AlphaMath
Journal of Mathematics Education, 11(1) May 2025
p-ISSN 2477-409X, e-ISSN: 2549-9084
Available online: https://jurnalnasional.ump.ac.id/index.php/alphamath/

Analysis of Mathematics Education Students' Errors in Solving Monotonic Sequence Problems Using Newman's Taxonomy

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http://dx.doi.org/10.30595/alphamath.v11i1.26446

ABSTRACT

The purpose of this study is to examine the types of errors made by students of the Mathematics Education Study Program at the State University of Medan when attempting to solve monotonic sequence problems in the Real Analysis course. This study employs a qualitative descriptive methodology using the Newman Taxonomy approach, which categorizes errors into five types: reading, comprehension, transformation, process skills, and writing final answers. The data collection technique involved distributing essay questions online through Google Forms to selected students. Five students who had completed the monotonic sequence material were given a written test consisting of essay questions. The data were then analyzed using data reduction, data presentation, and conclusion-drawing techniques. The analysis revealed that the most common errors made by students were in process skills and final answer writing. Errors in writing final answers occurred when students failed to use correct notations or symbols in their solutions, despite understanding the subject matter and procedures. Process skill errors stemmed from difficulties in algebraic manipulation and the application of proof techniques. These errors were caused by a limited understanding of the concept of monotonic sequences and weaknesses in applying the steps of mathematical proofs. The findings highlight the need for instructional approaches that emphasize conceptual understanding and the systematic application of analytical thinking.
Keywords: Error Analysis, Monotonic Sequences, Newman's Taxonomy

ABSTRAK

Penelitian ini bertujuan untuk menganalisis bentuk-bentuk kesalahan yang dilakukan oleh mahasiswa Program Studi Pendidikan Matematika Universitas Negeri Medan dalam menyelesaikan soal barisan monoton pada mata kuliah Analisis Real. Penelitian ini menggunakan metode deskriptif kualitatif dengan pendekatan Taksonomi Newman, yang mengklasifikasikan kesalahan ke dalam lima kategori, yaitu kesalahan membaca, memahami, transformasi, keterampilan proses, dan penulisan jawaban akhir. Teknik pengumpulan data melibatkan distribusi pertanyaan esai secara online melalui Google Forms kepada siswa yang terpilih. Data diperoleh melalui pemberian tes tertulis berbentuk soal esai kepada 5 mahasiswa yang telah menempuh materi barisan monoton, dan dianalisis menggunakan teknik reduksi, penyajian data, serta penarikan kesimpulan. Hasil analisis menunjukkan bahwa kesalahan keterampilan proses dan penulisan jawaban akhir merupakan jenis kesalahan yang paling dominan dilakukan oleh mahasiswa. Kesalahan keterampilan proses disebabkan oleh kelemahan dalam penerapan prosedur pembuktian dan manipulasi aljabar sedangkan kesalahan penulisan jawaban akhir terjadi saat mahasiswa gagal menuliskan solusi dengan notasi atau simbol yang tepat, meski telah memahami konsep dan prosedur dengan benar. Kesalahan-kesalahan ini disebabkan oleh rendahnya pemahaman konsep barisan monoton dan kelemahan dalam menerapkan langkah-langkah pembuktian. Temuan ini menunjukkan perlunya strategi pembelajaran yang lebih menekankan pada pemahaman konsep dan latihan berpikir analitis secara sistematis.
Kata kunci: Analisis Kesalahan, Barisan Monoton, Taksonomi Newman

Received : May 5, 2025
Accepted : May 21, 2025
Published : May 22, 2025

Introduction

In higher education mathematics learning, especially in the Real Analysis course, students often face challenges in understanding basic concepts such as monotonic sequences. This problem becomes more complex when students are asked not only to understand the concept but also to prove the properties of the sequence formally. One of the dominant difficulties that arises is the students' inability to construct mathematical arguments logically and systematically, especially in terms of transformation and process skills, which are essential parts of mathematical proofs in the context of monotonic sequences (Darmadi et al., 2024). One of the main causes of this problem is the lack of students' habit of analyzing theorems during the learning process (Perbowo & Pradipta, 2017).

Error analysis holds high urgency in mathematics education because it can serve as a key indicator of students' understanding of a concept. Through error identification, teachers or lecturers can pinpoint the location of misconceptions or weaknesses in students' thinking processes, allowing them to develop more targeted instructional improvement strategies. Without error mapping, the learning process tends to focus only on final results without understanding the reasoning behind them. In the context of higher education (especially in courses that emphasize deductive reasoning, such as real analysis), errors are often latent and not immediately apparent unless systematically analyzed. As stated by Suwartina et al. (2023), analyzing students' errors based on conceptual understanding indicators in mathematics problems can help identify the types of errors students make, enabling educators to design appropriate interventions to improve students' conceptual understanding of mathematics. Thus, error analysis is not only an evaluation tool but also an essential pedagogical strategy to enhance the quality of mathematics instruction.

