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Conceptual and Transformational Errors in Solving Non-Routine Algebra Problems: A Newman's Error Analysis of Junior High School Students

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Abstract

This study investigates the types and underlying causes of students' errors when evaluating non-routine algebraic problems that present procedurally plausible but logically invalid solution steps. The participants were 37 ninth-grade junior high school students from East Java, Indonesia, who had previously studied basic algebraic operations. Data were collected through a diagnostic task involving an algebraic fallacy that leads to a contradictory conclusion (e.g., 2 = 3), followed by semi-structured interviews with selected students. The analysis was guided by Newman's Error Analysis (NEA), focusing on reading, comprehension, transformation, process skills, and encoding errors. Students' written responses were independently coded by the researchers using predefined NEA indicators, and discrepancies were resolved through discussion. Descriptive statistics were used to summarize error frequencies, while interview data were analyzed qualitatively to explore students' reasoning. The results indicate that transformation errors were the most dominant, occurring in 48.64% of students' responses, particularly due to inappropriate cancellation of algebraic factors without considering domain restrictions. Many students accepted contradictory conclusions such as 2 = 3 or 3 = 2 as valid, as long as the solution steps appeared procedurally correct. These findings suggest that students tend to rely on mechanical algebraic procedures rather than validating the conceptual legitimacy of each transformation. The study highlights the importance of emphasizing equivalence-preserving transformations and domain conditions in algebra instruction, especially through non-routine tasks that require justification and critical validation of solution steps.

Keywords: Error Analysis; Student Errors; Algebraic Problems; Mathematical Reasoning; Conceptual Understanding.

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INTRODUCTION

Mathematics is one of the compulsory subjects taught to train students to think logically, analytically, systematically, critically, and creatively (Yayuk & As'ari, 2020). Das (2019) mathematics as a science-based subject or discipline is known as the queen of all subjects. Mathematics helps develop logical thinking, problem-solving, and analytical skills. Furthermore, mathematics is also the foundation for many other disciplines (Ahzan et al., 2022; Fulgensius Efrem Men, 2017). This is because mathematics originated from practical problems, and humans needed to solve these problems, thereby promoting scientific skills and knowledge that explain natural phenomena and shape scientific thinking as times change. Mathematics as a discipline is often viewed as abstract, challenging, and even intimidating by many students (Ahzan et al., 2022; Dairo et al., 2024). However, effective teaching strategies have the potential to change students' perceptions of mathematics, making it more accessible, interesting, and relevant (Mahisna et al., 2024). Integrating theory into practice allows educators to apply research-based methods that encourage deep understanding, critical thinking, and problem-solving skills that are essential in both mathematics and everyday life (Al-Thani & Ahmad, 2025). Connecting mathematical concepts to real-life situations can benefit students, helping them understand mathematical concepts quickly and solve mathematical problems accurately (Kohen & Orenstein, 2021; Setiawati, 2022).

Mathematics is one of the subjects considered challenging due to its abstract nature (Langoban & Langoban, 2020). Because of this, mathematics learning is carried out by prioritizing creativity, including teaching in the classroom using various learning models to enable students to become critical, excellent, active, intelligent, and creative thinkers with a strong work ethic (Hulu & Telaumbanua, 2022; Matondang et al., 2020). Based on the Ministry of Education and Culture 2022, the objectives of mathematics learning consist of (1) improving intellectual abilities, especially high-level abilities of students; (2) developing students' abilities in solving problems systematically; (3) achieving high learning outcomes; (4) training students in communicating ideas, especially in writing scientific papers; and (5) developing students' character. Mathematics is one of the most important subjects in education because it enables students to think logically, rationally, and critically (Dirasti Novianti, 2022; Zakaria Muchtar & Widiastuti, 2022).

Algebra has been recognized as an important topic in mathematics for secondary schools and forms the basis of almost all mathematics subjects in secondary schools and the gateway to advanced mathematics (Utami & Prabawanto, 2023). In addition, the demand for algebra at various levels of education is increasing, and individuals often use algebra in their daily lives without realizing it. Various stores use algebra to predict demand for certain products and then place orders; for example, when shopping, calculating annual taxable income; and banks calculate interest and loan installments (Adisaka et al., 2022; Andriyani et al., 2021). Therefore, algebra can help each individual develop mathematical reasoning that is important in all aspects of life. Algebra influences the decisions people make in many areas, such as personal finance, travel, and how often someone should exercise to achieve a certain level of fitness, and much more (Ayu et al., 2023; Siregar & Restati, 2017).

