25 (1), 2024, 468-485

Jurnal Pendidikan MIPA

e-ISSN: 2685-5488 | p-ISSN: 1411-2531

http://jurnal.fkip.unila.ac.id/index.php/jpmipa/

Learning Mathematics through Students' Worksheets with Open-Ended Approach: A Students' Errors Analysis on Mathematical Problem-Solving Ability

Melania Eva Wulanningtyas[1]*, Arfin[2], Yudiani Linling[3], Dafid Slamet Setiana[4], & Gumpanat Boriboon[5]

[1]Department of Mathematics, Catholic Parahyangan University, Indonesia
[2]Department of Physics, Catholic Parahyangan University, Indonesia
[3]Department of Mathematics, Yogyakarta State University, Indonesia
[4]Non Formal Education Study Programme, Yogyakarta State University, Indonesia
[5]Department of Adult Education and Lifelong Education, Srinakharinwirot University, Thailand

Abstract: Open-ended approach has a valuable impact in supporting students' mathematical problem solving ability. This approach allows students' to explore different ways in solving mathematical problems, not only focusing on one solution but also considering other alternatives. However, students inevitably make mistakes in solving the problems in their learning process. Therefore, it is important to analyze the errors made by students in mathematics learning using student worksheets with an open-ended approach. This research is a descriptive qualitative study conducted in 6 Private National Junior High Schools in Yogyakarta. These schools were randomly selected using a spinning wheel from 13 schools in the third quartile. The subjects of this study were 384 students selected from 12 classes out of 22 classes in all the research schools. Data were collected using a problem-solving ability test on the subject of systems of linear equations in two variables and interviews. Student errors were categorized based on Newman's Error Analysis, which includes: (1) reading errors, (2) comprehension errors, (3) transformation errors, (4) process skill errors, and (5) encoding errors. The results of this study show that the dominant error sequence made by students is process skill errors, reading errors, comprehension errors, transformation errors, and encoding errors. These errors are caused by students' inaccuracy in calculations, difficulties in calculations, errors in reading the questions, comprehension errors in understanding the given mathematical problems, errors in translating the information provided in the questions, and errors in concluding the problem-solving results due to students not understanding the question instructions properly, and the given mathematical problems being unfamiliar to the students

Keywords: student errors, student worksheet, open-ended approach, problem-solving skills.

▪ INTRODUCTION

Post-pandemic learning activities that have transformed from online to offline have undergone many significant adjustments. One way to facilitate students to actively participate in learning activities is to implement structured learning with the help of student worksheets. Student worksheets are specifically designed to meet students' needs in learning activities, adjust student characteristics, and also encourage the achievement of learning objectives that have been designed (Shalihah, Wibowo, & Yuzianah, 2022; Angraini, Sthephani, & Ain, 2021; Meilinda, Putri, Zulkardi, Inderawati, & Desnita, 2024). Student worksheets are not actually a substitute for teachers in learning activities, but through student worksheets they can learn to be more independent, discuss and collaborate, and train students to be able to solve problems presented on the student worksheets. In addition, teachers can focus more on their duties to accompany students, help students who are having difficulties, become facilitators in activities, and encourage

Melania Eva Wulanningtyas
*Email: melaniaeva@unpar.ac.id

DOI: http://dx.doi.org/10.23960/jpmipa/v25i1.pp468-485
Received: 14 July 2024
Accepted: 13 August 2024
Published: 26 August 2024

students to be able to solve their own problems (Purwasih & Rahmadhani, 2021; Deda & Maifa, 2021; Virtanen, Niemi, & Nevgi, 2017). The student worksheets that are created are not only adapted from textbooks and other reference sources, but are also adjusted to the needs, characteristics of students, learning objectives to be achieved, and learning conditions in the classroom. One approach that can guide students to be able to learn independently by using student worksheets is the open-ended approach. The open-ended approach offers various solutions to the problems faced by students so that students do not only focus on one solution (Mahuda, 2017; Bray, 2013; Ozuru, Briner, Kurby, & McNamara, 2013). In addition, the open-ended approach encourages students to be able to think critically where the solutions or solutions to the problems given are not only one or absolute. Through student worksheets with an open-ended approach, students are invited to think inductively, collect a lot of data on the given mathematical problems, so that students can solve the problems independently (Janan, Sitaresmi, & Nuryami, 2022; Rizos & Gkrekas, 2023). In addition, by thinking inductively, students can draw conclusions at the end of learning activities gradually and independently.

In the learning process, of course, students will not be free from many mistakes made in solving the given mathematical problems. However, teachers can help and encourage students to be able to obtain correct problem-solving solutions. Some of the mistakes that often occur in students in general include: (1) errors in understanding the problem, (2) errors in writing down information contained in the problem; (3) calculation errors; and (4) errors in drawing conclusions from calculations that have been made. These errors can also be broken down into more specific sub-errors based on the material studied (Ojose, 2015; Egodawatte & Stoilescu, 2015). Student worksheets developed with an open-ended approach are used to analyze students' errors in problem-solving skills. These problem-solving skills include; (1) understanding the problem (understanding); (2) planning a solution (setting); (3) implementing the planned solution (adjusting); (4) evaluating the results of the problem solving carried out (elaborating) (Pamungkas & Kowiyah, 2021; Yuniarti, Kusumah, Suryadi, & Kartasasmita, 2017). Through the independent learning curriculum that is currently being implemented, students' problem-solving skills are one of the important highlights besides literacy skills and collaboration skills, therefore learning activities in the classroom are designed not only to focus on the final results but also to focus on the discovery process until conclusions are drawn (Cassel & Victor, 2015; Farida, 2015; Olivares, Olmo-Muñoz, González-Calero, & Arnau, 2024). One form of mathematical problem that can be presented to analyze students' errors in their problem-solving skills is through the material on two-variable linear equation systems.

The open-ended approach used in developing student worksheets on the material on two-variable linear equation systems presents mathematical problems that have more than one solution/resolution. Some contextual problems presented can contain more than one closed answer but can also contain various open answers. This open-ended approach does not have a standard syntax in its implementation, but has several characteristics that are outlined in the development of student worksheets. These characteristics include (Magelo, Hulukati, & Djakaria, 2020; Bahar & Maker, 2015): (1) The student worksheets developed are flexible, meaning that they allow for various answers, responses, or solutions to the given mathematical problems. This condition is also not limited or related to previous answers, thus providing students with the opportunity to express their ideas

in order to find solutions to the given mathematical problems. This also encourages students to be independent and not afraid to make mistakes if the answers obtained are different from those of other friends. (2) The student worksheets developed have full involvement, meaning that students are encouraged to be able to explore their abilities in depth as a form of analytical ability. Because in the open-ended approach there are no absolute right and wrong answers, students can obtain appropriate solutions and diverse perspectives on the given mathematical problems. (3) The developed student worksheets contain open-ended questions, meaning that the questions given to students tend to elicit diverse responses and perspectives. Not only focused on single answers, short and concise answers, or absolute answers. (4) The developed student worksheets encourage students to be able to think critically, creatively, and innovatively, meaning that through the open-ended approach students can discuss with each other to express ideas, concepts, and solutions to the given mathematical problems. Students are even allowed to use information outside the field of mathematics as long as it is in accordance with the needs of the mathematical problems presented. Through this learning condition, students are expected not only to find solutions but to be able to create solutions so that they gain meaningful learning experiences.

