result Number 2

$$\begin{array}{l}
 \text{3. Player \& headphone} \\
 155 + 86 = 241 \\
 d\% = 241 \times \frac{20}{100} = \\
 \\
 \text{Uang yg hrs dibayar} \\
 \Rightarrow \text{player \& speaker} \\
 155 + 79 = 234 \\
 d\% = 234 \times \frac{20}{100} \\
 \Rightarrow \text{Semua}
 \end{array}$$

Figure 5. S8 Answer Result Number 3

Figures 4 and 5 indicate that the subject cannot perform mathematical processing. Number 2 S10 can understand and transform what is meant by the question. Where the subject has written down what is known and asked in the question and can determine the comparison formula precisely. However, S10 stops at the step of writing $(100 \text{ sauces}) / (60 \text{ salad oil}) = (150 \text{ sauces}) / x$. The subject could not complete the processing step to determine the milliLiter naura needed to make 150 mL of sauce. Problem number 3 S8 can not choose the discount and money to be paid to buy players & headphones, buy players & speakers, or all three. Based on the results of interviews of both subjects, they forgot which calculation operation should come first between multiplication and division.

Referring to the results of student interviews, the factors that cause process skills errors are:

- Students are less skilled in using counting operations
- Students are not careful in the calculation process
- Students are in a hurry to do questions

Students make process skill mistakes because they are less skilled in running counting operations. In line with the results of Murdiyasa & Wulandari (2020), research wrongly prioritizes the calculation operation, got the wrong count result, and miscalculated into a mistake that students often make in processing. The results of Rohmah & Sutiarsa (2018) show that students are not careful in counting is the cause of miscalculation. Christinove & Mampouw (2019) added that miscalculations occur because students do not write down calculation procedures. Other reasons for students rushing to solve the problem (Fazzilah et al., 2020).

Encoding Errors

The mistake of encoding errors becomes the most common mistake students make. The total encoding errors made by students are 30, with a percentage of errors of 39.48%. Similarly, Sari & Valentino (2016) found that the most common errors were 26% of encoding errors. Problem number 3 made an error of 14 students, meaning that all students made mistakes on this indicator. Here is table 6 description of encoding errors.

Tabel 6. Encoding Errors

Question Number	Error Description	n	%
1	Unable to represent the answer correctly	7	23,33

2	Unable to select and specify formulas, operations, & procedures	9	30
3	Unable to select and specify formulas, operations, & procedures	14	46,67

1. Diket: 9 km 900.000 cm
langkah 22.500 kaki

Ditanya: Berapa rata-rata Panjang langkah kaki Dwi?

Jawaban: $\frac{900.000}{22.500} = 9000 \div 225 = 40$

2. Diket: minyak salad 60 ml
luka 30 ml
kelap 10 ml
100 ml saus

Ditanya: Bcr ml yg dibutuhkan Naura utk membuat 150 ml saus

Jawaban: $\frac{100 \text{ saus}}{60 \text{ minyak salad}} = \frac{150 \text{ saus}}{x}$

$x = 5$
 $x =$

Figure 6. S10 Answer Results Number 1 and 2

Figure 6 on question number 1 shows that the subject made a mistake writing the encoding errors by not being able to interpret the answer that had been obtained even though the final result was correct. Question number 2 of the subject has made a processing error so that it cannot write the encoding obtained precisely and correctly. Based on the S10 interview, the subject is not used to writing conclusions from the final results obtained.

The factors that encoding errors are

- Students are not used to writing down the final answer
- Students ignore the further information referred to about

Students make mistakes encoding errors because they are not used to writing and miswriting the final answer on the answer sheet. In line with Murdiyasa & Wulandari research (2020), the cause of solution writing errors is that students are not used to writing conclusions (final answers). Other reasons are that students are not accustomed to paying attention to further information, and the result of determining the formula used to be the cause of the final answer error (Djadir et al., 2018).

Based on the above research results, the encoding errors are the biggest mistake made by students. The second biggest mistakes are comprehension of problems and errors in process skills. Errors in understanding occur because students are not used to using the solving process in working on issues. Therefore, teachers should get used to giving examples of doing problems sequentially and using the logic of thinking correctly. While students should be accustomed to doing questions with the correct procedures, such as writing known and asked in questions. Process skill errors occur because students

are less skilled in counting operations. Teachers should give more practice to PISA-type questions, especially on the content of numbers, to improve students' ability to solve math problems. Students should practice doing PISA type calculation questions, especially quantity content. The error encoding occurs because the student ignores the further information that the question means. Therefore, teachers should always remind students to re-examine the results of student work. Students should constantly re-examine the results of the work obtained and make conclusions. In addition, students must be more severe in participating in learning in the classroom and must be open to conveying the difficulties experienced in solving math problems.

4. CONCLUSION

The encoding errors became the most mistakes made by students with a percentage of 39.48%. Comprehension and skill have the same magnitude as a percentage of 23.68%. The percentage of transformation errors is 13.16%. Based on the results of student work and interviews, the factors that cause errors in this study include students not understanding the meaning of the problem, not writing down the initial solution obtained, being confused about filtering information and using relevant mathematical procedures, students are less skilled in carrying out calculation operations, and are not accustomed to writing conclusions on answer sheets.

This research is limited to the topic of a quantity content. Therefore, it is expected to conduct error analysis with different issues and broader discussion materials for further research. The findings of mistakes made by students can be used as a reference to improve learning in the future. It can also minimize the errors made by students in solving math problems.

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