Based on this explanation, it can be seen that a deep understanding of algebra is very important for improving not only the understanding of various mathematical concepts, but also life in general. However, many students still experience obstacles in learning this topic. The difficulties faced by students are more evident when solving problems that require them to convert mathematical sentences into mathematical operations (Ling & Mahmud, 2023; Tanjung & Yahfizham, 2023). Meanwhile, researchers highlight similar difficulties such as translating words into algebra or vice versa, misinterpreting the meaning of algebraic expressions, misunderstanding and misplacing signs, and using incorrect algebraic concepts to solve general mathematical problems (As’ari et al., 2020; Moru & Mathunya, 2022). The type of error and the factors causing it are determined by the student's ability to solve problems. While, according to Ying et al. (2020), the main difficulties students experience in solving story problems related to algebra are converting problems into symbolic mathematical problems and formulating equations, schemes, or diagrams. In the study by Pongsakdi et al. (2020), other difficulties were identified, including textual challenges, unfamiliar circumstances, the application of unsuitable tactics, and insufficient problem-solving abilities. Students are unable to achieve satisfactory scores in mathematics examinations due to insufficient algebraic skills required for other mathematical subdisciplines. Students must possess algebraic problem-solving skills to effectively formulate algebraic equations and derive accurate solutions (Beatrix Anela Silitonga & Zul Amry, 2024).

The large number of students making errors in algebra material can be proven by the results of The Trend in International Mathematics and Science Study (TIMSS) as seen from the AKM Achievement of the Ministry of Education and Culture in 2023, which Indonesia has participated in several times, where Indonesia's position is still below the international average

(Dewi, 2025). TIMSS organized by the International Association for the Evaluation of Educational Achievement (IEA) is an international study that measures the ability of knowledge and skills in science and mathematics subjects to improve teaching and learning, one of which measures student abilities in algebra material (Fadillah et al., 2022; Windiyani et al., 2022). The algebra content domain tested in TIMSS has a proportion of 30% of the total number of question content domains given. In TIMSS 2003, Indonesia ranked 35th among 46 participating countries, achieving an average score of 411, compared to the international average score of 467. In TIMSS 2007, Indonesia was ranked 36th out of 49 participating countries with an average score of 397 and TIMSS 2011 was positioned 38th among 42 participating nations, achieving an average score of 386, which is below the average international score those two years was 500. In TIMSS 2015, Indonesia attained the 44th position among 49 countries, achieving a score of 397 out of a possible 500. The following is a graph of TIMSS scores.

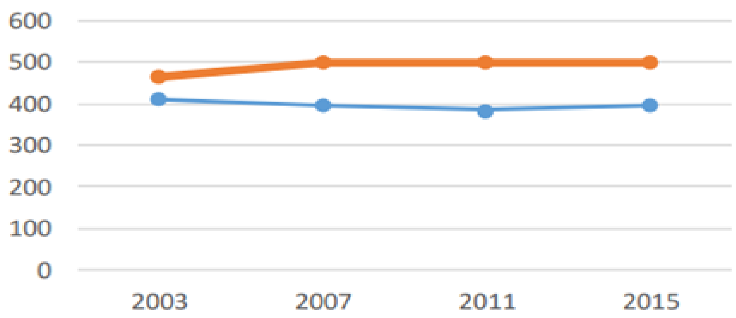

Figure 1. Score TIMSS

In the 2022 PISA assessment, Indonesia ranked 71st out of 81 countries with an average mathematics score of 366, far below the OECD average of 472. This indicates that many Indonesian students still struggle with mathematical reasoning (OECD, 2023)). Therefore, it can be said that Indonesian students' mathematical understanding is inadequate. PISA tests and other contextual challenges still feel new to students due to their lack of higher-order abilities. This finding highlights the importance of addressing issues that meet PISA criteria by approaching them with Indonesian students in learning and assessment.