The development of student worksheets with an open-ended approach in learning on the material of two-variable linear equation systems is appropriate for measuring students' mathematical problem-solving abilities, because students are encouraged to believe in their abilities and use them in discussing and collaborating to solve problems until they find alternative solutions that are in accordance with the mathematical problems presented. The problem-solving abilities that will be analyzed in this study are (1) the ability to understand problems (understanding), (2) the ability to design the required mathematical problem solving (setting), (3) the ability to solve predetermined mathematical problems using a predetermined design (adjusting), and (4) the ability to interpret the obtained solution (elaborating) (Wijaya, Heuvel-Panhuizena, Doormana, & Robitzschc, 2014; Nicolas & Emata, 2018). Problem-solving abilities are actually a series of activities carried out by students in using their thinking to collect information/data, analyze the information/data obtained, design various alternative problem solving based on the information/data obtained, and determine the most appropriate, effective, and efficient problem solving for the given contextual problem.

▪ METHOD

Participants

This research was conducted in 6 National Private Junior High Schools in Yogyakarta City selected from a total of 13 existing national private junior high schools using a spinning wheel. These private schools were selected based on the regional school rankings which were in the third quartile. Meanwhile, the total number of private schools in Yogyakarta is 49 national private junior high schools. A total of 12 classes from 22 classes in all the research schools were used as research subjects. The selection of these classes was carried out based on the validator teacher of the worksheet material that had been created as well as the teacher who taught mathematics in each school. A total of 2 classes with 6 mathematics subject teachers in each school were selected. The number of students involved in this study was 384 students from 704 students spread across the 6 schools.

Research Design and Procedures

This research is a descriptive qualitative research that aims to describe phenomena or events in detail and in depth. This research emphasizes a comprehensive understanding of a situation, process, or phenomenon being observed (Lichtman, 2023). The main focus of this study is to analyze the errors made by students through mathematics learning on the material of two-variable linear equation systems with the help of student worksheets through an open-ended approach. The steps taken in this study are divided into 3 terms, namely (1) Pre-research activities which include preliminary studies, field observations, and teacher interviews. (2) Research activities which include the development of student worksheets, implementation of student worksheets in learning activities, and final learning evaluations. (3) Post-research activities which include analysis of research data, grouping types of errors obtained based on student answers, and student interviews when needed. This research was conducted for approximately 10 weeks with the following details:

1. First week: Preliminary study includes identifying the problem to be studied, determining the research school, and contacting the mathematics teacher who will be the research collaborator, and preparing letters/documents needed during the research activities.
2. Second week: Field observation in the form of a visit to the school while identifying student characteristics, learning styles used, and teaching media that are usually used in learning activities.
3. Third week: Interviewing teachers regarding methods, models, or approaches that have been used in mathematics learning activities. And consulting whether the open-ended approach is suitable for use in learning activities and in accordance with student characteristics.
4. Fourth week: Making a research proposal and reporting to each teacher in 6 schools regarding the research plans and activities to be carried out.
5. Fifth to sixth weeks: Making student worksheets and validating them with material experts, namely mathematics teachers in each school.
6. Seventh to eighth weeks: Carrying out research activities in the form of mathematics learning using the student worksheets. The researcher only becomes an observer/observer and facilitator in learning activities. Learning activities are carried out entirely by teachers and students as usual.
7. Ninth Week: Conducting analysis of all the answers given by students on the completed worksheets and selecting students as interview subjects based on the error categories to be analyzed.
8. Tenth Week: Conducting interviews with selected students as samples of errors made for further study.

Instruments

The instrument used in this study was a problem-solving ability test in the form of questions on the material of two-variable linear equation systems with an open-ended approach and an interview guide. The questions consisted of 4 items with the aim of measuring mathematical problem-solving abilities which include understanding, setting, adjusting, and elaborating. In these questions, students' errors will be sought in solving the given mathematical problems according to Newman's error categories. These

problem-solving ability test questions do not use statistical validity and reliability tests but use expert judgment from 6 mathematics teachers who are research collaborators (Steedle & Ferrara, 2016; Lima, Hernández, & Tobon, 2019). In addition, there is an interview instrument that is made as a guide for interview activities with students when exploring the errors that have been made by students in working on the questions given. The question instruments are presented in the table below.

Table 1. Problem solving ability test

No	**Soal**
1.	*Nyatakan 3 pasangan bilangan yang memenuhi persamaan* $k \equiv 2x + 3y = 24$
2.	*Sebuah koperasi sekolah menerapkan koperasi jujur bagi setiap siswa. Siswa boleh membeli apapun yang dijual koperasi tersebut, membayar barang pembeliannya dengan uang pas, dan memasukkan uang tersebut pada kotak yang sudah disiapkan. Pada minggu kedua petugas koperasi melihat banyak pensil dan penghapus berkurang dari minggu pertama. Harga sebuah pensil adalah Rp1.500,00 dan harga sebuah penghapus adalah Rp1.000,00. Petugas koperasi menghitung jumlah uang yang ada di dalam kotak tersebut adalah Rp10.000,00. Bantulah petugas koperasi tersebut menghitung kemungkinan-kemungkinan banyak pensil dan penghapus yang terjual pada minggu kedua.*
3.	*Gambarlah sistem persamaan linear dua variabel berikut ini dalam bentuk grafik dan analisa apa yang kalian peroleh:* *a.* $x + 2y = 3\ dan\ 4x + 3y = 2$ *b.* $3x + y = 1\ dan\ 6x + 2y = 2$ *c.* $2x - y = 2\ dan\ -4x + 2y = 2$
4.	*Made mempunyai sepetak taman bunga yang berada di taman samping rumahnya. Taman bunga yang dimiliki Made berbentuk persegi panjang. Keliling taman bunga Made adalah 42* m*. Selisih dari panjang dan lebar taman bunga Made adalah 9* m*. Bantulah Made untuk menghitung luas taman bunga yang dimilikinya.*

