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Analyzing Students' Errors and Epistemological Obstacles in Sequences and Series

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Abstract

This study investigates students' errors in solving sequence and series problems using Newman Error Analysis (NEA) and examines the underlying epistemological obstacles. A descriptive qualitative design was applied to 32 eleventh-grade students, with data collected through problem-solving tests and semi-structured interviews. The results show that transformation errors were the most frequent (34.4%), followed by process skill errors (25.0%), comprehension errors (21.9%), reading errors (12.5%), and encoding errors (6.2%). These findings indicate that students face significant challenges in translating contextual problems into mathematical models and executing accurate procedures. Furthermore, three types of epistemological obstacles were identified: generalization, conceptual, and intuitive obstacles. This study contributes by integrating error analysis with epistemological perspectives, providing deeper insights into students' cognitive processes. The findings offer practical implications for designing instruction that emphasizes conceptual understanding and mathematical modeling.

Keywords: epistemological obstacles; newman error analysis; sequence and series; student errors.

Introduction

Logical, analytical, and problem-solving skills are essential competencies that must be developed through mathematics learning in schools (NCTM, 2000; Schoenfeld, 2016). Mathematics education does not only aim at mastering concepts and procedures, but also at training students to understand problems and formulate appropriate solution strategies. However, various international reports indicate that Indonesian students' mathematical abilities still require improvement. The results of the Programme for International Student Assessment (PISA) study show that Indonesian students' numeracy literacy remains below the international average (OECD, 2023). This condition suggests that many students still experience difficulties in understanding mathematical concepts and applying them in problem-solving situations.

One important topic in secondary school mathematics is sequences and series. From an epistemological perspective, sequences and series form the foundational bridge between discrete arithmetic and continuous calculus, playing a critical role in developing inductive reasoning and algebraic thinking. This topic plays a crucial role as it relates to number patterns and the modeling of various real-life phenomena, such as population growth, compound interest calculations, and numerical pattern analysis. Contextually, mastering this material equips students with the mathematical literacy needed to analyze trends and make data-driven predictions in economic, scientific, and technological domains. Nevertheless, several studies indicate that students often encounter difficulties in understanding concepts and applying problem-solving procedures, particularly when problems are presented in the form of contextual or word problems (Hariyani et al., 2022; Verschaffel et al., 2020; Wijaya et al., 2022). These difficulties are often reflected in the errors students make during the problem-solving process.

Error analysis is a widely used approach in mathematics education research to identify the sources of students' learning difficulties. One commonly used method is Newman Error Analysis (NEA), which classifies students' errors into five stages: reading, comprehension, transformation, process skills, and encoding (Cuevas & Sides, 2020). Previous studies have shown that errors frequently occur at the transformation and process skill stages, indicating students' difficulties in translating contextual problems into appropriate mathematical representations (Rohmah Mushlihah & Sugeng, 2018).

In addition to procedural errors, students' difficulties are closely related to learning obstacles, particularly epistemological obstacles. These obstacles arise when students' prior knowledge, although valid in certain contexts, becomes inappropriate when applied to different situations. Epistemological obstacles can influence how students represent and model mathematical problems, leading to errors in the solution process (Ario & Jupri, 2025) Furthermore, research by (Milazoni et al., 2022) shows that students frequently experience errors at the stages of comprehension, transformation, process skills, and encoding when solving mathematical word problems.

Understanding the root causes of student errors in mathematics is highly urgent, as persistent misconceptions can hinder subsequent learning of advanced STEM concepts. While traditional assessments identify *what* errors students make, they often fail to explain *why* these errors occur, leaving a critical blind spot for educators seeking to design effective remedial interventions. Therefore, a deeper diagnostic approach that links operational errors to foundational cognitive difficulties is severely needed to improve instructional outcomes.

Despite the growing body of research on Newman Error Analysis (Kurnianto et al., 2019; Rohmah Mushlihah & Sugeng, 2018; Yusuf et al., 2023), most studies primarily focus on identifying types of errors without examining the underlying cognitive and epistemological factors in depth. Moreover, previous research tends to focus on general mathematical topics such as algebra or linear equations (Chirume, 2021), while studies specifically addressing sequences and series remain relatively limited. This indicates a significant research gap, particularly in integrating error analysis with epistemological obstacle theory. To bridge this gap, a comprehensive understanding of students' thinking processes can be achieved by linking these cognitive obstacles to a broader didactical framework that considers how mathematical concepts are presented and understood by students (Turmudi et al., 2014).