Previous studies applying Newman's Error Analysis (NEA) have predominantly focused on routine algebraic word problems or contextual mathematical literacy tasks, where students are required to translate verbal information into symbolic representations (Sari & Putri, 2024; Sinaga, 2024). While these studies provide valuable insights into students' procedural difficulties, they offer limited understanding of how students evaluate the *validity* of algebraic transformations themselves. In particular, misconceptions related to equivalence-preserving operations and domain restrictions in rational expressions remain underexplored within the NEA framework (Pauji, 2022; Radiusman, 2020).

This study addresses this gap by employing a non-routine algebraic fallacy task in which students are not asked to solve for a numerical answer, but rather to judge the correctness of solution steps that appear procedurally sound yet lead to logically contradictory conclusions. By focusing on students' evaluation and justification of invalid algebraic transformations, this study extends prior NEA research and contributes a novel perspective on students' conceptual understanding of algebraic equivalence and division-by-zero conditions.

This study analyzed student errors in solving algebra problems using the Newman Method (NEA). According to Syarnubi et al. (2024) the Newman method is a mathematical concept development based on students' mathematical ability levels. This method has specific stages and is accompanied by clear indicators in analyzing student errors, such as reading errors, understanding problems, transformations, process skills, and also errors in writing answers. Through this error analysis, it is hoped that it can provide input and improvements in the mathematics learning process in the future.

METHOD

Research Design

This study uses a qualitative descriptive approach with the aim of in-depth describing the forms and causes of student errors in analyzing algebraic problems. This design was chosen because the focus of the study was not on quantitative measurement of learning outcomes, but rather on a deeper understanding of students' thought processes when faced with problems containing mathematical logic errors.

Participant

The subjects of this study were 37 ninth-grade junior high school students from a high school in East Java, Indonesia (Table 1). Subjects were selected using a purposive sampling technique, selecting students who had demonstrated basic algebra skills.

Table 1. Subject Characteristics

Characteristics		Frequency (n)	Percentage (%)
Gender	Female	22	59.45%
	Male	15	40.55%
Mathematical Ability	high	6	16.21%
	Medium	27	72.98%
	Low	4	10.81%

Instrument

Researchers used two instruments, namely non-routine questions containing invalid solution steps, which gave rise to cognitive conflict and encouraged students to provide logical explanations of the solution steps.

Given an algebraic problem as follows:	Question:
$\Rightarrow \frac{x-3}{x+2} = \frac{x-3}{x+3}$ $\Rightarrow (x-3)(x+2) = (x-3)(x+3)$ $\Rightarrow (x+2) = (x+2)$ $\Rightarrow 2 = 3$	1. Are these steps valid? Explain your opinion! 2. What causes the results to different, 2=3? Explain your opinion!

Figure 2. Non Routine Tasks

The next instrument was a semi-structured interview guide, which was used to delve deeper into students' reasoning, thinking strategies, and conceptual understanding of the properties of algebraic operations. This type of interview falls into the in-depth interview category and is conducted more freely than structured interviews. The interview questions in this study were adapted from the test questions and were also adapted to the research subjects' answers.

The presented solution contains an intentionally invalid transformation, namely the cancellation of the factor $(x-3)$ without considering the domain restriction that $x \neq 3$. This step results in a non-equivalent equation and leads to a contradictory conclusion. The task was designed to elicit students' ability to recognize violations of equivalence-preserving transformations rather than to compute a final numerical solution.

Data collection

Data were collected through instruments (1) diagnostic tests in the form of algebraic statements that appear procedurally correct, but produce illogical conclusions. Through these questions, students were asked to assess the validity of the solution steps and explain the reasons for the erroneous results. (2) semi-structured interviews to explore students' conceptual understanding of algebraic properties. Data collection was conducted over a week, and all participants were asked to complete the diagnostic test instruments

