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Analysis of Student Errors in Solving Algebra Problems: A Newman's Error Analysis Perspective

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A B S T RAK

Penelitian ini bertujuan menelaah jenis-jenis kesalahan siswa kelas VIII saat mengerjakan soal aljabar dengan menggunakan kerangka Newman's Error Analysis (NEA) sebagai acuan klasifikasi. Tiga puluh siswa dari satu SMP Negeri di Kota Bandung dipilih secara purposif. Instrumen pengumpulan data berupa empat butir soal uraian yang mencakup Sistem Persamaan Linear Dua Variabel (SPLDV), fungsi linear, persamaan kuadrat kontekstual, dan operasi aljabar, serta panduan wawancara semiterstruktur. Setiap kesalahan dikodekan ke dalam salah satu dari lima kategori NEA: kesalahan membaca, memahami, transformasi, keterampilan proses, dan penulisan jawaban akhir. Dari 328 kesalahan yang teridentifikasi, transformation error menempati posisi tertinggi (38,7%), diikuti process skill error (27,4%), comprehension error (18,6%), encoding error (10,2%), dan reading error (5,1%). Temuan menunjukkan bahwa hambatan terbesar bukan pada tahap membaca soal, melainkan pada saat siswa mengubah informasi kontekstual menjadi model matematis—hambatan yang berkaitan dengan lemahnya pemahaman konseptual dan minimnya pengalaman mengerjakan soal bertipe kontekstual. Penelitian ini merekomendasikan pendekatan pembelajaran yang menekankan kemampuan matematisasi, penguatan konseptual, dan representasi matematis.

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A B S T R A C T

This study examines the types of errors made by eighth-grade students when solving algebra problems using the Newman's Error Analysis (NEA) framework. Thirty students from a public junior high school in Bandung were selected through purposive sampling. Data collection instruments included four essay items covering Systems of Linear Equations in Two Variables (SPLDV), linear functions, contextual quadratic equations, and algebraic operations, complemented by semi-structured interview

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guidelines. Each error was categorized into one of the five NEA stages: reading, comprehension, transformation, process skill, and encoding. Analysis of 328 errors revealed that transformation errors were most prevalent (38.7%), followed by process skill errors (27.4%), comprehension errors (18.6%), encoding errors (10.2%), and reading errors (5.1%). These findings indicate that the primary obstacle is not reading the problem but translating contextual information into a mathematical model—a difficulty rooted in weak conceptual understanding and limited exposure to context-based tasks. The study recommends instructional approaches that prioritize mathematization competence, conceptual reinforcement, and multiple mathematical representations.

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1. INTRODUCTION

Mathematics serves as the foundation of logical thinking, and its role extends far beyond the academic domain. Various national and international assessments have consistently shown that Indonesian students' mathematical competence still faces considerable challenges. PISA 2022 data placed Indonesia at 68th out of 81 participating countries, with an average mathematics score of 366 well below the OECD average of 472 (OECD, 2023). This gap of more than a hundred points is not merely a statistical difference; it reflects the genuine weakness in the mastery of fundamental mathematical competencies, including algebra, which is the central focus of this study. In the junior high school mathematics curriculum, algebra occupies a highly strategic position. The ability to manipulate symbols, construct equations, and interpret relationships among variables is a prerequisite for virtually all advanced mathematics content. When students fail to build a solid algebraic understanding at this level, the impact tends to persist and grow more complex in subsequent years (Jupri et al., 2014). This reality is further confirmed by the 2023 Education Report Card published by the Ministry of Education, Culture, Research, and Technology, which reveals that algebra is among the domains with the lowest national achievement, particularly in the areas of conceptual understanding and contextual problem-solving (Kemendikbudristek, 2023).

Numerous studies in Indonesia have documented student difficulties in algebra, and what is concerning is that the pattern of difficulties has remained relatively consistent over time. Students encounter obstacles in understanding the meaning of variables, converting word problems into mathematical models, and applying procedural steps without adequate conceptual understanding. Suraji et al. (2018) found that both conceptual understanding and problem-solving skills in SPLDV material were still low, especially in real-life applications. The consistency of this pattern suggests that the problem is structural in nature and closely related to how the material is taught, rather than being merely an individual issue (Rohmah & Sutiarso, 2018). Effective improvement of learning requires a deep understanding of where and how students make errors. Error analysis rests on the principle that every mistake a student makes is a source of diagnostic information that can reveal how they process and construct mathematical understanding. Not all error analysis approaches are capable of producing sufficiently detailed and actionable information to serve as a basis for targeted instructional interventions (Singh et al., 2010).