Many studies show that students' errors in solving math problems reflect conceptual and procedural understanding gaps. For example, in the context of monotonic sequences, students often make mistakes in recognizing patterns, establishing monotonicity hypotheses, and determining the limit of the sequence accurately (Takaendengan et al., 2022). Students often have difficulty identifying whether a sequence is increasing or decreasing, especially when the sequence involves recursive functions or complex algebraic expressions. In addition, there is also a misconception regarding the relationship between monotonicity and convergence, where students frequently assume that all monotonic sequences must converge without considering their boundedness. These issues indicate that students' understanding of monotonic sequences is still superficial and prone to both logical and procedural misconceptions. Although monotonic sequences are an important foundation in advanced learning, such as limits, series, and calculus, many students still fail to solve related problems correctly.

Research by Putri et al. (2021) also stated that understanding monotonic sequences is essential because it serves as a foundational skill for more advanced topics such as limits, series, and calculus. The ability to comprehend and demonstrate the properties of sequences is a critical part of developing logical, critical, and systematic thinking, particularly in higher education and within mathematics education programs. Moreover, studying monotonic sequences not only supports conceptual understanding but also enhances students' abilities in mathematical proof and analytical reasoning.

To systematically understand the types of student errors in solving mathematical problems, this study adopts Newman's Error Analysis (NEA), a diagnostic framework designed to evaluate students' problem-solving processes in five essential stages. According to Newman, students must go through the following steps when solving a mathematical word problem: (1) Reading – reading and recognizing the information presented in the problem; (2) Comprehension – understanding what has been read; (3) Transformation – converting the verbal statement into a suitable mathematical model or strategy; (4) Process Skill – executing the appropriate procedures or calculations required by the chosen strategy; and (5) Encoding – clearly expressing the final answer using correct mathematical notation and language (Karnasih, 2015).

At each of these stages, students are prone to commit specific errors. These include: (1) reading errors, where students misread symbols or terms; (2) comprehension errors, involving failure to grasp the meaning of the question; (3) transformation errors, where students are unable to correctly formulate the mathematical representation of the problem; (4) process skill errors, which involve procedural or computational mistakes; and (5) encoding errors, where the answer is incorrectly written or not expressed in an acceptable form (Samosir et al., 2025). Several previous studies have applied NEA in various mathematical contexts, such as linear equations, statistics, and geometry, and consistently found that transformation and process skill errors are the most frequently encountered types of errors by students (Lestari et al., 2018).

Unfortunately, although the Newman Taxonomy approach has been widely used, there are still limitations in the literature that specifically analyze its application in the context of monotonic sequences in Real Analysis courses. Research by Simamora et al.

(2025) analyzes student errors in Real Analysis courses, but does not use Newman Error Analysis. This indicates a research gap that needs to be filled to enhance the understanding of the types of errors made by students at the conceptual level of mathematical analysis.

Based on that background, this research aims to analyze the types of errors made by students of the Mathematics Education Study Program at Universitas Negeri Medan in solving monotonous sequence problems. Using the Newman Taxonomy framework, this study identifies types of errors, such as reading, understanding, transformation, process skills, and final answer writing errors. The results of this study are expected to contribute to the development of Real Analysis learning strategies that place greater emphasis on students' conceptual understanding and analytical-logical thinking. In addition, these findings are also expected to enrich the literature on students' learning difficulties in understanding the concept of monotonic sequences, which is an important foundation for advanced learning, such as limits, series, and calculus.

Research Methods

This research employs a descriptive qualitative approach aimed at identifying and detailing the types of errors made by students in solving monotonic sequence problems, based on the indicators of Newman's Taxonomy (Fitri et al., 2024). This approach was chosen because it is better suited to uncovering students' thought processes, understanding, and errors in depth, rather than merely evaluating outcomes. A descriptive design enables researchers to examine errors across various stages of students' problem-solving processes, particularly in the context of monotonic sequence material (Alaslan, 2021). In line with this, qualitative research has historically had two main objectives: to describe and explore, and to describe and explain. In the context of this study, both objectives are applied simultaneously to gain insight into students' errors, not only in terms of their types but also concerning the underlying cognitive processes that lead to those errors (Saleh, 2017).