Data Analysis

Data analysis was conducted by adapting Newman's Error Analysis framework, which includes errors in reading, comprehension, transformation, process skills, and answer writing. Three types of data analysis used in this study are data reduction, data analysis, and data conclusions. Data reduction was carried out by comparing the results of student answer sheets and interviews based on student error indicators and factors contributing to student errors based on Newman's theory. In this way, researchers were finally able to determine the types of student errors and factors contributing to student errors in analyzing non-routine algebraic problems involving rational expressions. Students' written responses were analyzed using Newman's Error Analysis indicators adapted to the context of rational expressions. Each response was examined to identify errors related to reading, comprehension, transformation, process skills, and encoding. Transformation errors were identified when students performed algebraic manipulations that violated equivalence conditions, such as canceling factors without verifying domain restrictions. Interview data were used to triangulate students' written work and to explore their underlying reasoning processes. To enhance the trustworthiness of the analysis, students' written responses were independently reviewed by two researchers using the same Newman's Error Analysis indicators. Any differences in coding were discussed until consensus was reached

RESULTS AND DISCUSSION

Results

This study involved 37 high school students who had learned basic algebraic operations. Students were presented with non-routine problems that presented invalid algebraic solutions. The purpose of these problems was not to obtain numerical results, but rather to explore students' ability to recognize logical fallacies and provide mathematical justification for procedures that appear correct but lead to incorrect conclusions. Analysis of students' answers was based on Newman's Error Analysis (NEA) framework, which groups errors into five stages of mathematical thinking. The analysis revealed the following error distribution:

Table 2. Types of errors

Type of Error	N of Students	%	Description
Reading error	0	0	Unable to read the questions and do not understand the meaning of the questions.
Comprehension Error	4	10.81	Unable to determine what is known and what is asked in the question.
Transformation Error	18	48.64	Unable to identify errors when cross multiplying without considering the domain of the numerator and denominator.
Process Skill Error	10	27.03	Errors in operating calculations and determining integer operations in solving problems.
Encoding Error	5	13.52	Wrong in determining conclusions or determining the final answer.

The table shows that the dominant errors occurred at the transformation stage. To delve deeper into these errors, five students were selected for interviews (Table 3).

Table 3. Interview participant

Initial name	Gender
AP	Male
AT	Female
NT	Female
MR	Male
KI	Female

The following are the results of interviews conducted with five students to dig deeper into the errors they made.

Interview with AP

AP: I solve it by directly cross-multiplying each equation in the problem.

AP: If there is a number or factor that is the same on both sides, then I will cross it out, because eventually the two factors will cancel each other out.

Interview with AT

AT: Yes, the steps are correct. I cross-multiplied and then crossed out (x-3) because I thought it was okay to cross out the same values on both sides.

AT: I feel my answer and work are correct, but why doesn't the result make sense?

Interview with NT

NT: The first step, according to me, is to move the right side first. I moved the right side to the left so that it became negative.

NT: As far as I know, any number or letter divided or multiplied by 0 will result in 0.

NT: I think the result is correct and valid, because it yields 0=0. Furthermore, in terms of execution, I don't think there's anything wrong with my solution.

Interview with MR

MR: For me, to make it easier, I just cross-multiply the denominators.

MR: I didn't check whether (x-3) could be crossed out,, because as far as I know, if there's a similarity on both sides, I'll just cross it out.

Interview with KI

KI: I do it differently from my friends. Most of my friends cross multiply, but I directly add +1 to the equation (x+2) to make the equation the same.

KI: I don't know if step +1 is allowed, I just had an idea. Based on the data in Table 1, it shows that many students are still fixated on manipulative procedures without checking the validity of the concepts used, as seen in Figures 2 and 3, and 4.