The Newman's Error Analysis (NEA) framework offers a more comprehensive diagnostic approach than conventional assessment. First developed by Anne Newman in 1977 and extended by White (2010), the framework views the process of solving a mathematics problem as a series of hierarchical stages: reading, comprehension, transformation, process skill, and encoding. This hierarchical nature makes NEA highly valuable diagnostically: failure at one stage prevents success at the next, so NEA-based analysis enables precise identification of where a student's thinking breaks down (White, 2010; Singh et al., 2010).

Several studies in Indonesia have applied NEA to investigate student errors in algebra, particularly in SPLDV. Mauliddiana and Gozali (2023) reported a dominance of transformation errors in eighth-grade SPLDV problems. Firdaus and Ihsanudin (2024) found that transformation and process skill stages showed the highest error percentages among eighth-graders. Fitria and Rismawati (2024) confirmed similar patterns in verbal SPLDV problems. However, studies that systematically compare NEA error distributions across multiple algebra topics within a single integrated investigation remain limited, particularly those combining written document analysis with in-depth diagnostic interviews (Ahzan et al., 2022; Annisa et al., 2023). A methodological gap also needs to be addressed. Relying solely on written answer sheets has a fundamental limitation: it can identify that a student made an error, but cannot always reveal why the error occurred. In-depth diagnostic interviews based on the NEA protocol are far more effective at uncovering the cognitive processes behind errors, yielding information that is much more useful for designing targeted instructional interventions.

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Grounded in these two gaps, this study was designed to answer three core questions: first, what types of errors are most prevalent in eighth-grade students' algebraic problem-solving from an NEA perspective? Second, does the distribution of errors vary depending on the topic of the problem? Third, what factors underlie the occurrence of errors based on interview data? Answering these three questions is expected to provide a comprehensive diagnostic picture that teachers can use to design more effective algebra instruction.

2. METHOD

This study employed a descriptive qualitative approach with a case study design. This design was chosen because the research goal was not merely to measure the frequency of errors, but to trace the cognitive processes behind each error. A case study design allows for deep and contextual exploration of the phenomenon under investigation without reducing its complexity to numbers alone (Creswell & Poth, 2018). The study was conducted at a public junior high school in Bandung, West Java, during the second semester of the 2024/2025 academic year.

Participants

Thirty eighth-grade students participated through purposive sampling. Grade 8 was selected for substantive reasons: at this level, all algebra topics that are the focus of this study SPLDV, linear functions, quadratic equations, and algebraic operations have been fully covered, making the data diagnostically relevant. Of the 30 participants, eight were selected for in-depth interviews based on the principle of maximum variation, ensuring that all NEA categories were adequately represented in the interview data.

Research Instruments

The primary instrument consisted of four essay-type algebra problems, each covering a different topic and presenting varying cognitive demands. Problem 1 (SPLDV) required simultaneous mathematization of two variables; Problem 2 (Linear Function) combined computation with graphical interpretation; Problem 3 (Contextual Quadratic Equation) required evaluation of the meaningfulness of solutions; and Problem 4 (Algebraic Operations) tested the ability to construct and solve equations from verbal narrative. All four problems were validated by three experts one mathematics education lecturer and two experienced junior high school mathematics teachers using the Content Validity Ratio (CVR) method, yielding values of 0.85–1.00. Reliability testing using Cronbach's Alpha produced $\alpha = 0.82$. The second instrument was a semi-structured interview guide based on the NEA protocol, containing open-ended questions to elicit students' thinking processes. The problem items are presented in Table 1.

Table 1. Diagnostic Problems Used in the Study

No.	Topic	Problem Item
1	SPLDV (Systems of Linear Equations in Two Variables)	A seller offers two types of stationery packages. Package A contains 2 notebooks and 1 pencil, priced at IDR 14,000. Package B contains 1 notebook and 3 pencils, priced at IDR 16,000. Determine the price of one notebook and one pencil!
2	Linear Function	Given $f(x) = 3x - 5$. If $f(a) = 10$, find the value of a. Then calculate $f(2a - 1)$ and describe its position relative to the x-axis based on the graph of the function!
3	Contextual Quadratic Equation	A rectangular garden has a length 3 m more than twice its width. If the area of the garden is 90 m², determine the length and width! Is there more than one possible solution? Explain!