The research sample consisted of five active students in the Mathematics Education Study Program at Universitas Negeri Medan, selected through purposive sampling. This sampling technique was chosen because it allows researchers to deliberately select participants based on specific criteria that align with the research objectives, such as having completed the topic of monotonic sequences in the Real Analysis course (Lenaini, 2021; Rasnawati et al., 2023).

The main instrument in this study is a set of essay questions specifically developed to identify types of errors based on Newman's Taxonomy, which includes five indicators:

Department of Mathematics Education, Universitas Muhammadiyah Purwokerto, Purwokerto, Indonesia
p-ISSN 2477-409X, e-ISSN: 2549-9084

reading errors, comprehension errors, transformation errors, process skill errors, and errors in answer writing (Anisa et al., 2023). The questions were designed as open-ended items within the context of monotonic sequence problems, requiring conceptual understanding, procedural application, and the ability to present logical and systematic answers. These questions were administered using Google Forms to ensure easy access for students and to facilitate the data collection process.

Data collection was carried out using an online questionnaire via Google Forms, allowing for efficient distribution without the need for paper. Respondents could access and complete the form using various internet-connected devices (Sianipar, 2019). The submitted data was automatically compiled and could be directly analyzed using Google Sheets. The data collection technique involved distributing essay questions online through Google Forms to selected students. They were instructed to complete the questions within a specified time frame without receiving assistance from others.

The data analysis technique in this study follows the stages of qualitative data analysis according to Miles and Huberman, namely: (1) data reduction, (2) data presentation, and (3) conclusion drawing (Zulfirman, 2022). At the data reduction stage, the researcher categorizes students' answers into five error categories based on the Newman Taxonomy indicators, namely reading errors, comprehension errors, transformation errors, process skill errors, and final answer writing errors. This process is carried out by closely examining each step of the students' work on the monotonous sequence problems, then noting which parts contain indications of errors and categorizing them according to Newman's classification.

Next, at the data presentation stage, the reduced information is organized in the form of a frequency table of errors by type and by subject, accompanied by direct quotes from students' answers that illustrate the characteristics of each type of error. In addition, the researcher also includes visual documentation (answer excerpts) to support data interpretation. This aims to help readers understand the context of students' mistakes more concretely and objectively.

At the final stage, which is concluding, the researcher interprets the patterns of errors that emerge, both individually and collectively. The conclusion is not only based on the frequency of error types but also considers the conceptual background that may cause these errors, such as misconceptions, procedural errors, or weaknesses in proof skills. All stages of analysis are conducted iteratively, where researchers continuously verify and reflect on the existing data until a valid and in-depth interpretation of student errors is obtained.

Result and Discussions

The answers on the research subjects' test sheets were analyzed using the Newman error analysis procedure. The types of errors made by the subjects were found to be reading errors, comprehension errors, transformation errors, process skill errors, and encoding errors.

Table 1. Type of Research Subject Error

Research Subject	Question Number	Type of Error				
		Type 1	Type 2	Type 3	Type 4	Type 5
S1	1	√				√
S2	1				√	
S3	2		√			
S4	3			√		
S5	4				√	√

Based on the error data of each subject in Table 1, it is evident that some students made mistakes according to the Newman error analysis procedure in solving Real Analysis problems. From Table 1, it can be seen that the most common mistakes made by students are process skills and errors in writing the final answer. Based on the analysis results from the test sheets, errors in process skills occur because students do not use the limit theorem correctly. Meanwhile, the mistake of writing the final answer occurs because the students cannot express the correct solution steps. Each error made by the students based on the Newman procedure will be discussed in more detail as follows.

Reading errors

This error occurs when students misread or misinterpret the form of a math problem. This error is the initial stage of the entire problem-solving process, and if not identified early on, it can lead to subsequent errors in the following stages, such as understanding, transformation, or the solution process. An example of this error can be seen in Figure 1. In the image above, it is evident that Subject 1 made this mistake on question number 1. The student misread the form of the question. The problem asks for the limit of $\frac{1}{\sqrt{n}}$, but what was worked on was $\frac{1}{n^2}$, the problem was unconsciously altered. This mistake shows that the student did not read or understand the form of the question carefully, resulting in an unconscious alteration of the question's form. As a result, the entire problem-solving process becomes irrelevant to the actual question. As a result, the entire resolution process becomes irrelevant to the actual question.