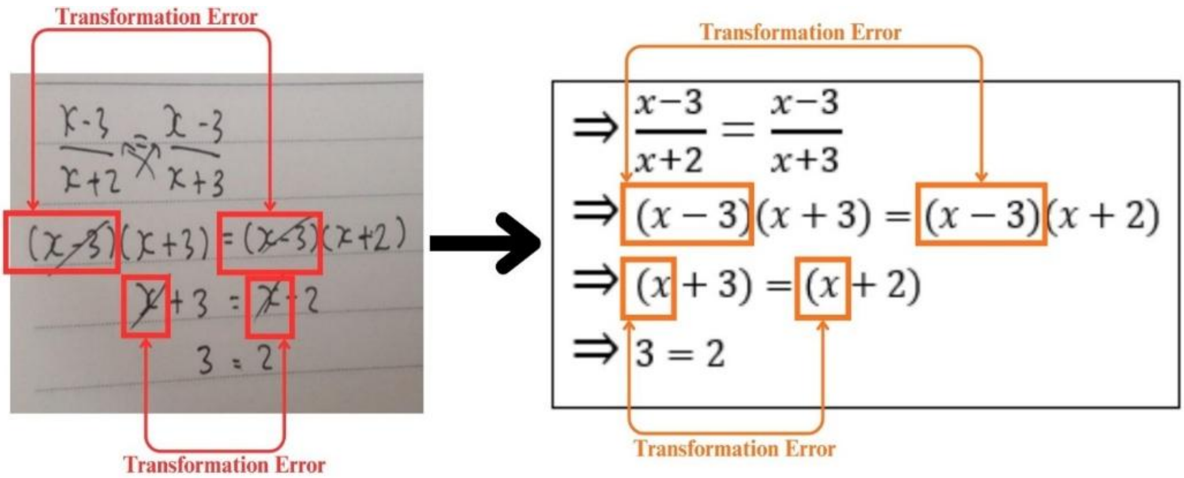

Figure 2. AP's Answer

Based on the results of the AP's work on the non-routine problem given, it was found that the student made several fundamental errors in understanding algebraic manipulation procedures. The AP began by equating the two fractions using cross multiplication. Then, the AP divided $(x-3)$ by both sides, as shown in Figure 2. Then, the AP divided both sides again by x, resulting in $3=2$. From the AP's answer, it can be seen that the AP assumed that any common factor on both sides of the equation could always be canceled, without understanding the requirement that cancellation is only valid if both sides are nonzero and the factor is truly a factor of the entire equation. Therefore, it can be concluded that the AP experienced a transformation error because it failed to identify cross multiplication by considering the domains of the denominator and numerator and used an inappropriate systematic resolution.

Transformation errors are seen when students directly cross-multiply both sides of an equation without first considering the domains of the numerator and denominator. This occurs in subject AP. In the analyzed solution, subject AP cross-multiplies and then eliminates the factor $(x-3)$ by classifying it, assuming that common factors on both sides can always be crossed out. This is reinforced by the argument given during the interview, AP assumes that "if there is a number or factor that is the same on both sides, then I will cross it out because eventually the two factors will be able to cancel each other out." This procedure is carried out mechanistically without considering that the elimination of the factor requires certain variable values, specifically that $(x-3)\neq 0$. As a result of this transformation error, AP obtains an illogical form of the continued equation, namely $x+3=x+2$, which is further simplified by classifying x to obtain the contradictory statement, namely $3=2$. Although this result clearly contradicts mathematical principles, AP shows an attempt to verify or question the reasonableness of the obtained result. This indicates that students tend to accept the final result as long as the solution steps appear procedurally correct, without reflecting on the mathematical meaning of each transformation performed.