Based on this gap, this study addresses the following research questions: (1) What types of errors do students make in solving sequence and series problems based on Newman Error Analysis? (2) What epistemological obstacles underlie these errors?

Accordingly, the objectives of this study are to analyze students' errors in solving sequence and series problems using Newman Error Analysis and to identify as well as explain the epistemological obstacles that influence these errors. This study is expected to contribute both theoretically and practically; theoretically, it extends previous research by integrating Newman Error Analysis with epistemological obstacle theory, while practically, it provides actionable insights for educators to design more effective instructional strategies that emphasize conceptual understanding and mathematical modeling skills.

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Method

This study employed a descriptive qualitative approach to identify students' errors in solving sequence and series problems based on Newman's procedure and to reveal the underlying learning obstacles. The descriptive qualitative approach was chosen because it allows for an in-depth, nuanced exploration of students' internal thinking processes and cognitive structures in a natural classroom setting, which cannot be adequately captured through quantitative metrics alone (Creswell & Poth, 2016).

The research was conducted through several operational stages adapted from the qualitative data analysis framework by (Miles, 2014): (1) developing research instruments in the form of a problem-solving test on sequences and series and an interview guide; (2) validating the instruments by mathematics education experts; (3) administering the test to students; (4) analyzing students' work based on Newman's error stages; (5) selecting research subjects based on variations in error types; (6) conducting in-depth interviews to explore students' thinking processes; and (7) analyzing the data and drawing conclusions.
The material covered in this study was arithmetic and geometric sequences and series, including the concept of the n-th term and the sum of the first n terms. Mathematically, the n-th term of an arithmetic sequence is expressed as :

$$U_n = a + (n-1)b \tag{1}$$

while the sum of the first n terms is formulated as:

$$S_n = \frac{n}{2}(2a + (n-1)b \tag{2}$$

For a geometric sequence with a constant ratio, the nth term is given by:

$$U_n = ar^{(n-1)} \tag{3}$$

and the sum of the first n terms is formulated as:

$$S_n = \frac{a(1-r^n)}{(1-r)}, \quad r \neq 1 \tag{4}$$

These equations were used as the basis for constructing the problem-solving test instruments in this study. The analysis of students' errors employed Newman's procedure, which classifies errors into five stages: reading, comprehension, transformation, process skills, and encoding (Alkhasanah et al., 2023)

The study was conducted at a public senior high school in the second semester of the 2024/2025 academic year. The accessible population consisted of three parallel eleventh-grade classes totaling 96 students. Through purposive sampling, one specific class comprising 32 eleventh-grade students who had formally studied sequences and series was selected as the research sample. From this sample, six students were chosen as the main subjects representing high, medium, and low ability levels, as well as variations in error types.

The instruments used in this study consisted of :

(1) A problem-solving test in the form of essay questions designed to assess students' ability to: (a) understand problem information, (b) transform problems into mathematical models, (c) perform calculations, and (d) write final answers. This instrument serves to screen and categorize the specific types of operational errors committed by students during written work.

(2) Semi-structured interview guidelines to explore students' thinking processes and identify the causes of errors. This instrument is utilized to cross-examine students' written responses and uncover the underlying epistemological obstacles.

(3) An error analysis sheet based on Newman Error Analysis. This instrument functions as a standardized rubric to systematically map and log the frequency of errors during the data reduction phase.

The material covered arithmetic and geometric sequences and series, including the nth term and the sum of the first n terms.Prior to implementation, all instruments underwent content validation through expert judgment by two mathematics education experts. Validation focused on: (1) content relevance to the curriculum, (2) clarity and coherence of item construction, and (3) appropriateness of language.

A quantitative index of content validity was also computed using Aiken's V to determine the degree of agreement among experts. Items with $V \geq 0.80$ were considered valid and retained, while items below the threshold were revised.

In addition, pilot testing was conducted with a small group of students to examine item readability and clarity. Revisions were made based on feedback to ensure that the instruments accurately captured students' understanding and minimized ambiguity.