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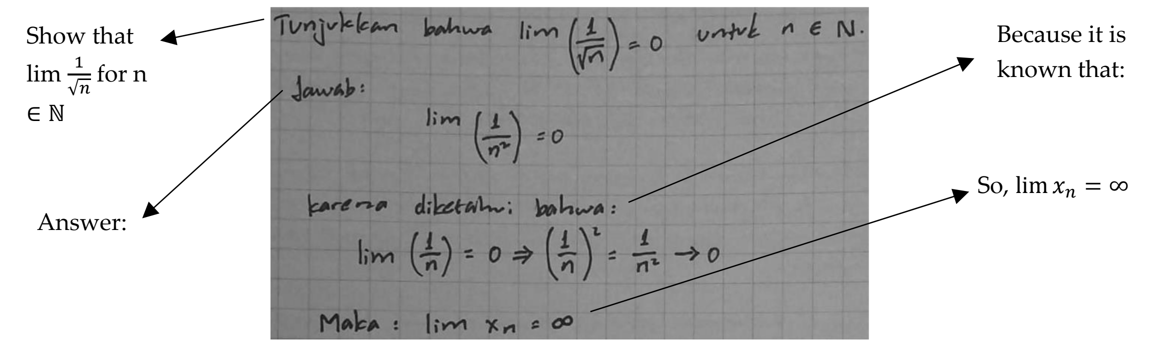


Figure 1. Subject-1's Answer to Question Number 1

A similar phenomenon was also found in research by Hidayah & Rejeki (2022), which analyzed students' errors in solving exponentiation problems based on Newman's theory. The research results show that reading errors often occur in students with low mathematical ability.

Research results show that reading errors often occur in students with low math skills. Reading errors can also be caused by factors such as lack of attention to detail, carelessness, or haste in reading questions. Reading errors can also be caused by factors such as a lack of attention to detail, carelessness, or haste in reading the questions. Lubis et al. (2021) in their study on mathematical literacy and error analysis, Newman, from the perspective of habits of mind, states that poor thinking habits, such as lack of attention to detail and haste, can increase the risk of reading errors.

Comprehension errors

An example of a misunderstanding error is the mistake made by subject 3 (S-3) while working on question number 2. An example of this mistake can be seen in Figure 2. In Figure 2, it can be seen that Subject 3 states that because the terms in the sequence are getting smaller, the sequence x_n will converge to a certain value. He also provided a numerical illustration of the value of x_n increases slowly and appears to approach some $\mathbb{L} \in \mathbb{R}$. Based on this, the subject concludes that the sequence x_n is convergent. Based on this, the subject concludes that the sequence x_n is convergent. Based on the results of the analysis, it can be concluded that the misunderstanding occurred due to a failure to understand the basic concepts of convergence and divergence of infinite sequences, particularly in the context of the harmonic series.

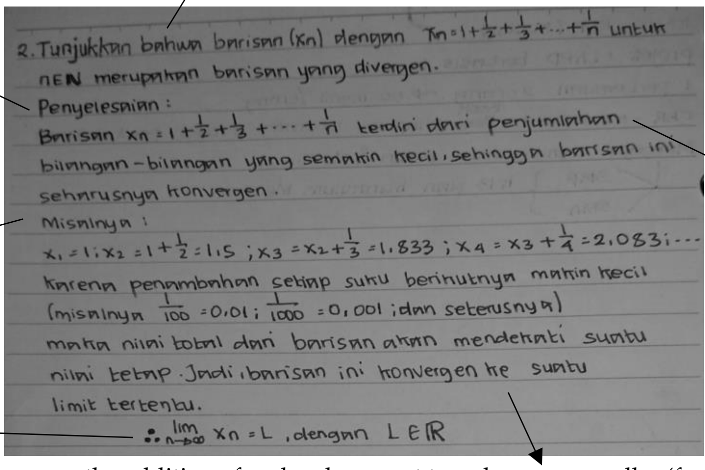
Based on the test analysis results, it can be concluded that the misunderstanding occurred in the form of failure to understand the meaning and basic concepts of convergence and divergence of infinite sequences, particularly in the context of the harmonic series. The subject seems to understand that terms like $\frac{1}{n}$ are getting smaller and tend to approach zero. However, the subject mistakenly concluded that the sum of the decreasing terms would yield a constant value (convergent). This is one of the common misconceptions in mathematical analysis, namely the assumption that: "If the terms approach zero, then the total sum will also approach a certain value." The sequence x_n is the sequence of partial sums of the harmonic series, which is classically known to be divergent. Although their terms decrease, their sum continues to increase without bound as n increases, because the addition of these terms is not small enough to stop the value from increasing indefinitely.

Show that the sequence (x_n) with $x_n = 1 + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{n}$ for $n \in \mathbb{N}$ is a divergent sequence.