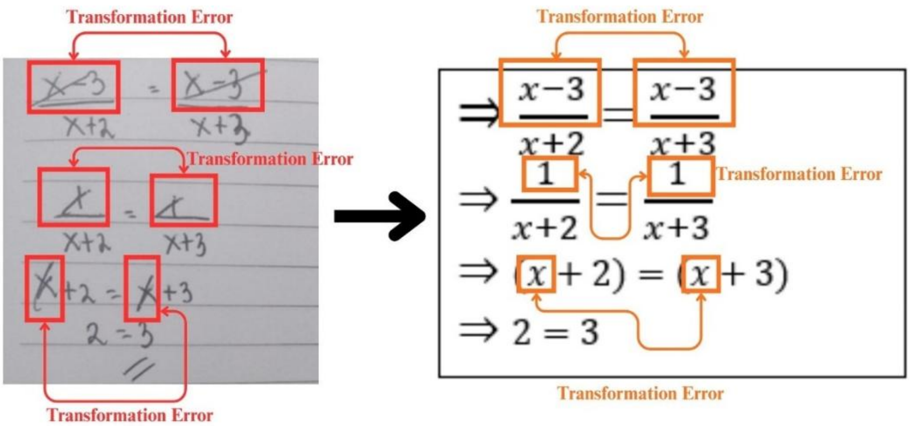

Figure 3. AT's Answer

Based on the results of the AT work, it is known that the initial step of AT to solve the problem is to eliminate the factor $(x-3)$ in both fractions and assume that eliminating $(x-3)$ in both fractions is valid. Then the result is obtained, namely $(\frac{1}{x+2}=\frac{1}{x+3})$ then the student eliminates the number 1 again in the equation so that $x+2=x+3$ is obtained. After that, the student eliminates the variable so that the result is $2=3$. Based on the AT work, it can be seen that AT experiences a transformation error in the Neuman error type, where AT cannot consider the domains in the denominator and numerator.

Similar errors were found in one of the subjects, namely subject AT. AT generally did not show errors at the reading stage. This was evident from the students' ability to rewrite the given equation correctly, including the structure of the numerator and denominator on both sides of the equation. In addition, at the comprehension error stage, students also demonstrated an initial understanding of the question's requirements, namely solving or checking the given algebraic equation. Errors began to appear significantly at the transformation stage, when students directly eliminated the factor $(x-3)$ without considering the domain of the numerator and denominator. Then the equation was obtained, namely $\frac{1}{x+2}=\frac{1}{x+3}$, then AP reclassified the number 1 to obtain the equation $x+2=x+3$ as AP's solution. The inability of the majority of subjects to identify the domain of the numerator and denominator resulted in transformation errors in solving algebraic operations and produced invalid answers. Subjects AP and AT then obtained a further equation in the form of $(x+2=x+3)$ which was simplified to the contradictory statement $2=3$.. Even though the results were mathematically illogical, some subjects believed their method was correct and still accepted the conclusion. This was also conveyed by AP who said that *"yes the steps were correct. I cross multiplied and then crossed out* $(x-3)$ *because I thought that the same thing on both sides could be crossed out."* However, there were also several subjects who made the same type of error who felt strange and when interviewed said *"I feel my answer and work are correct, but why is the result illogical?"*.