Data Analysis

This study uses data collection techniques through mathematical problem-solving ability tests of students on the material of two-variable linear equation systems. This problem-solving ability test is collected after learning activities and assessed by the teacher concerned as a result of student learning. Meanwhile, student work is then analyzed by researchers to be grouped based on Newman's error categories. Interviews are conducted with students later online according to research needs and not all students will be interviewed. In this study, the data analysis method used is qualitative data analysis. The qualitative analysis process aims to tidy up data, group data into manageable parts, compile syntheses, identify patterns, reveal things that are significant and valuable to learn, and determine the narrative that will be conveyed to others. This data analysis process includes data reduction and data presentation. The steps taken in the data reduction process include simplifying data by summarizing it, highlighting important aspects, focusing on the essence, identifying patterns, and deleting irrelevant data. The steps taken in the data presentation process include conveying data in the form of concise narratives, graphs, interconnections between categories, flow diagrams, and so on. (Hennink, Hutter, & Bailey, 2020; Msomi & Bansilal, 2022)

The student errors that have been found will be categorized through error analysis based on Newman's Error Analysis (Chusnul, Mardiyana, & Retno, 2017). The stages of this analysis include: (1) reading errors, (2) comprehension errors, (3) transformation

errors, (4) process skill errors, (5) encoding errors. Meanwhile, the mathematical problem-solving abilities that will be analyzed based on the Newman error categories that have been found include: (1) the ability to understand problems (understanding), (2) the ability to plan solutions (setting), (3) the ability to apply planned solutions (adjusting), (4) the ability to evaluate problem-solving results (elaborating) (Hanim, Kurniati, Oktavianingtyas, Susanto, & Jatmiko, 2023; Maharani & Subanji, 2018).

▪ RESULT AND DISSCUSSION

Based on the results of students' answers received through problem-solving ability tests, errors were found based on Newman's error categories. The data is presented in the following table:

Table 2. Student errors in problem solving ability test

No	A	B	C	D	E
1	12 students	8 students	8 students	23 students	4 students
2	33 students	47 students	151 students	91 students	112 students
3	10 students	18 students	27 students	19 students	11 students
4	105 students	211 students	137 students	101 students	116 students

Notes:
A: Errors in reading questions
B: Errors in understanding questions
C: Errors in translation
D: Error in process skills
E: Errors in conclusions

Based on Newman's error categories, the results show that in question number 1, the dominant error sequence made by students is Process Ability Error, Reading Error, Understanding Error, Translating Error, and Conclusion Error. After analyzing student answers, discussing with teachers, and interviewing students, the error made in number 1 was caused by students not being careful in calculating. Some students find it difficult to calculate algebraically by involving addition, multiplication, subtraction, and division operations. This is because when they were in elementary school, most students experienced online school which resulted in a lack of assistance in calculating skills. This is because when students go to online school, they focus on the results of the assignments given by the teacher and most of them are assisted by their parents.

Researcher	:	*Mengapa pasangan bilangan yang dipilih adalah (0,8), (12,0), dan (5,9). Apakah menurutmu jawabannya sudah tepat?*
Respondent L	:	*Sudah miss, karena jika dimasukkan ke persamaan hasilnya 24 semua.*
Researcher	:	*Yakin? Sekarang coba hitung kembali untuk titik (5,9) ini.*
Respondent L	:	*2 kali 5 ditambah 3 kali 9 adalah 10 ditambah 27. Ternyata bukan 24 ya miss?*
Researcher	:	*Ya betul, kira-kira bisa tunjukkan dimana salahnya dari hasil ini?*
Respondent L	:	*2x+3y=24* *Saya pilih x nya adalah 5, jadi 2 kali 5 ditambah 3y sama dengan 24. Maka 3y ini sama dengan 12. Terus saya hitung y nya 12-3 jadi 9. Tapi kok pas dimasukkan kembali hasilnya gak 24 ya miss?*
Researcher	:	*Coba temukan kesalahanmu ada dimana?*
Respondent L	:	*Gak tau miss, kayaknya sudah benar hitungannya.*

When entering junior high school, students are faced with quite complex algebraic forms, so that many students find it difficult to perform these algebraic operations. This has an impact on several mathematical materials or topics that contain calculations with algebraic forms, one of which is the material on the system of linear equations in two variables. This is because, among other things, during the pandemic, many students experienced learning loss, resulting in low mathematical abilities, especially arithmetic abilities. In fact, arithmetic is an ability that requires reasoning and algebraic skills that function to solve mathematical problems in all activities of daily human life (Ariyanti, Azizah, & Amir, 2022; Khalil, 2022; Haser, Doğan, & Gönül Kurt Erhan, 2022; Barbieri & Booth, Mistakes on Display: Incorrect Examples Refine Equation Solving and Algebraic Feature Knowledge, 2020).

Reading errors in this question are caused by students who are not careful in reading the equations given. There are students who read the equation upside down to 3x+2y=24 so that in the end in the calculation to the answer gets the wrong result. Misunderstanding, mistranslation, and misconception in this question are caused because students do not understand the question instructions properly and correctly.

Researcher	:	*Menurut pendapatmu, kenapa saya salahkan jawaban nomor satu ini padahal memenuhi persamaan yang kamu tulis?*
Respondent P	:	*Salah hitung ya miss?*
Researcher	:	*Coba perhatikan soalnya dan jawaban yang kamu tulis ini.*
Respondent P	:	*Memang kenapa miss? Salahnya dimana ya miss? Ini kan sudah benar semua. Kalau x nya 0 berarti y nya 12, kalau y nya yang nol x nya 8, sama kalau x nya 4 y nya 6. Sudah tepat semua.*
Researcher	:	*Sekali lagi, coba perhatikan soalnya dan apa yang kamu tulis.*
Respondent P	:	*(diam sejenak) Hah! Oh iya, kebalik miss ini harusnya 2x+3y=24 ya. Yah salah soal deh.*

In question number 1, it is asked to provide 3 pairs of numbers that meet, but there are some students who only write 1 pair of numbers because they feel they have found the answer without looking back at the instructions given. This is because students are actually able to use the mathematical concepts that have been learned but sometimes students make mistakes in entering data into the available variables.