Solution:

For example:

with


2. Tunjukkan bahwa barisan (x_n) dengan $x_n = 1+\frac{1}{2}+\frac{1}{3}+\dots+\frac{1}{n}$ untuk $n \in \mathbb{N}$ merupakan barisan yang divergen.
Penyelesaian :
Barisan $x_n = 1+\frac{1}{2}+\frac{1}{3}+\dots+\frac{1}{n}$ terdiri dari penjumlahan bilangan-bilangan yang semakin kecil, sehingga barisan ini seharusnya konvergen.
Misalnya :
$x_1 = 1; x_2 = 1+\frac{1}{2} = 1{,}5 ; x_3 = x_2+\frac{1}{3} = 1{,}833 ; x_4 = x_3+\frac{1}{4} = 2{,}083; \dots$
karena penambahan setiap suku berikutnya makin kecil (misalnya $\frac{1}{100} = 0{,}01; \frac{1}{1000} = 0{,}001$; dan seterusnya) maka nilai total dari barisan akan mendekati suatu nilai tetap. Jadi, barisan ini konvergen ke suatu limit tertentu.
$\therefore \lim_{n\to\infty} x_n = L$, dengan $L \in \mathbb{R}$

The sequence $x_n = 1 + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{n}$ consists of the sum of increasingly smaller numbers, so this sequence should converge.

because the addition of each subsequent term becomes smaller (for example: $\frac{1}{100} = 0{,}01; \frac{1}{1000} = 0{,}0001; etc$) the total value of the series will approach a fixed value. so, this sequence converges to a certain limit

Figure 2. Subject-3's Answer to Question Number 2

The research by Murtiyasa & Wulandari (2020) also identified this type of error. Misunderstanding errors occur when students incorrectly write down what is known, what is being asked, and do not write down any information at all. This is in line with Fitriatien's (2019) research, which states that students make comprehension errors because they do not write down what is known and what is being asked in the given math word problems.

The reason students make comprehension errors is that they do not understand the meaning of the sentences in the questions, so they do not know what to look for. Students are said to have reached the understanding stage when they can explain what the problem is. At this stage, students can understand the context of the given problem and know what is provided and what they will be looking for (Oktaviana, 2017).

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Transformation errors

Transformation error is a type of error that occurs when students are unable to convert information from a problem into the appropriate mathematical form for solving it. This error includes inaccuracies in translating the problem into a mathematical model, mistakes in selecting or applying formulas, and errors in manipulating algebraic or geometric expressions. Examples of transformation errors can be seen in the following Figure 3.