Interviews were conducted in a semi-structured manner to obtain information about students' thinking processes and the factors causing their errors. Before being used, the test and interview instruments were validated by two mathematics education experts through an expert judgment process. The validation covered: (1) the relevance of the material to the curriculum, (2) the clarity of item construction, and (3) the appropriateness of language use. The instruments were considered valid if they met the validity criteria based on the experts' assessments. The use of written tests and interviews aimed to obtain more in-depth data regarding students' thinking processes in solving mathematical problems ((Rohmah Mushlihah & Sugeng, 2018). Data analysis was conducted based on Newman Error Analysis (NEA), which consists of five stages: (1) reading error, (2) comprehension error,

(3) transformation error, (4) process skill error, and (5) encoding error (Febriana et al., 2024; Irianti et al., 2024)

The data analysis process was carried out through the following stages: (1) Identifying students' errors at each stage of Newman's procedure based on their written test results. (2) Classifying the types of errors made at the stages of reading, comprehension, transformation, process skills, and encoding. (3) Analyzing interview results to determine the causes of errors at each stage of problem-solving. (4) Drawing conclusions regarding patterns of student errors and the underlying learning obstacles.

To ensure data validity, this study employed method triangulation by comparing data obtained from written tests and student interviews. Triangulation wa used to ensure the consistency of data regarding students' errors in solving mathematical problems. This approach is essential for obtaining a more comprehensive understanding of students' thinking processes in mathematics learning (Arias Valencia, 2022; Ediyanto et al., 2025)

Results and Discussion

This study aims to identify students' errors in solving sequence and series problems based on Newman Error Analysis (NEA). The research data were obtained through a problem-solving test administered to 32 students, as well as interviews with selected research subjects to gain a deeper understanding of students' thinking processes.

Error analysis was conducted based on the five stages of Newman's procedure, namely reading error, comprehension error, transformation error, process skill error, and encoding error, as described in the study by Muslihah Rohmah and Sutiarso on mathematical problem-solving error analysis.

The results of the student error analysis are presented in Table 1.

Table 1. Percentage of Student Errors Based on the Stages of Newman Error Analysis

No	Type of Error	Number of Students	Percentage (%)
1	Reading Error	4	12,5
2	Comprehension Error	7	21,9
3	Transformation Error	11	34,4
4	Process Skill Error	8	25,0
5	Encoding Error	2	6,2
	Total	32	100

The results in Table 1 indicate that the most dominant error is transformation error at 34.4%, followed by process skill error at 25.0%. This occurs because students often rely on "keywords" without fully understanding the context. For example, when encountering the word "increase," students tend to assume it represents the common difference (b) in an arithmetic sequence, whereas it may actually refer to the ratio (r) in a geometric growth context. These findings indicate that students have difficulty transforming information from word problems into appropriate mathematical models.

To examine the types of errors in greater detail, further analysis was conducted on each problem given to the students.

Table 2. Indicators of Newman Errors for Each Item

No	Item Indicator	Reading	Comprehension	Transformation	Process Skill	Encoding
1	Determining the nth term of an arithmetic sequence based on the first term and common difference in a contextual problem	-	✓	✓	✓	-
2	Calculating the sum of the first n terms of an arithmetic series from a contextual situation	-	✓	✓	✓	✓
3	Determining the number of elements in the last term based on an arithmetic sequence pattern	✓	✓	✓	✓	-
4	Calculating the total number of elements in an arithmetic sequence in a real-life context	-	✓	✓	✓	-
5	Determining the value of a specific term in a geometric sequence based on a known ratio	-	✓	✓	✓	-
6	Writing the mathematical model of the nth term of a geometric sequence	-	✓	✓	-	-
7	Determining the height of a bouncing ball based on a geometric sequence model	✓	✓	✓	✓	-
8	Calculating the total distance based on the concept of a geometric series	-	✓	✓	✓	✓
9	Determining the amount of savings in a particular month using an arithmetic sequence model	-	✓	✓	✓	-
10	Calculating the total savings over a certain period using the concept of an arithmetic series	-	✓	✓	✓	✓

Note: ✓ = error occurred; – = correct (no error)

Based on Table 2, it can be seen that errors most frequently occur at the transformation and process skill stages. This indicates that students still experience difficulties in determining appropriate mathematical models and performing accurate calculation procedures.

To further explore the error analysis, interviews were conducted with several research subjects. The following are excerpts from the student interviews.

Subject S-3 (moderate ability)

"I know the formula for arithmetic sequences, but I am confused about determining the values of *a* and *b* from the word problem. So, I just try to substitute the numbers given in the problem".
This statement indicates that the student experienced an error at the transformation stage, specifically difficulty in converting information from the problem into a mathematical model.

Subject S-5 (low ability)

"I read the problem, but I do not really understand what it means. I do not know what I should find first." This response shows an error at the comprehension stage.