Researcher	:	*Coba perhatikan jawaban kamu nomor satu ini. Menurut kamu salahnya dimana?*
Respondent V	:	*Kalau dari perhitungan sudah benar Ibu, tidak salah.*
Researcher	:	*Perhatikan soalnya sekali lagi dan perintah soalnya. Dibaca, diucapkan, bukan di dalam hati ya.*
Respondent V	:	*Nyatakan tiga pasangan bilangan yang memenuhi persamaan k adalah dua x ditambah tiga y sama dengan 24. (sejenak terdiam).*
Researcher	:	*Jadi?*
Respondent V	:	*Harusnya tiga pasang Bu, saya cuma tulis x nya 6 dan y nya 4 aja. Maaf ya Bu. Kurang dua lagi.*

In addition, students also make mistakes in understanding the information provided, so that students have not actually completed all the solutions requested. This is because students do not read the complete question information (Khatimah & Asdarina, 202; Veloo, Krishnasamy, & Abdullah, 2015; Barbieri, Booth, Begolli, & McCann, 2021).

In question number 2, the order of dominant errors made by students is Translation Error, Conclusion Error, Process Ability Error, Understanding Error, Reading Error. After analyzing student answers, discussing with teachers, and interviewing students, the error made in number 2 was caused because the question given was an open-ended story question. Questions like this are indeed not familiar enough to students because they involve the process of reading, observing, and analyzing the questions given in sufficient depth. Students find it difficult to interpret the meaning of the question, especially when the form of the question is open-ended.

Researcher	:	*Jawaban kamu salahnya cukup banyak, tapi saya mau bertanya terkait soal nomor 2 ini. Sebetulnya apa yang ada dalam pikiranmu ketika membaca soal ini?*
Respondent K	:	*Beli pensil sama penghapus di koperasi, tapi kayaknya gak ada penjualnya ya Bu? Bayarnya langsung aja, gak ada yang dagang?*
Researcher	:	*Ya, tujuannya untuk menguji kejujuran siswa. Selain beli pensil dan penghapus, apalagi informasi yang kamu tangkap dari soal tersebut?*
Respondent K	:	*Harga pensilnya 1.500 rupiah dan harga penghapusnya 1.000 rupiah.*
Researcher	:	*Selain itu?*
Respondent K	:	*Bu, ini soalnya rumit sekali. Saya gak ngerti saya harus apa. Ini ngitungnya gimana to? Gak mudeng Bu.*
Researcher	:	*Jadi begini, anggap saja di meja saya ini ada beberapa pensil dan penghapus. Harga pensilnya 1.500 dan harga penghapusnya 1.000. Lalu saya tidak tahu siapa saja yang mengambil pensil dan penghapus ini tetapi ada uang 10.000 receh-receh yang saya terima. Saya belum menghitung berapa pensil dan penghapus yang diambil. Tapi saya bisa menebak, kira-kira kalau penghapusnya diambil 1 pensilnya diambil berapa ya soalnya ada uang 10.000. Begitu kurang lebihnya. Kamu paham?*
Respondent K	:	*Sedikit Bu. Berarti gak boleh kembali ya Bu?*
Researcher	:	*Tidak boleh, karena ini koperasi kejujuran. Taruh uang sesuai dengan harga barangnya.*
Respondent K	:	*Kalau saya beli pensilnya 1 berarti nanti kembali, berarti gak mungkin ya Bu?* *Kalau saya beli pensilnya 2 kayaknya bisa.*
Researcher	:	*Coba kalau kamu beli pensilnya 2 berarti sudah habis berapa rupiah dan butuh berapa rupiah lagi untuk bisa sampai 10.000.*
Respondent K	:	*Bu, kalau saya beli pensil 2 kan 3.000 ya berarti sisa 7.000 jadi penghapusnya saya beli 7.*
Researcher	:	*Nah, seperti ini. Bisakah kamu temukan satu pasangan lagi banyak pensil dan penghapus yang mungkin?*
Respondent K	:	*Bisa sih Bu, tapi ngitungnya agak lama. Saya coba dulu ya Bu.*

Students are not able to understand the correlation between the sentence "the number of pencils and erasers is decreasing" and "the money in the box". For students who understand, they understand that when the pencils are decreasing and there is money in the box it means "the pencils have been sold" or "someone bought the pencils and erasers, then paid with that amount of money". However, for students who do not understand, this sentence is too complicated to understand. This is because students' literacy skills are not very high. Students are not yet accustomed to contextual story problems and are more often given routine problems that are directly worked on with mathematical operations. This is because students only memorize concepts obtained

through learning activities in class. Students are not yet able to understand, use, and manipulate information related to the material being studied, especially when faced with new problem situations. Students are able to work on problems properly and correctly when the problem has been changed into a mathematical model in a two-variable linear equation system that is ready to be worked on or if the teacher helps translate the problem into mathematical form (Sidik, Hendriana, & Sariningsih, 2018; Brizuela, Blanton, Sawrey, AshleyNewman-Owens, & Gardiner, 2015; Darabi, Arrington, & Sayilir, 2018). In question number 3, the dominant order of errors made by students is Translation Error, Process Skills Error, Understanding Error, Conclusion Error, Reading Error. After analyzing student answers, discussing with teachers, and interviewing students, the error made in number 3 was caused by students having difficulty placing coordinate points, especially if the form contains 0 on the ordinate or abscissa. Many students make mistakes in distinguishing coordinates (0,-2) and (-2,0). In addition, some students are fixated on having to use coordinate points containing 0 on the grounds that it is easier to connect between points, even though this step does not have to be done. There are many other numbers that can be used which will actually make the calculation easier than replacing one of the variables with the number 0. This happens because in learning activities, teachers emphasize replacing one of the variables with 0 to find the value of another variable.

Researcher	:	*Saya mau bertanya terkait soal nomor 3 yang kamu kerjakan. Kenapa semua ini ada 0 nya ya?*
Respondent A	:	*Biar gampang aja miss. Kalau ngitung pake 0 kan enak, tinggal ditutup terus sisanya dibagi aja.*
Researcher	:	*Em, ya boleh. Tidak salah, tetapi ini kira-kira apakah semua ini benar? Kenapa tidak digambar juga grafiknya?*
Respondent A	:	*Untuk x ditambah 2y sama dengan 3 ini kalau x nya 0 berarti y nya 3/2 sedangkan kalau y nya 0 berarti x nya 3. Jadinya 0 dan 3/2 terus satunya 0 dan 3* *Untuk 4x ditambah 3y sama dengan 2 kalau x nya 0 maka y nya 2/3 dan kalau y nya 0 maka x nya 1/2 boleh kan miss?*
Researcher	:	*Pelan-pelan ya, apa yang kamu hitung sudah benar. Tetapi penempatannya yang salah. Jika ada koordinat maka yang ditulis di depan itu x nya atau y nya?*
Respondent A	:	*Emmm harusnya x nya miss.*
Researcher	:	*Apa yang kamu tulis disitu, sama tidak dengan penjelasan kamu barusan?*
Respondent A	:	*Oh, berarti kalau 0 tidak ditulis di depan ya miss?*
Researcher	:	*Bukan karena 0 nya ya A, tetapi karena x dan y nya. Coba jika diperbaiki penulisannya jadi bagaimana?*
Respondent A	:	*Untuk x ditambah 2y sama dengan 3 tu 0 dan 3/2 sama 3 dan 0 ya miss? Sedangkan yang 4x ditambah 3y sama dengan 2 jadinya 0 dan 2/3 satunya 1/2 dan 0. Gitu miss?*
Researcher	:	*Nah, kalau seperti itu kan jadi bisa digambar grafiknya to. Ini semua nanti diperbaiki lagi ya. Lagipula, apa tidak susah jika bilangannya pecahan? Kenapa tidak ambil bilangan bulat saja?*
Respondent A	:	*Hehehe.. Enak ada 0 nya miss.*