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4	Algebraic Operations	Three times a number minus eight equals twice the sum of that number and seven. Find the number! If that number is the side of an equilateral triangle, calculate its perimeter!

Data Collection and Analysis Procedures

Data collection was carried out in three sequential stages. First, diagnostic testing: all 30 students completed the four problems in a single 90-minute session; the researcher informed them that the results would not affect their school grades, so students would write their genuine understanding. Second, independent coding of answer sheets by two coders using an NEA rubric; Cohen's Kappa coefficient yielded κ = 0.84, classified as 'almost perfect' agreement. Third, in-depth interviews with eight selected students, lasting 20–35 minutes per session, recorded with the consent of students and parents, then transcribed verbatim.

Data analysis followed the interactive model developed by Miles et al. (2020), which encompasses three concurrent workflows: data condensation, data display, and drawing conclusions. This process is iterative each new finding prompts a re-examination of previously collected data. Triangulation between written test data and interview data was applied consistently to strengthen the validity of findings; every interpretation constructed was confirmed through at least two different data sources.

3. RESULT AND DISCUSSION

From all analyzed answer sheets, 328 errors were identified and classified into the five NEA categories. This figure means that, on average, each student made approximately 10–11 errors across the four problems a finding that suggests the problem is not incidental but reflects a systematic and widespread pattern. The complete distribution is presented in Table 2.

Table 2. Distribution of Errors by NEA Category

No.	Error Category	Frequency	Percentage	Rank
1	Reading Error	17	5,1%	5 (lowest)
2	Comprehension Error	61	18,6%	3
3	Transformation Error	127	38,7%	1 (highest)
4	Process Skill Error	90	27,4%	2
5	Encoding Error	33	10,2%	4
	Total	**328**	**100%**	

The data in Table 2 reveals a fairly clear hierarchy among the five categories. Transformation errors dominated with 127 cases (38.7%) nearly one and a half times the process skill errors in second place with 90 cases (27.4%). Reading errors at the bottom with only 17 cases (5.1%) indicate that the ability to read the problem text is generally not the main obstacle for students. This dominance of transformation errors is consistent with previous NEA findings in Indonesia (Rohmah & Sutiarso, 2018; Mauliddiana & Gozali, 2023; Firdaus & Ihsanudin, 2024), reinforcing the hypothesis that the greatest barrier in algebra learning lies in the mathematization process, not in computational ability.

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Error Distribution Per Problem Item

A more detailed analysis of the error distribution per problem item yields a far more informative picture. Differences in distribution across the four problems were quite significant and reflect the influence of problem characteristics on the types of errors that emerge. Table 3 presents the comparison of the percentage of each NEA category for each problem item.

Table 3. Distribution of NEA Errors per Problem Item (%)

Category	Problem 1 (SPLDV)	Problem 2 (Linear Fn.)	Problem 3 (Quadratic)	Problem 4 (Operations)	Average
Reading Error	3,8%	6,2%	5,3%	5,1%	5,1%
Comprehension Error	19,2%	14,9%	26,3%	14,1%	18,6%
Transformation Error	44,2%	33,0%	36,8%	41,0%	38,7%
Process Skill Error	21,2%	35,1%	21,1%	38,5%	27,4%
Encoding Error	11,5%	10,6%	10,5%	1,3%	10,2%

Table 3 reveals three patterns that deserve closer attention. First, transformation errors were highest in Problem 1 (44.2%) and Problem 4 (41.0%) the two problems most heavily laden with verbal narrative requiring conversion of information into mathematical form. This suggests that high mathematization load directly correlates with increased transformation errors. Second, process skill errors dominated Problems 2 (35.1%) and 4 (38.5%), which had the longest and most sequential solution procedures. Third, comprehension errors in Problem 3 were strikingly high (26.3%), well above the overall average (18.6%), even though this problem was not more procedurally demanding. This phenomenon is discussed in depth below.

Transformation Errors and Barriers to Mathematisation

Transformation The transformation errors that dominated with 38.7% of all errors are not merely a statistic they reflect the most fundamental cognitive barrier in algebra learning: the inability to convert a contextual situation into an appropriate mathematical representation. This process, referred to by scholars as horizontal mathematization, is the essential bridge between the real world and the abstract language of mathematics (Jupri et al., 2014). Failure in this process is not merely a procedural failure but a failure at a deeper conceptual level.