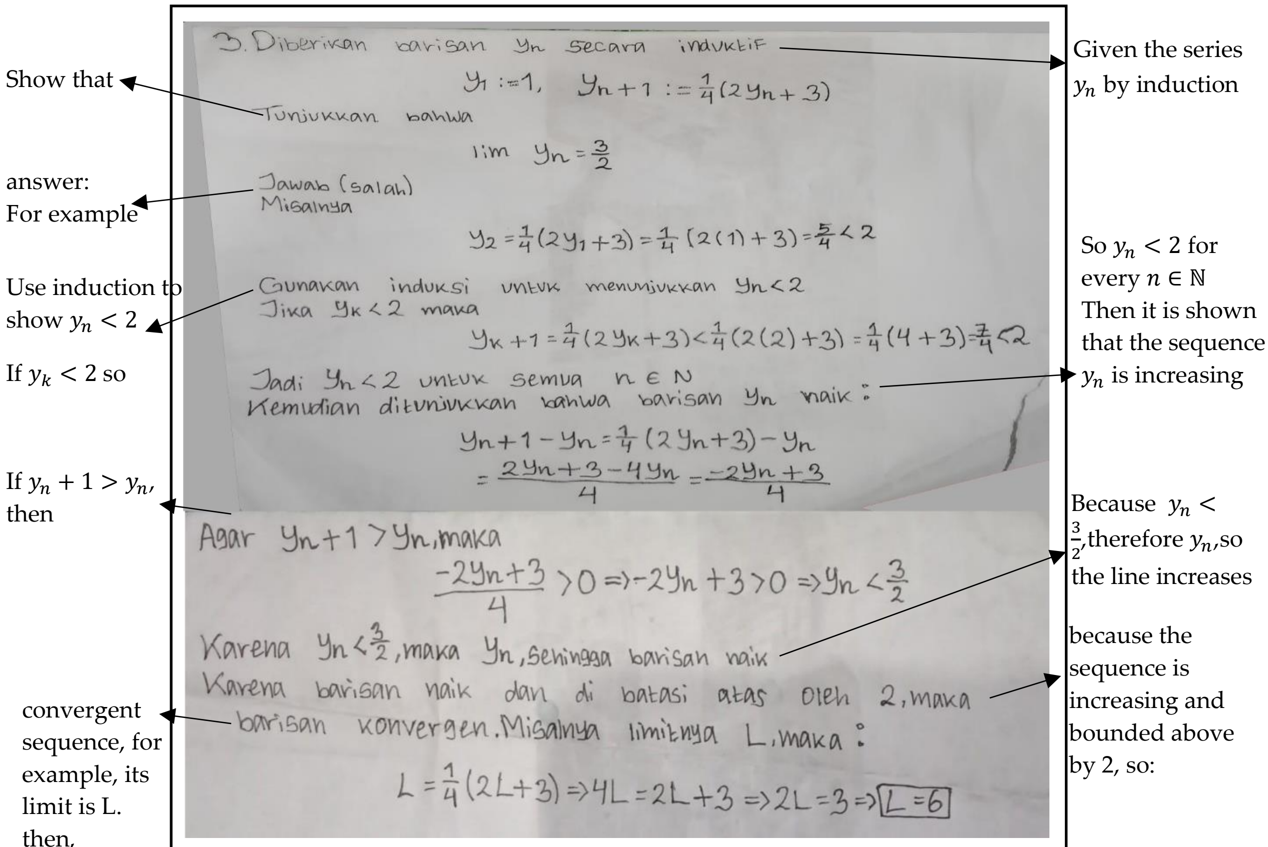

Figure 3. Subject-4's Answer to Question Number 3

In this study, a transformation error was identified in Subject 4 while solving question number 3 about recursive sequences. Although the subject successfully demonstrated that the sequence is monotonically increasing and bounded above, they made an error when determining the limit value by solving the recursive equation. The subject wrote the following Formula 1:

$$L = \frac{1}{4}(2L + 3) \Longrightarrow 4L = 2L + 3 \Longrightarrow 2L = 3 \Longrightarrow L = 6 \qquad (1)$$

The correct solution is:

$$4L = 2L + 3 \Longrightarrow 2L = 3 \Longrightarrow L = \frac{3}{2} \qquad (2)$$

As shown in Formula 2, this error indicates that the subject is having difficulty transforming the algebraic form of the recursive relation into a limit resolution, specifically in solving simple linear equations.

Research by Maifa (2019) revealed that students often make mistakes in proving that a mapping is a geometric transformation. These errors include mistakes in interpreting the definition of a mapping, errors in determining the domain and codomain of a mapping, and mistakes in identifying two contradictory aspects when proving that a mapping is an injective function. This shows that transformation errors do not only occur in algebraic manipulation but also in understanding the basic concepts of transformation geometry.

Additionally, research by Khusnah et al. (2022) shows that students with low self-efficacy tend to make transformation errors when solving PISA problems in the 'Change and Relationship' domain. These errors are caused by the students' inability to convert information from the problem into an appropriate mathematical model, as well as difficulties in selecting the correct solution strategy. Meanwhile, Kania & Arifin (2018) state that transformation errors occur because students tend to use direct mathematical procedures (such as algorithm formulas) without analyzing whether they are necessary or not.

Process skill errors

Process skill errors in Newman's Taxonomy refer to students' inability to correctly apply mathematical procedures or algorithms after understanding and transforming the problem. These errors include mistakes in performing arithmetic operations, algebraic manipulations, or other procedural steps necessary to solve mathematical problems (Zalfa & Rahmawati, 2024). In this study, process skill errors were identified in Subject 2 and Subject 5. Examples of these errors are shown in Figure 4.