Students have difficulty making graphs in Cartesian form and then analyzing the given graph form. Some students are also less able to interpret the meaning of parallel

graphs and overlapping graphs. For students, both are graphs that have no solution because they do not intersect each other. This is because students do not understand the material in depth because they focus only on the intersecting graph form. This material displays the solution of a system of linear equations in two variables that must be solved, the solutions offered are solving using the graphical method, solving using the elimination method, and solving using the substitution method. So if you find two graphs that do not intersect each other, students assume that both graphs have no solution.

Researcher	:	*Menurut pendapatmu kenapa grafik yang saling sejajar dan berimpit ini tidak memiliki solusi? Mengapa hanya grafik yang saling berpotongan yang memiliki solusi?*
Respondent TL	:	*Soalnya ada titik temunya Bu. Titik ininya Bu, garis ini ketemu sama garis ini, jadi inilah titik temunya.*
Researcher	:	*Titik potong ya namanya. Bukan titik temu. Apakah yang terlihat tidak punya titik temu pasti tidak punya solusi?*
Respondent TL	:	*Gimana mau punya solusi Bu, kalau tidak ketemu. Kan patokannya harus ketemu dulu. Berpotongan seperti ini.*
Researcher	:	*Perhatikan grafik yang berimpit ini, sebetulnya dia itu berpotongan lho tetapi saling menimpa, jadi titik potongnya tetap ada.*
Respondent TL	:	*Banyak banget dong Bu?*
Researcher	:	*Ya tidak apa-apa, tetapi ada kan. Nah dalam persamaan linear dua variabel itu jika kedua grafik saling berimpit ini maka memiliki banyak solusi atau solusi tak hingga.*
Respondent TL	:	*Oh, jadi solusinya ada tapi banyak banget, gitu ya Bu? Saya kira gak ada solusinya. Mungkin saya gambarnya salah kali ya Bu. Harusnya pake pulpen yang beda warna biar kelihatan.*
Researcher	:	*Ya itu juga bisa, jadi sebetulnya ini grafiknya dua ya bukan satu. Kalau sejajar kenapa tidak punya solusi?*
Respondent TL	:	*Karena gak ketemu sampai kapanpun meski sampai ujung sini dan sana.*
Researcher	:	*Ya betul.*

This is because the ability to translate graphs is related to the mathematical reasoning ability and mathematical literacy ability that students have. When their mathematical literacy ability is good enough, students can distinguish between other types of graphs that do not intersect each other. This is also related to students' ability to understand the meaning of the given question instructions, students' inability to use the theories/rules conveyed. Specifically in this case, graphs that are parallel and overlapping have different solutions even though they do not intersect. So that in the end students are unable to conclude the answer correctly (Norhidayah, 2023; Blanton, Brizuela, Gardiner, Sawrey, & AshleyNewman-Owens, 2017; Kapur, 2014). In question number 4, the dominant order of errors made by students is Understanding Errors, Translating Errors, Concluding Errors, Reading Errors, Process Ability Errors. After analyzing student answers, discussing with teachers, and interviewing students, the error made in number 4 was due to the most complex conditions of all the questions given. Question number 4 is a story problem that is actually not open-ended but contains basic information that students should already know. The sentence "Made's flower garden is rectangular. The circumference of Made's flower garden is 42 m." This means that students are expected to know the formula for the circumference of a rectangle. When the problem to be solved is related to the area of the flower garden, it means that students will solve it using the

form of a multiplication operation between the length and area of the flower garden that has been obtained through the problem-solving process carried out. However, many students also have difficulty in the problem-solving process because they cannot translate the sentence "The difference between the length and width of Made's flower garden is 9 m". Many students also try two pairs of numbers that have a difference of 9 without paying attention to the conditions in the previous sentence which states that "Made's flower garden circumference is 42 m". Of course, this greatly affects the calculation results obtained regarding the area of the flower garden to be calculated.

Researcher	:	*Coba jelaskan hasil pekerjaanmu pada nomor 4 ini dari awal ya.*
Respondent S	:	*Made mempunyai taman berbentuk persegi panjang sehingga ada ukuran panjang dan ukuran lebar. Ukuran panjang dimisalkan p dan ukuran lebar dimisalkan l. Kelilingnya 42 meter berarti p+l nya adalah 42. Lalu ini kan ada selisih, selisih artinya pengurangan, jadi p-l nya itu 9. Setelah itu eliminasi aja satu-satu untuk dapat p sama l nya. Karena yang ditanya luas maka luas adalah p kali l jadinya 51/2 kali 33/2 hasilnya segini Bu.*
Researcher	:	*Apakah kamu yakin keliling lingkaran itu p+l?*
Respondent S	:	*Salah ya Bu? Saya ingatnya p+l. Tapi bu, ini kalau dicari selisihnya tu 9 kok Bu. 51/2 – 33/2 itu 18/2 kan sama dengan 9.*
Researcher	:	*Ya kalau selisihnya 9 memang benar. Kalau 13 dan 4 juga selisihnya 9, tetapi kan ada syarat penting dimana keliling 42 juga harus diperhitungkan. Bukan hanya selisihnya saja. Ayo, apa rumus keliling persegi panjang?*
Respondent S	:	*Em.. p+l Bu.*
Researcher	:	*Hmmm.. Bukan dong, kurang sedikit lagi.*
Respondent S	:	*Bu,gak ingat. Saya tau nya p+l aja*
Researcher	:	*Bukan ya, keliling persegi panjang itu 2p+2l bukan hanya p+l saja*
Respondent S	:	*Oh, berarti ini nanti 42 nya bisa dibagi 2 aja ya?*
Researcher	:	*Iya bisa, tetapi kamu harus paham dulu bahwa mula-mula itu berasal dari 2p+2l bukan p+l. Pasti hasilnya berbeda nanti.*

Story problems like number 4 are the most difficult problems for all students to solve, as evidenced by the results of students' work on question number 4, where students made the most mistakes. This is because the procedural errors made by students were apparently lacking or even incorrect, so that students felt that they had carried out the mathematical solution operations correctly but the results were not appropriate and inaccurate. In addition, these procedural errors ultimately have an impact on the problem-solving process, failure to conclude answers, and even being unable to find the final answer which is the solution to the problem given (Aswin & Juandi, 2022; McLaren, Gog, Ganoe, Karabinos, & Yaron, 2016; Abdullah, Abidin, & Ali, 2015).