In Problem 1 on SPLDV, transformation errors took several specifically identifiable forms. The most common was the failure to define two separate independent variables. Of the 30 students, seven (23.3%) constructed only one equation with one variable, attempting to express the second quantity in terms of the same variable. This strategy failed because it did not capture the simultaneous nature of a two-equation system. A second form involved correctly defining two variables but incorrectly constructing the equations for example, swapping the coefficients between Package A and Package B, or omitting relevant components. Five students (16.7%) made this type of error. A third form involved selecting an inappropriate solution method: some students wrote the correct system of equations but then attempted to solve it using an unsuitable or incorrect procedure.

Interview findings enriched this understanding. Student S-07 stated: 'I don't know how if there are two unknowns. Usually there's only one.' This statement directly reveals the cognitive schema limitation of S-07: they had not yet built the conception that two simultaneously unknown quantities can be represented by two different variables and resolved through two interrelated equations. This aligns with Suraji et al.'s (2018) finding that in SPLDV material, students generally have weak conceptual understanding at the very stage of representing the

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problem as a mathematical model, even when they are already familiar with the solution procedures.

In Problem 2 on linear functions, transformation errors took a different but equally fundamental form. Four students read the notation f(a) = 10 as a declarative statement as if the number 10 were the 'content' of variable a without recognizing that this expression is an equation requiring a solution. Three other students wrote 'f (10) = a', reversing the positions of the independent variable and the function value. This confusion about function notation is a manifestation of a deeper conceptual misunderstanding: an insufficiently formed conception of function as a relationship between input and output. When this understanding is not yet solid, mathematical notation that should aid comprehension instead becomes a source of confusion (Annisa et al., 2023).

The pedagogical implication of the dominance of transformation errors is clear: algebra instruction needs to allocate far more space for structured mathematization activities. Teachers should explicitly train students to identify relevant quantities in a narrative, define variables, and construct mathematical models not merely demonstrate sample problems and ask students to imitate them. Problem-Based Learning and Realistic Mathematics Education approaches are highly relevant because both place the process of building mathematical representations from real-world contexts at the core of the learning activity (Ratnasari et al., 2018).

Process Skill Errors and Procedural Weaknesses

Process skill errors at 27.4% describe a situation somewhat different from transformation errors: students who experienced them had generally succeeded in understanding the problem and choosing the correct solution approach, but made mistakes when executing the mathematical procedures. This type of error appeared most frequently in problems with long, sequential procedures, such as Problem 2 (linear function, 35.1%) and Problem 4 (algebraic operations, 38.5%).

In Problem 2, the most consistent pattern was errors in the transposition step. Most students correctly wrote the equation 3a − 5 = 10 meaning the transformation stage was not problematic. However, in the next step, they wrote 3a = 10 − 5 = 5, rather than 3a = 10 + 5 = 15. This sign-direction error fundamentally reflects a misunderstanding of the principle underlying the transposition operation. The common classroom shorthand 'move to the other side and change the sign' teaches a procedural step without explaining why it works. Students who only memorise this jargon lack the conceptual understanding to handle problem variations (Rohmah & Sutiarso, 2018).

Student S-03 acknowledged in the interview: 'I usually just move it across, I never think about the reason.' This admission clearly shows that the procedure used does not rest on an understanding of the underlying principle, but entirely on memorized step sequences. When the memorized steps do not match the problem at hand, there is no internal mechanism that allows the student to detect and correct the error.

In Problem 4, the most common process skill errors related to the application of the distributive property. The phrase 'twice the sum of that number and seven' should be written as 2(x + 7), which when distributed yields 2x + 14. However, 11 of the 30 students wrote it as 2x + 7 multiplying 2 by the variable x only, while the constant 7 was not multiplied. As a result, the equation was wrong from the outset: instead of 3x − 8 = 2x + 14, they wrote 3x − 8 = 2x + 7, yielding an incorrect value of x. Even though all subsequent steps were performed correctly, the result was wrong because the foundation was already incorrect.

This type of distributive error reflects a misperception of the structure of algebraic expressions. Students who write 2x + 7 instead of 2(x + 7) do not understand that 'x + 7' in the context of 'twice the sum of x and 7' is a single unit one operand whose entirety must be multiplied by 2 (Fitria & Rismawati, 2024). This error often occurs because students are accustomed to purely procedural problems that present expressions directly in symbolic form,

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leaving them untrained in translating verbal phrases into the correct algebraic structure. This case reaffirms the importance of mathematization practice as a regular part of instruction, not only procedural drill.