Subject S-2 (high ability)

"I already found the formula, but when calculating, I made a mistake in substituting the values."
This statement indicates that errors among high-ability students generally occur at the process skill stage.

Analysis of Epistemological Obstacles

The findings of this study can be further analyzed using the concept of epistemological obstacles within the theory of didactical situations proposed by Brousseau (1997). This theory explains that students' errors in mathematics are not solely caused by a lack of knowledge, but may also stem from prior knowledge that is actually correct but becomes inappropriate when applied in different contexts. In this study, several forms of epistemological obstacles were identified.

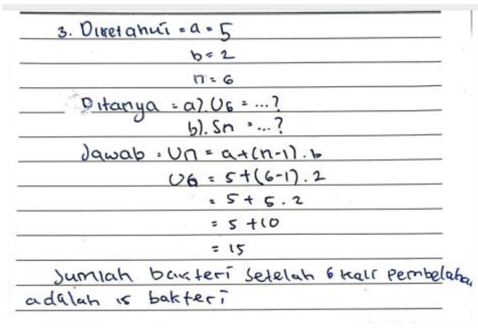
1. Generalization Obstacle

Some students showed a tendency to use arithmetic sequence formulas to solve geometric sequence problems. This indicates the presence of a generalization obstacle, where students overgeneralize previously learned concepts.

The relationship for the nth term of an arithmetic sequence is expressed as follows:

$$U_n = a + (n-1)b$$

An example of a student's response is as follows:



3. Diketahui = a = 5
b = 2
n = 6
Ditanya = a). U_6 = ...?
b). Sn = ...?
Jawab : Un = a+(n-1).b
U_6 = 5+(6-1).2
= 5+5.2
= 5+10
= 15
Jumlah bakteri setelah 6 kali pembelahan adalah 15 bakteri

Figure 1. Student's Answer

Some students assume that every increase in a sequence always has a constant difference, which leads them to fail in identifying the concept of ratio in geometric sequences. This finding is consistent with the study conducted by (Ekasari, 2024) which shows that many student errors occur at the transformation stage, namely the inability to convert contextual problems into appropriate mathematical models. The study found that approximately 78.5% of students experienced errors at the transformation stage because they were unable to interpret information from word problems into correct mathematical representations.

2. Conceptual Obstacle

In contextual problems, it was found that students were able to read the questions but failed to understand the relationship between the given information and the relevant mathematical concepts. This indicates the presence of a conceptual obstacle, where students perceive mathematics as a set of formulas disconnected from real-life contexts.

An example of a student's response is as follows:

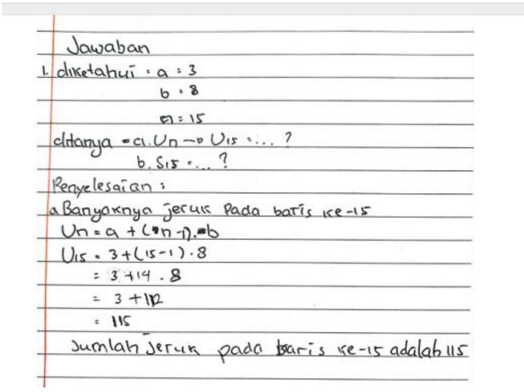


Figure 2. Student's Answer 2

This error indicates that students interchange the values of the first term and the common difference. As a result, they use incorrect data in the calculation process, leading to inaccurate answers. Such errors in interpreting information are generally caused by a lack of carefulness in identifying important details in the problem.

3. Intuitive Obstacle

Based on the analysis of students' responses, it was found that some students with relatively high mathematical ability still experienced difficulties when dealing with geometric sequence problems involving negative ratios. A negative ratio produces an alternating pattern (positive–negative–positive), which is intuitively perceived as illogical by students because it does not align with their everyday experiences of growth and decay. This difficulty arises because students intuitively assume that the ratio in a geometric sequence must always be positive. Consequently, when faced with a negative ratio, students become confused in determining the pattern of the sequence terms.

This error reflects the presence of an intuitive obstacle, a learning barrier that originates from students' initial intuitions formed through prior learning experiences but not fully aligned with formal mathematical concepts. In previous learning, students are more frequently exposed to geometric sequences with positive ratios, such as $r = 2$ or $r = 3$. These experiences shape an intuitive understanding that geometric sequences always produce patterns that consistently increase or decrease in one direction (Susilawati et al., 2022).

This phenomenon indicates that students' conceptual understanding of mathematics is often influenced by prior learning experiences, where they find it easier visualize patterns that move in a single direction (either continuously increasing or decreasing).