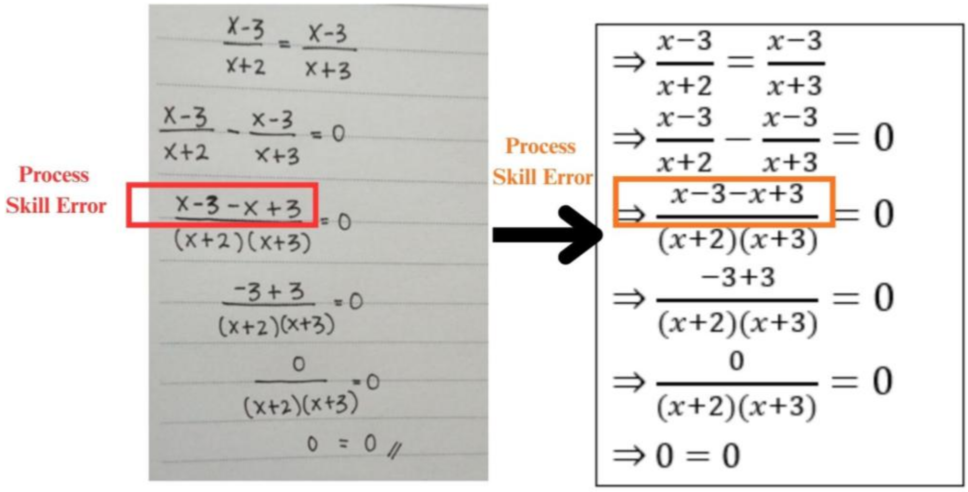

Figure 4. NT's Answer

In the results of NT's work, it was found that NT moved the side that was previously $\frac{x-3}{x+3}$ on the right side to the left side so that there was a change in the operation to negative so that it became $\frac{x-3}{x+2}-\frac{x-3}{x+3}$. After that, NT equated the denominator by multiplying the denominator so that the result in figure 4 was obtained. NT got the result $\frac{0}{(x+2)(x+3)}$ so that when divided it produced 0. This was reinforced by NT's statement during the interview, namely "*Any number or letter when divided or multiplied by 0 will produce 0.*" This strengthens the statement that the result of the algebraic solution is $0=0$. This statement is valid and true, this was said by NT when interviewed *"In my opinion, the result is correct and valid because it has a result of* $0=0$ *and seen from the workmanship aspect, I also feel there is nothing wrong with the solution I made.*" From this view, it can be seen that NT experienced errors in the transformation stage and also process skills in the work. This can be seen based on NT's incorrect work when equating the denominators by multiplying the denominators, but NT does not multiply the numerators and directly subtracts between the numerators. This shows that NT is unable to identify errors when cross multiplying without considering the domain of the numerator and denominator. Furthermore, in providing a statement that $0=0$ is a correct and valid answer, but he forgets that the result is the result of an invalid and correct algebraic operation, it can be said that the result given is also invalid and correct. Because NT only looks at the procedural aspect but does not see the conceptual aspect in understanding algebraic operations correctly.

Discussion

According to Newman's theory, there are five types of errors in problem solving, namely reading error, comprehension error, transformation error, process skill error, and encoding error (Prameshti et al., 2024). The following is a presentation of the results of the subject's error analysis regarding the types of errors based on Newman's theory, namely: The research subject with the initials AP is classified as having a transformation error because the subject cannot identify the error when cross-multiplying the non-routine problem. These results indicate that the most dominant error occurs at the transformation stage in Newman's Error Analysis. In general, the subject did not experience significant obstacles at the reading and understanding stages of the problem (comprehension). This can be seen from the table presented which shows that the subject's ability to identify the goal of the problem as an algebraic solution. However, this understanding has not been followed by the ability to transform the problem into a conceptually valid mathematical form. This transformation error indicates the student's weak understanding of the concept of division by zero and the conditions for the validity of rational equations. Students view the process of cross-multiplying and canceling out factors as a general rule that can be applied mechanistically, without realizing that such actions can eliminate certain solutions or even produce equations that are not equivalent to the original equation.

This finding aligns with Novia & Malasari (2023), who found that the most common student errors occurred in the transformation and comprehension sections, where students failed to fully understand the problem and were unable to transform the information contained in the problem into the correct mathematical form. However, the characteristics and forms of the errors analyzed differed from my research findings. Novia & Malasari (2023) study focused on story-based math problems, leading to more transformation errors when students were unable to model the emerging mathematical problems into mathematical models. Another study by Mubarokah & Amir (2024) found that the most dominant student errors were in comprehension and transformation. In this study, students experienced errors in understanding the context of the problem and transforming the information in the problem into the correct mathematical model. However, the difference with my research is in the type of problem and the character of the errors that appear, in the research of Mubarokah & Amir (2024) the research used contextual mathematical literacy questions, so that transformation errors occur more when students understand the problem situation and choose the right mathematical representation. More deeply, Mubarokah & Amir (2024) explained that students tend to solve problems by relying on routine procedures where students tend not to re-examine (reflect) the results obtained so that this finding supports the results of my research that students only accept illogical conclusions such as $3 = 2$ because they assume that the procedure carried out is correct so the resulting answer is correct and valid.

Research conducted by Maulana & Purwanto (2020) shows that the most common student errors occur at the transformation and process skills stages. These errors occur when students make mistakes when correctly executing mathematical problem-solving procedures and modeling the given mathematical problems. This finding aligns with the results of my research, which found that errors predominantly occurred in the transformation and conceptual understanding stages. This similarity indicates that transformation errors are a crucial factor influencing students' failure to correctly solve mathematical problems and the mathematical procedures used in solving given problems. However, Maulana & Purwanto (2020) study used Polya's problem types and implementation of problem-solving steps. Therefore, the study focused on solving mathematical problems using Polya's steps and problem types that were mathematically literate and contextual. This finding aligns with that of Rohmah & Sutiarso (2018), which found that the most dominant student errors occurred at the transformation and process skills stages. These errors are indicated when students are unable to transform the information contained in the given mathematical problem into a correct mathematical model. However, the problem in Rohmah & Sutiarso (2018) research uses problems that focus on mathematical logic errors, where the results of this study emphasize transformation errors as a failure in selecting and implementing problem-solving strategies, so that there are differences in the depth of analysis and characteristics of the problems studied with my research.