Referring to the results of the analysis of student errors based on Newman's categories, the stages of students' problem-solving abilities can be presented in the following table:

Table 3. Student problem solving ability stage

No	P	Q	R	S
1	380 siswa	376 siswa	371 siswa	362 siswa
2	304 siswa	293 siswa	272 siswa	233 siswa
3	373 siswa	362 siswa	357 siswa	356 siswa

4	183 siswa	168 siswa	147 siswa	72 siswa

Notes:
P: Ability to understand the problems
Q: Ability to plan the solutions
R: Ability to implement the solutions
S: Ability to evaluate the problem solving results

Based on the error analysis that has been done on question number 1, almost all students are able to apply the steps to solve mathematical problems well. This is because the questions designed are in the category of easy questions and are already in the form of two-variable linear equations. The questions presented are quite simple so that the mathematical problems presented in question number 1 are not complex. In question number 2, there are many students who start to have difficulty understanding the mathematical problems given. This is because the form of the questions given is a story problem that must be changed into a mathematical model first which must then be solved until a solution is found. The questions are open-ended so that some students have difficulty finding other solutions. In question number 3, students' problem-solving abilities are similar to number 1. This is because the questions given are already presented in the form of a mathematical model. Students are able to understand the problem and design solutions to the problems presented. Only a few students found difficulty in drawing graphs so that they were unable to apply solutions and evaluate the results of problem solving that had been done in drawing and interpreting the graphs. In question number 4, students' problem-solving abilities decreased quite drastically. Many students had difficulty solving the problem because the questions presented were quite complex and contained information outside the questions. Many students forget the formula for the area and circumference of a rectangle and many students do not understand the relationship between the information given in the problem. This makes it difficult for students not only to determine the solution to the problem given but from the moment they understand the problem given, many students have experienced difficulties (Heemsoth & Heinze, 2014; Metcalfe, 2017; Verschaffel, Schukajlow, Star, & Dooren, 2020).

Through the problem-solving process for the given questions, students have gone through the process of understanding the problem, planning solutions to the given problems, implementing the solutions, and evaluating the results of the problem solving carried out. In the results of this study, not all students were able to meet and exceed all stages of problem-solving ability processes well (Achmetli, Schukajlow, & Rakoczy, 2019). Through the interview process that has been carried out, students were able to provide reasons why errors in the stages carried out can occur. This means that every error in problem-solving ability can be corrected and students can use the learning experience in solving future mathematical problems. This study is a qualitative study containing descriptive analysis, of course the results of this study are not general in nature that can be applied to all schools or to the material on the system of linear equations of two variables. However, the results of this study can be used as a mapping of the errors made by students and students' mathematical problem-solving abilities in the material on the system of linear equations of two variables. Through this descriptive analysis, teachers can find out the problems experienced by students in the material on the system of linear equations of two variables. This research can also be developed by using remediation

procedures to reduce errors made by students and improve students' mathematical problem-solving abilities in the material of two-variable linear equation systems (Boatman & Long, 2018).

▪ CONCLUSION

Based on the results of the study on the Newman error category, it was found that the dominance of errors in each question was different. This depends on the level of difficulty of the question and the mathematical problem-solving abilities of the students. Indirectly, the Newman error categories that have been compiled can cover all the errors found in the research subjects. Although the dominance of the error categories is different in each question given, reading errors, comprehension errors, transformation errors, process skill errors, and encoding errors were found in this study. Through the open-ended approach, students are trained to be able to hone their mathematical problem-solving abilities. This is because the learning carried out and the mathematical problems given have more than one solution. This situation can train students to be able to use various methods to obtain various problem solutions, of course more than one. When the results found are different from other friends, students do not need to be afraid of being wrong as long as they are in accordance with the mathematical concepts being studied. In addition, through the open-ended approach, students can review the steps of solving mathematics and apply the concepts contained in the two-variable linear equation system more concretely through real problems given. Through the interview process, students are able to learn from the mistakes they make and can provide real experience so that students are expected not to make the same type of mistakes in the future. Learning mathematics with the help of student worksheets through the open-ended approach can guide and encourage students to be able to solve mathematical problems given in a structured manner starting from understanding the problems given to evaluating the results of problem solving. With this open-ended approach, mathematics learning becomes more interesting and challenging because there are various solutions that can be found. Through the open-ended approach, students can carry out various explorations to solve mathematical problems because students do not only focus on one solution but also consider other alternatives. For teachers, the results of the analysis related to these types of errors can provide information regarding the types of errors that often occur, the causes of errors, and students' perspectives on finding solutions in solving these problems. This is expected to encourage teachers to design more effective learning strategies. Teachers can use certain learning approaches, learning media that are in accordance with the characteristics of the teaching materials presented, learning methods according to student needs. The purpose of all this is to overcome student errors that arise and improve students' mathematical problem-solving abilities. Through analysis and interviews, teachers can carry out remedial programs according to student needs and abilities so that meaningful, differentiated learning is created. Analysis of student errors provides valuable data for learning evaluation. Teachers can use this information to evaluate the effectiveness of the methods, media, and learning approaches used and make improvements as needed to improve student learning outcomes.

This study has several limitations, including: (1) The sample used only includes 6 schools so that it can limit generalization to a larger sample population. Especially because the schools used in this study are schools in the third quartile category. (2)

Schools in the third quartile are spread across several locations, so their students also come from diverse backgrounds. (3) The limited research time means that not all students can be interviewed so that students with unique and fatal errors are taken to be studied further according to Newman's error categories. (4) In addition to the diverse backgrounds of students, the abilities and skills of teachers in teaching using student worksheets through an open-ended approach also vary. Not all teachers routinely use media, teaching methods other than lectures and discussions, and certain approaches in learning activities. This certainly also affects the class situation which suddenly changes unlike usual.