When instruction emphasizes only limited examples, students tend to develop intuitive generalizations that do not always correspond to actual mathematical concepts. Therefore, when students encounter situations that differ from their previous experiences, they struggle to adjust their understanding.

Based on a comprehensive analysis, it can be synthesized that there is a close relationship between Newman's error types and students' learning obstacles. The transformation errors that appear dominantly in this study can be seen as surface-level errors, while epistemological obstacles act as the underlying root causes.

Students' inability to convert contextual problems into appropriate mathematical models is rooted in limited conceptual understanding and incomplete cognitive structures. This condition is further exacerbated by didactical obstacles, where instructional practices tend to emphasize procedural use of formulas without strengthening logical structures, leading students to merely memorize mechanical steps. As a result, when faced with slightly different or counter-intuitive problem situations, students fail to make conceptual adaptations and consequently make errors at the transformation and process skill stages.

The findings of this study indicate that students' errors are not only caused by carelessness in calculations but also by limitations in conceptual understanding and mathematical modeling abilities (Yunarti, 2022)

Theoretically, this study contributes to the field of mathematics education by integrating Newman Error Analysis with the theory of epistemological obstacles. Practically, the findings can serve as a basis for teachers to design more effective instructional strategies, such as the use of contextual problems and problem-based learning approaches, to help students develop a deeper understanding of mathematical concepts.

Conclusion and Suggestion

Based on the results of this study on students' error analysis in solving sequence and series problems using the Newman Error Analysis approach, it can be concluded that students still experience errors at several stages of problem-solving, namely reading the problem, understanding the problem, transforming the problem into a mathematical model, performing calculations, and writing the final answer. The most dominant errors occur at the process skill and transformation stages, indicating that some students still have difficulties in performing accurate calculations and in determining appropriate mathematical models from the given problems.

In addition, the findings reveal the presence of learning obstacles experienced by students, including intuitive obstacles, epistemological obstacles, and didactical obstacles. Intuitive obstacles arise when students' initial intuitions do not align with formal mathematical concepts. Epistemological obstacles occur because students' conceptual understanding is limited to specific contexts, while didactical obstacles are related to instructional processes that emphasize the use of formulas rather than conceptual understanding. These findings indicate that students' errors are not solely caused by computational ability but are also influenced by conceptual understanding and the learning processes they experience.

Based on these results, teachers are recommended to emphasize conceptual understanding in instruction and to provide a variety of problem types so that students can apply mathematical concepts in different contexts. Furthermore, students should be encouraged to solve problems systematically, starting from understanding the problem to writing the final conclusion. Future researchers may extend this study by applying specific instructional approaches or by further investigating students' learning obstacles in other mathematical topics.

References

Alkhasanah, N., Murtiyasa, B., Yulia M, H., Sutama, S., & Markhamah, M. (2023). Analisis Kesalahan dalam menyelesaikan soal cerita Matematika Siswa Kelas V SD. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *12*(2), 2214–2223.

Arias Valencia, M. M. (2022). Principles, Scope and Limitations of the Methodological Triangulation. *Investigacio y Education En Enfermeria*, *40*(2).

Ario, M., & Jupri, A. (2025). Students ' Errors and Learning Obstacles in Solving Algebraic Word Problems : Hermeneutic Phenomenology. *MDPI Education Sciences*.

Chirume, S. (2021). An Analysis of Errors Committed by Students in Solving Linear Equations. *World Journal of Educational Research (WJER)*, *2*(4). https://doi.org/10.33552/WJER.2021.02.000542

Creswell, J. W., & Poth, C. N. (2016). Qualitative Inquiry and Research Design: Choosing Among Five Approaches. *SAGE Publications*, *16*(4), 473–475. https://doi.org/DOI: 10.1177/1524839915580941

Cuevas, J. A., & Sides, J. D. (2020). *Effect of Goal Setting for Motivation , Self-Efficacy , and Performance in Elementary Mathematics*. *13*(4), 1–16.

Ediyanto, E., Zulkipli, Z., Sunandar, A., & Yunus, M. (2025). Triangulation in Educational Research : A Literature Review. *Advances in Social Science, Education and Humanities Research*, *Icemt 2024*. https://doi.org/10.2991/978-2-38476-370-2

Ekasari, A. (2024). Jurnal Pendidikan Sains Error Analysis of Learners ' Problem-Solving Abilities in Mathematics Courses : A Newman Error Analysis (NEA) Approach

Error Analysis of Learners ' Problem-Solving Abilities in Mathematics Courses : A. *Jurnal Pendidikan Sains*, *12*(1).