Meanwhile, research conducted by Suratih & Pujiastuti (2020) showed that students experienced various types of errors according to Newman's stages, namely reading, comprehension, transformation, process skills, and encoding errors. However, the main finding of this study was that the errors made by students were predominantly at the final writing stage of the answer (encoding). Many students did not write conclusions correctly and also did not link the correct solution to the given mathematical problem. This study used a contextual linear program problem. In this study, transformation errors had the lowest frequency, indicating that students were relatively able to transform information into mathematical models correctly. This contradicts the research conducted by the researcher. In my study, errors were predominantly at the transformation and conceptual understanding stages. Thus, overall, the research conducted by Suratih & Pujiastuti (2020) contradicts the results of my study.

Based on research conducted Saputra et al. (2025) on grade VII students of Madani Integrated Model State Middle School showed various errors in solving algebraic story problems, although the types of errors tend to be similar. This is caused by the different levels of students' mathematical abilities so that the errors that occur are also diverse. In research Doni & Prabawanto (2025) it was found that the average level or percentage of students making errors in Newman's stages varied such as reading errors, transformation errors, process skill errors, and also coding.. Meanwhile, (Setiawati, 2022) analyzed students' errors in solving algebraic operations based on the SOLO taxonomy. The results of this study indicate that students at different levels have different errors at each level. One of them is that students at the multistructural level cannot complete the answers they have started and relate them to several concepts, and at the relational level, students make mistakes in the calculation process. The research conducted by (Marisa et al., 2020) was carried out at SMP Negeri 1 Turi with algebraic material. The researchers found that students had difficulty solving problems related to algebraic material, such as not being able to understand the problem, find solutions to solve the problem, and solve problems using addition, subtraction, multiplication, or division operations.

CONCLUSION

The results of this study demonstrate that students' errors in evaluating non-routine algebraic problems predominantly occur at the transformation stage of Newman's Error Analysis. These errors are closely related to students' failure to recognize domain restrictions and to distinguish between valid and invalid algebraic transformations. Rather than questioning the logical validity of the solution steps, many students relied on procedural familiarity, which led them to accept contradictory conclusions such as $2 = 3$ as mathematically valid. This study contributes to mathematics education research by highlighting the importance of explicitly teaching equivalence-preserving operations and domain conditions in rational expressions. The use of algebraic fallacy tasks provides a meaningful instructional approach to promote reflective validation and conceptual understanding beyond routine procedural execution. Thus, the limitation of this study is that it is limited by the subjects focusing on junior high school students with a focus on one type of non-routine algebra problem. Therefore, teachers must to assist students in deconstructing and converting contextual difficulties into mathematical terminology, potentially utilizing think-alouds, collaborative dialogues, or visual mapping strategies. Overall, These findings highlight the efficacy of Newman's Error Analysis as a diagnostic paradigm that can provide information not only about what students do wrong but also why they struggle and future research is expected to involve a broader subject and a more varied type of problem to analyze as well as involving logical, contextual, and reflective skills so that students do not only carry out procedures in solving problems and students can understand the problem well and correctly and understand the final answer is valid and correct.

RECOMMENDATION

Based on the results of this study, mathematics teachers are encouraged to emphasize conceptual understanding in algebra learning, particularly regarding the validity of algebraic transformations and the conditions of rational equations. The use of non-routine problems and reflective learning strategies is recommended to help students evaluate the logic of solution steps rather than relying solely on procedural correctness. In addition, Newman's Error Analysis can be utilized as a diagnostic tool to identify students' difficulties and support targeted instructional interventions. Future research is recommended to involve broader samples and more varied types of algebraic problems to further explore students' conceptual and reflective reasoning skills.

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AUTHOR CONTRIBUTIONS STATEMENT

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
A.T. Putra Farabibah	✓	✓		✓	✓	✓	✓	✓	✓			✓	✓	✓
Sri Suryanti		✓	✓		✓	✓	✓	✓		✓	✓	✓		✓

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' institutional review board or equivalent committee.

DATA AVAILABILITY

The data that support the fiindings of this study are available on request from corresponding author.

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