▪ REFERENCES

Abdullah, A. H., Abidin, N. L., & Ali, M. (2015). Analysis of students' errors in solving higher order thinking skills (HOTS) problems for the topic of fraction. Asian Social Science, 11(21), 133-142. doi:10.5539/ass.v11n21p133

Achmetli, K., Schukajlow, S., & Rakoczy, K. (2019). Multiple solutions for real-world problems, experience of competence and students' procedural and conceptual knowledge. International Journal of Science and Mathematics Education, 17, 1605–1625. doi:10.1007/s10763-018-9936-5

Angraini, L. M., Sthephani, A., & Ain, S. Q. (2021). *Pengaruh bahan ajar berbasis penalaran matematis untuk meningkatkan kemampuan komunikasi matematis* [the influence of instructional materials based on mathematical reasoning to enhance mathematical communication skills]. FIBONACCI: Jurnal Pendidikan Matematika dan Matematika, 7(1), 11-18. doi:10.24853/fbc.7.1.11-18

Ariyanti, N., Azizah, N. L., & Amir, M. F. (2022). *Upaya meningkatkan kemampuan hitung anak pasca pandemi covid-19 melalui pelatihan permainan kreatif metode jarimatika* [Efforts to Improve Children's Calculation Skills Post-Covid-19 Pandemic Through Creative Game Training Using the Jarimatika Method]. Jurnal Terapan Abdimas, 7(1), 136-142.

Aswin, & Juandi, D. (2022). Using watson criteria for analyzing student errors: systematic literature review (SLR). Hipotenusa : Journal of Mathematical Society, 4(1), 13-23. doi:10.18326/hipotenusa.v4i1.7239

Bahar, A., & Maker, C. J. (2015). Cognitive backgrounds of problem solving: a comparison of open-ended vs. closed mathematics problems. Eurasia Journal of Mathematics, Science and Technology Education, 11(6), 1531-1546. doi:10.12973/eurasia.2015.1410a

Barbieri, C. A., & Booth, J. L. (2020). Mistakes on display: incorrect examples refine equation solving and algebraic feature knowledge. Applied Cognitive Psychology, 34(4), 862-878. doi:10.1002/acp.3663

Barbieri, C. A., Booth, J. L., Begolli, K. N., & McCann, N. (2021). The effect of worked examples on student learning and error anticipation in algebra. Instructional Science, 49(4), 419-439. doi:10.1007/s11251-021-09545-6

Blanton, M., Brizuela, B. M., Gardiner, A. M., Sawrey, K., & AshleyNewman-Owens. (2017). A Progression in first-grade children's thinking about variable and variable notation in functional relationships. Educational Studies in Mathematics, 95, 181-202. doi:10.1007/s10649-016-9745-0

Boatman, A., & Long, B. T. (2018). Does remediation work for all students? how the effects of postsecondary remedial and developmental courses vary by level of

academic preparation. Educational Evaluation and Policy Analysis, 40(1), 29-58. doi:10.3102/0162373717715708

Bray, W. S. (2013). How to leverage the potential of mathematical errors. Teaching Children Mathematics, 19(7), 424-431. doi:10.5951/teacchilmath.19.7.0424

Brizuela, B. M., Blanton, M., Sawrey, K., AshleyNewman-Owens, & Gardiner, A. M. (2015). Children's use of variables and variable notation to represent their algebraic ideas. Mathematical Thinking and Learning, 17(1), 34-63. doi:10.1080/10986065.2015.981939

Cassel, S., & Victor, B. (2015). A structured approach to training open-ended problem solving. IEEE Frontiers in Education Conference (FIE), 1-4. doi:10.1109/FIE.2015.7344088

Chusnul, R. C., Mardiyana, & Retno, D. S. (2017). Errors analysis of problem solving using the newman stage after applying cooperative learning of TTW Type. AIP Conference Proceedings, 1913(1). doi:10.1063/1.5016662

Darabi, A., Arrington, T. L., & Sayilir, E. (2018). Learning from failure: a meta-analysis of the empirical studies. Educational Technology Research and Development, 66(5), 1101–1118. doi:10.1007/s11423-018-9579-9

Deda, Y. N., & Maifa, T. (2021). Development of student worksheets using the context of local wisdom on integers and fractions. Jurnal Pendidikan Matematika, 15(1), 71-82. doi:10.22342/jpm.v.i.12824.71-82

Egodawatte, G., & Stoilescu, D. (2015). Grade 11 students' interconnected use of conceptual knowledge, procedural skills, and strategic competence in algebra: a mixed method study of error analysis. European Journal Of Science And Mathematics Education, 3(3), 289-305.

Farida, N. (2015). *Analisis kesalahan siswa SMP Kelas VIII dalam menyelesaikan masalah soal cerita matematika* [analysis of errors made by eighth grade middle school students in solving mathematical word problems]. AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 4(2), 42-52.

Hanim, S. V., Kurniati, D., Oktavianingtyas, E., Susanto, & Jatmiko, D. D. (2023). *Proses pemecahan masalah numerasi tipe uraian pada materi SPLDV berdasarkan tahapan polya* [the process of solving descriptive numerical problems on SPLDV material based on polya's stages]. Sigma: Jurnal Pendidikan Matematika, 9(1), 25-42. doi:10.1063/1.5016662

Haser, Ç., Doğan, O., & Gönül Kurt Erhan. (2022). Tracing students' mathematics learning loss during school closures in teachers' self-reported practices. International Journal of Educational Development, 88, 1-8. doi:10.1016/j.ijedudev.2021.102536.

Heemsoth, T., & Heinze, A. (2014). Eratum to: the impact of incorrect examples on learning fractions: A Field Experiment With 6th Grade Students. Instructional Science, 42(4), 659–660. doi:10.1007/s11251-014-9313-x

Hennink, M., Hutter, I., & Bailey, A. (2020). Qualitative research methods. London: SAGE Publication.

Janan, T., Sitaresmi, P. D., & Nuryami. (2022). *Analisis kesalahan mahasiswa dalam menyelesaikan soal teori himpunan pada mata kuliah himpunan dan logika* [analysis of students' errors in solving set theory problems in the sets and logic

course]. JPMI: Jurnal Pembelajaran Matematika Inovatif, 5(2), 495-504. doi:10.22460/jpmi.v5i2.495-504

Kapur, M. (2014). Productive failure in learning math. Cognitive Science, 38(5), 1008–1022. doi:10.1111/cogs.12107

Khalil, I. A. (2022). How is learning loss treated in mathematics classrooms at the intermediate stage? a mixed methods study. Education 3-13, 52(4), 488-506. doi:10.1080/03004279.2022.2108873

Khatimah, H., & Asdarina, O. (202). *Diagnosis kesalahan siswa dalam memahami materi faktorisasi bentuk aljabar pada siswa kelas VIII* [diagnosis of students' errors in understanding algebraic factorization material in eighth grade students]. Mathema Journal, 2(1), 40-56.