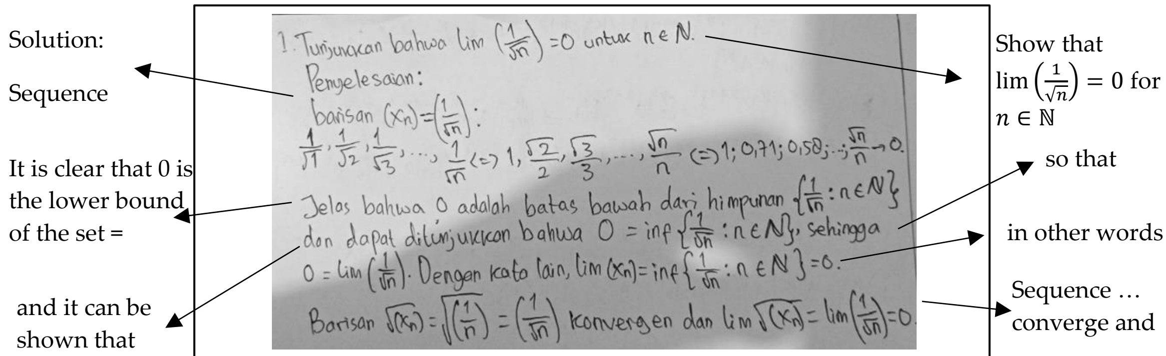

Figure 4. Subject-2's Answer to Question Number 1

When solving problem number 1 related to the limit of the sequence $\frac{1}{\sqrt{n}}$, Subject 2 made a mistake by confusing the form of the sequence with $\frac{\sqrt{n}}{n}$, which is a different and non-equivalent expression. Additionally, Subject 2 did not apply the correct theorem or mathematical method to prove the convergence of the sequence shown Figure 5.

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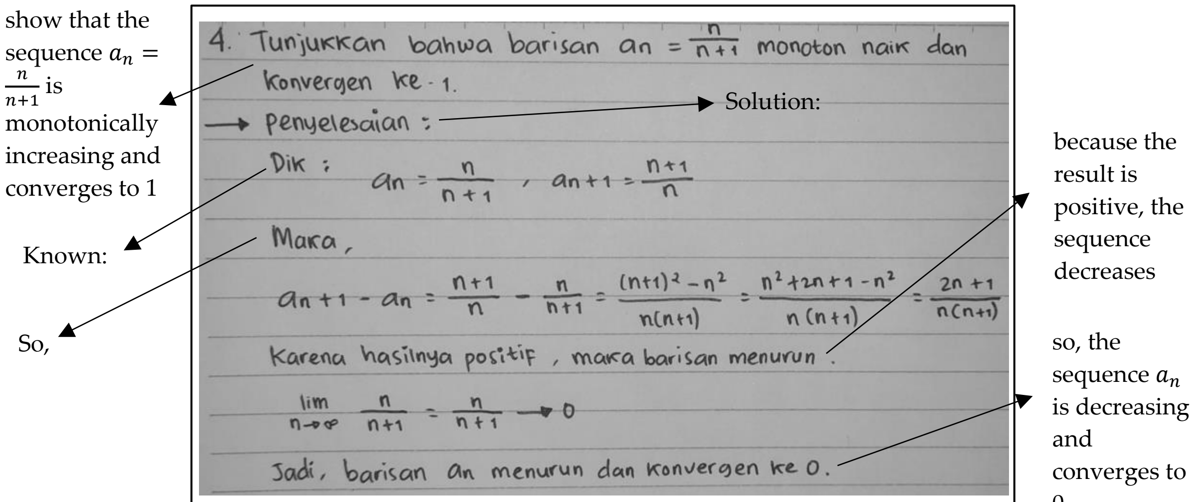

Figure 5. Subject-5's Answer to Question Number 4

Meanwhile, Subject 5 made an error in identifying the next term and the difference between terms in problem number 4, which involved the sequence $\frac{n}{n+1}$. This led to an incorrect conclusion. Subject 5 stated that the sequence was decreasing and convergent to 0, whereas in fact, it is increasing and convergent to 1.

This type of process skill error has also been identified in previous studies. For example, Maulana & Dachi (2021) in their research on the analysis of student errors in solving mathematical story problems based on the Newman procedure, specifically in solving systems of two-variable linear equations (SPLDV), found that process skill errors were the most dominant errors in student answer sheets, with a percentage of 56.19% in their study. Based on their interview results, the cause of these errors is due to students being less meticulous and lacking understanding of the calculation process of the SPLDV material.

Likewise, Arianti (2020) in her research on the analysis of student errors in solving mathematical problems based on Newman's stages, she found that male students experienced process skill errors at a rate of 90.91%, while female students experienced such errors at a rate of 54.54%. These errors were attributed to inaccuracies in calculations and a lack of understanding of problem-solving procedures.

Research by Mandasari & Ratnaningsih (2024) also emphasized the importance of differentiated process learning in addressing process skill errors. Their research demonstrated that implementing differentiated process learning successfully reduced students' process skill errors from 66% to 41%. This indicates that a learning approach tailored to students' needs can help minimize errors in applying mathematical procedures.

Process skill errors can also be influenced by students' learning styles. Wati et al. (2024) in their study on student errors in social arithmetic based on learning styles, found that students with auditory, visual, and kinesthetic learning preferences tended to make process skill errors. This finding suggests that incorporating learning approaches that accommodate students' learning styles may help reduce such errors.

To address process skill errors, it is essential for educators to provide varied and leveled exercises, along with constructive feedback. Furthermore, the use of instructional strategies that emphasize conceptual and procedural understanding—such as differentiated process learning, can support students in applying mathematical procedures correctly.