Febriana, M., Agustina, S., Valentina, V., Rakhmawati, R., & Anggoro, B. S. (2024). Analisis Kesalahan Siswa dalam Menyelesaikan Soal Cerita Pada Operasi Bilangan Berdasarkan Pada Prosedur Newman's Error Analysis (NEA) : Case Study. *Jurnal Ilmu Pendidikan Dasar*, *09*.

Hariyani, M., Herman, T., Suryadi, D., & Prabawanto, S. (2022). International Journal of Educational Methodology Exploration of Student Learning Obstacles in Solving Fraction Problems in Elementary School. *International Journal of Educational Methodology*, *8*(3), 505–515.

Irianti, N. P., Barr, F. D., Nurasiah, L., & Irsal, N. A. (2024). ERROR ANALYSIS IN SOLVING APPLIED MATHEMATICS PROBLEMS BASED ON THE NEWMAN PROCEDURE. *Jurnal Ilmu Pendidikan*, *7*(1), 110–117.

Kurnianto, A., Yunarti, T., & M. Coesamin. (2019). ANALISIS SELF-EFFICACY BERPIKIR KRITIS SISWA DALAM PEMBELAJARAN SAINTIFIK. *Jurnal Pendidikan Matematika*, *7*(3), 298–309. https://doi.org/http://jurnal.fkip.unila.ac.id/index.php/MTK

Milazoni, T. R., Maison, M., & Nizlel, N. (2022). Analisis Kesalahan Siswa Dalam Menyelesaikan Soal Cerita Matematika Berdasarkan Teori Pemrosesan Informasi dan Pemberian Scaffolding. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *11*(1), 654–666.

Miles, M. B. (2014). Qualitative data analysis: A methods sourcebook (3rd ed.). *SAGE Publications*.

NCTM. (2000). Principles and standards for School Mathematics. In *NCTM*.

OECD. (2023). *PISA 2022 Results (volume I): The State of Education. Organisation For Economic Co-operation and Development.*

Rohmah Mushlihah, & Sugeng, S. (2018). Analysis Problem Solving in Mathematical Using Theory Newman. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(2), 671–681. https://doi.org/10.12973/ejmste/80630

Schoenfeld, A. H. (2016). Research in Mathematics Education. *SAGE Journals*, *40*(1). https://doi.org/https://doi.org/10.3102/0091732X16658650

Susilawati, A, D., Wahyudi, S, A., & J, A. (2022). Concept understanding of students through core physics learning tools based on guided inquiry assisted by PhET virtual media Concept understanding of students through core physics learning tools based on guided inquiry assisted by PhET virtual media. *Journal Of Physics*, *2165*. https://doi.org/10.1088/1742-6596/2165/1/012045

Turmudi, Kusumah, Y. S., Juandi, D., & Mulyana, E. (2014). Development Of Didactical Design Of Mathematics Pedagogy Through Professional Program Of Mathematics Teacher Education. *Jurnal Pendidikan Dan Pembelajaran*, *21*(1), 10–23. https://doi.org/https://journal.um.ac.id/index.php/pendidikan-dan-pembelajaran/article/view/4518

Verschaffel, L., Schukajlow, S., Star, J., & Dooren, W. Van. (2020). Word problems in mathematics education: A survey. ZDM. *Mathematics Education*, *52*(1), 1–16. https://doi.org/[https://doi.org/10.1007/s11858-020-01130-4]

Wijaya, T. T., Rahmadi, F., Chotimah, S., Jailani, J., & Wutsqa, D. U. (2022). A Case Study of Factors That Affect Secondary School Mathematics Achievement: Teacher-Parent Support, Stress Levels, and Students' Well-Being. *International Journal of Environmental Research and Public Health*, *19*(23), 16247. https://doi.org/10.3390/ijerph192316247

Yunarti, T. (2022). Desain didaktis teori peluang sma. *Jurnal PMIPA*, *15*(1), 15–20.

Yusuf, I. M., Kadarisma, G., & Rosyana, T. (2023). ANALISIS KESULITAN SISWA SMK KELAS X DALAM MENYELESAIKAN SOAL MATERI BENTUK AKAR. *Jurnal Pembelajaran Matematika Inovatif*, *6*(1), 1805–1812. https://doi.org/10.22460/jpmi.v6i1.10920