Lichtman, M. (2023). Qualitative research in education a user's guide. New York: Routledge. doi:10.4324/9781003281917

Lima, A. J., Hernández, L. G., & Tobon, S. (2019). Design and validation of a rubric to evaluate the ethical project of life in university students. World Review of Science, Technology and Sustainable Development, 15(4), 300-312. doi:10.1504/WRSTSD.2019.104093

Magelo, C., Hulukati, E., & Djakaria, I. (2020). *Pengaruh model pembelajaran open-ended terhadap kemampuan berpikir kreatif matematik ditinjau dari motivasi belajar* [the influence of the open-ended learning model on mathematical creative thinking skills in terms of learning motivation]. Jambura Journal Of Mathematics, 2(1), 15-21. doi:10.34312/jjom.v2i1.2593

Maharani, I. P., & Subanji. (2018). Scaffolding based on cognitive conflict in correcting the students' algebra errors. International Electronic Journal of Mathematics Education, 13(2), 67-74. doi:10.12973/iejme/2697

Mahuda, I. (2017). *Pembelajaran kooperatif Co-Op Co-Op dengan pendekatan open-ended untuk meningkatkan kemampuan pemecahan masalah matematis siswa SMA* [cooperative learning using Co-Op Co-Op model with an open-ended approach to enhance high school students' mathematical]. JPPM: Jurnal Pelayanan dan Pemberdayaan Masyarakat, 10(2), 31-39.

McLaren, B. M., Gog, T. v., Ganoe, C., Karabinos, M., & Yaron, D. (2016). The efficiency of worked examples compared to erroneous examples, tutored problem solving, and problem solving in computer-based learning environments. Computers in Human Behavior, 87-99. doi:10.1016/j.chb.2015.08.038

Meilinda, Putri, R. I., Zulkardi, Inderawati, R., & Desnita, T. (2024). Enhancing teacher competence through collaborative worksheet development: an empirical investigation. International Journal of Evaluation and Research in Education (IJERE), 13(2), 1690-1702. doi:10.11591/ijere.v13i3.27266

Metcalfe, J. (2017). Learning from errors. Annual Review of Psychology, 465–489. doi:10.1146/annurev-psych-010416-044022

Msomi, A. M., & Bansilal, S. (2022). Analysis of students' errors and misconceptions in solving linear ordinary differential equations using the method of laplace transform. International Electronic Journal of Mathematics Education, 17(1), 1-10. doi:10.29333/iejme/11474

Nicolas, C. A., & Emata, C. Y. (2018). An integrative approach through reading comprehension to enhance problem-solving skills of grade 7 mathematics students.

International Journal of Innovation in Science and Mathematics Education, 26(3), 40-64.

Norhidayah, S. (2023). Mathematical reasoning ability as a tool to improve mathematical literacy. Hipotenusa: Journal of Mathematical Society, 5(2), 147-158. doi:10.18326/hipotenusa.v5i2.565

Ojose, B. (2015). Students' misconceptions in mathematics analysis of remedies and what research says. Ohio Journal of School Mathematics, 30-34.

Olivares, R. G., Olmo-Muñoz, J. d., González-Calero, J. A., & Arnau, D. (2024). Analysing the impact of erroneous examples on third-grade students' problem-solving proficiency. International Journal of Innovation in Science and Mathematics Education, 32(3), 52-64.

Ozuru, Y., Briner, S., Kurby, C. A., & McNamara, D. S. (2013). Comparing comprehension measured by multiple-choice and open-ended questions. Canadian Journal of Experimental Psychology / Revue Canadienne de Psychologie Expérimentale, 67(3), 215–227. doi:10.1037/a0032918

Pamungkas, G. P., & Kowiyah. (2021). The influence of open ended learning model on mathematical problem solving ability. Jurnal Ilmiah Sekolah Dasar, 5(3), 395-402.

Purwasih, S. M., & Rahmadhani, E. (2021). *Penerapan scaffolding sebagai solusi meminimalisir kesalahan siswa dalam menyelesaikan masalah SPLDV* [applying scaffolding as a solution to minimize students' errors in solving SPLDV Problems]. FIBONACCI: Jurnal Pendidikan Matematika dan Matematika, 7(2), 91-98. doi:10.24853/fbc.7.2.91-98

Rizos, I., & Gkrekas, N. (2023). Incorporating history of mathematics in open-ended problem solving: an empirical study. Eurasia Journal of Mathematics, Science and Technology Education, 19(3), 1-17. doi:10.29333/ejmste/13025

Shalihah, N. F., Wibowo, T., & Yuzianah, D. (2022). Development of open-ended-based mathematics e-module on quadrilateral material of junior high school. JTAM (Jurnal Teori dan Aplikasi Matematika), 6(2), 331-340. doi:10.31764/jtam.v6i2.7291

Sidik, M. J., Hendriana, H., & Sariningsih, R. (2018). *Analisis kesalahan siswa kelas IX pada materi bangun ruang sisi datar saat menyelesaikan soal berpikir kritis* [analysis of ninth grade students' errors in plane solid geometry material when solving critical thinking problems]. Jurnal Pembelajaran Matematika Inovatif, 1(5), 837-846.

Steedle, J. T., & Ferrara, S. (2016). Evaluating comparative judgment as an approach to essay scoring. Applied Measurement in Education, 29(3), 211–223. doi:10.1080/08957347.2016.1171769

Veloo, A., Krishnasamy, H. N., & Abdullah, W. S. (2015). Types of student errors in mathematical symbols, graphs and problem-solving. Asian Social Science, 11(15), 324-334. doi:10.5539/ass.v11n15p324

Verschaffel, L., Schukajlow, S., Star, J., & Dooren, W. V. (2020). Word problems in mathematics education: A Survey. ZDM: The International Journal on Mathematics Education, 52(1), 1-16. doi:10.1007/s11858-020-01130-4

Virtanen, P., Niemi, H. M., & Nevgi, A. (2017). Active learning and self-regulation enhance student teachers' professional competences. Australian Journal of Teacher Education, 42(12), 1-20. doi:10.14221/ajte.2017v42n12.1.

Wijaya, A., Heuvel-Panhuizena, M. v., Doormana, M., & Robitzschc, A. (2014). Difficulties in solving context-based pisa mathematics tasks an analysis of students' errors. 3, 555-584. doi:10.54870/1551-3440.1317

Yuniarti, Y., Kusumah, Y. S., Suryadi, D., & Kartasasmita, B. G. (2017). The effectiveness of open-ended problems based analytic-synthetic learning on the mathematical creative thinking ability of pre-service elementary school teachers. International Electronic Journal of Mathematics Education, 12(3), 655-666. doi:10.29333/iejme/640