Final answer writing errors (Encoding errors)

Final answer writing errors (encoding errors) occur when students are unable to express mathematical solutions accurately in the form of appropriate notation, symbols, or representations, even though they have understood the correct concepts and procedures. These errors include the use of incorrect notation, the presentation of ambiguous or incomplete final results, and inconsistencies in writing the steps of the solution. Examples of errors in writing the final answer can be seen in Figure 1 and Figure 5.

In this study, encoding errors were identified in Subject 1 and Subject 5. Subject 1 was unable to express the correct solution steps. He concluded that because $\left(\frac{1}{n}\right)^2 \to 0$ then $\lim x_n = \infty$, which is contradictory. Subject 5 also did not write the limit using the correct notational structure. At the end of the answer is in Formula 3.

$$\lim_{n\to\infty} \frac{n}{n+1} = \frac{n}{n+1} \to 0 \qquad (3)$$

This statement, as shown in Formula 3, contains two errors. First, it incorrectly states the limit value; it should be 1, not 0. The second mistake is that the limit notation is not used consistently, and there is a repetition of the irrelevant expression $\frac{n}{n+1}$ and the conclusion is not justified with a formal algebraic approach. Subject 4's error indicates that the student has not fully understood how to derive the next term in a sequence and how to formally prove the monotonicity and limit of the sequence.

By understanding the various types of errors made by students in solving math problems based on the Newman procedure, educators can design more effective learning strategies to minimize the occurrence of similar errors in the future. One of the approaches that can be applied is Learning Therapy, which emphasizes the provision of structured exercises to strengthen students' understanding of basic

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p-ISSN 2477-409X, e-ISSN: 2549-9084

concepts, their skills in reading and writing mathematical notation, and their ability to apply problem-solving procedures systematically (Rahmawati & Permata, 2018).

According to Agustiani (2021), this approach has proven effective in reducing student errors in solving sequence and series application problems, particularly at the transformation and process skills stages. A similar point was made by Irianti et al. (2024), who emphasized the importance of teachers' attention to the transformation stage and process skills, as well as the need for in-depth exercises to strengthen the understanding of basic concepts.

Furthermore, several other studies indicate that students' mistakes in solving math problems are also influenced by various internal factors. Annizar & Kumala (2023) found that learning interest and gender influence the types of errors made by students. Students with high learning interest tend to make mistakes at the encoding and process skills stages, whereas students with low learning interest more frequently make mistakes at the comprehension, transformation, and process skills stages. Gender differences also show a tendency for different types of errors.

Meanwhile, Noutsara et al. (2021) revealed that high initial math ability does not always guarantee success in problem-solving. They found that students with good initial abilities can still make mistakes at the reading and comprehension stage. This shows the importance of basic reading comprehension skills in the context of mathematics. Psychological factors such as math anxiety also contribute to errors in problem-solving. Brezavšček et al. (2020) state that anxiety and negative attitudes towards mathematics can hinder students' ability to think logically and analytically, which is crucial in the problem-solving process. Siskawati et al. (2021) also emphasize that difficulties in understanding information in word problems often lead to errors at the reading and comprehension stages. Students' inability to identify important information from the questions becomes the main obstacle in solving the problems correctly.

Considering these various factors, the design of a comprehensive learning strategy, which not only focuses on strengthening concepts but also on increasing learning interest, managing anxiety, and developing skills in reading math problems, is essential to reduce students' mistakes in solving problems.

Conclusion

This research reveals that transformation errors and process skill errors were the most prevalent. Transformation errors reflect students' inability to convert problem information into appropriate mathematical models, while process skill errors indicate a weak understanding of proof procedures and algebraic manipulation. The primary factors contributing to these errors are students' limited mastery of the fundamental concepts of monotonic sequences and the lack of practice opportunities that encourage logical and systematic thinking. Therefore, the results of this study highlight the need for learning strategies that emphasize conceptual understanding and the development of mathematical thinking skills through structured and progressive exercises. This study has certain limitations. The number of participants was limited to five students who had studied the topic of monotonic sequences. Future research is recommended to involve a larger and more diverse sample of participants across multiple universities, and to integrate additional data collection methods such as clinical interviews and think-aloud protocols.

Acknowledgement
The author expresses the deepest gratitude to all parties who have provided support in the process of preparing this article. Thanks are extended to the students who have willingly become research subjects, as well as to colleagues who provided input during the instrument development and data analysis stages. This research would not have been completed without the contributions and cooperation of all the parties mentioned above. Hopefully, this writing can make a positive contribution to the development of mathematics education, particularly in improving the quality of students.

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