Comprehension Errors in the Contextual Quadratic Problem

The comprehension errors reaching 26.3% in Problem 3 represent the most qualitatively interesting finding in this study. What makes it interesting is a paradox that emerged: most students who made comprehension errors on this problem had actually obtained correct numerical values through factorization. They correctly factored the resulting quadratic equation, finding both roots for example, width = 6 m (from the positive root) and width = −15/2 m (from the negative root). Yet when asked to answer the question 'Is there more than one possible solution?', their responses proved inaccurate.

The response patterns found fell into three groups. The first and most common group wrote 'there are two answers: 6 and −7.5' without providing any explanation of the relevance of both values in the problem context. This group failed to recognize that in the context of physical dimensions such as garden length and width, a negative value is meaningless and must be dismissed. The second group answered 'only one answer' without explanation possibly because they intuitively sensed something was wrong with the negative number, but could not articulate it mathematically. The third group left the question entirely unanswered. All three patterns point to the same underlying issue: students were unable to reconnect their mathematical calculation results back to the real-world context that served as the starting point of the problem.

This phenomenon in mathematics education literature is known as procedural fluency without conceptual understanding. These students demonstrated considerable fluency in the factorization procedure but lacked sufficient conceptual understanding to evaluate the meaning of solutions in a broader context. In the interview, student S-14 honestly revealed: 'I got two numbers from factorization, but I don't know which one to use because both came from the correct formula.' S-14's statement precisely describes their condition: they know how to work with the formula, but do not understand what the formula produces in the context of a real-world problem (Suraji et al., 2018).

The high comprehension error rate in Problem 3 can also be linked to students' limited experience with problems that require reflection on solutions. In procedurally-oriented mathematics instruction, the question 'Is the solution meaningful in context?' is rarely posed. As a result, students do not develop the habit of checking whether the mathematical answer they obtained corresponds to the conditions stated in the problem. This habit needs to be built explicitly through reflective questions that are a regular part of classroom routines, not only taught occasionally when facing certain types of problems.

Reading Errors, Encoding Errors, and Mathematical Literacy

Although reading errors (5.1%) were the least frequent, this finding should not be interpreted as meaning that reading ability requires no attention. The reading errors found were highly specific not a general inability to read text, but a failure to read key words meaningfully when those words carry specific mathematical functions within a sentence. This is the dimension referred to as mathematical literacy in the context of the ability to accurately and fully read mathematically-laden text (Singh et al., 2010; White, 2010).

In Problem 1, three students interpreted the word 'package' as the price of a single item rather than a collection of several items. This misinterpretation caused them to directly associate IDR 14,000 with the price of one notebook (rather than the price of one package containing two notebooks and one pencil), causing their entire mathematical model to be wrong from the start. In Problem 3, several students overlooked the phrase 'more than' in 'length that

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is 3 m more than twice its width', writing the equation p = 2l instead of p = 2l + 3. A difference of just two words fundamentally changed the mathematical model.

These findings show that mathematical literacy specifically the ability to precisely read mathematically-laden text is a competence that needs explicit attention in instruction, not assumed to have been automatically mastered. Teachers need to habituate students to read problems carefully using specific techniques, such as underlining key words and identifying sentence structure before beginning mathematical work. This critical problem-reading practice needs to be carried out systematically, not left to individual student initiative (White, 2010).

Encoding errors (10.2%), while ranking fourth in frequency, carry an equally important message. Of the 33 cases found, 21 (63.6%) involved incomplete final answers students wrote a numerical value without explaining its context. A student who found x = 4,000 from Problem 1 wrote '4000' without indicating that this is the price of one pencil in rupiah; a student who obtained the garden width from Problem 3 wrote the number without the unit 'metre'. The remaining eight cases involved errors in conversion or units.

Although seemingly trivial, encoding errors reflect an orientation of mathematical thinking that deserves attention. When students consider a problem solved as soon as a numerical value is obtained without needing to interpret or communicate its meaning in the original context this indicates they perceive mathematics as an activity of symbol manipulation disconnected from meaning. Yet the ability to interpret mathematical results and communicate them accurately in a relevant context is an integral part of complete mathematical competence (Singh et al., 2010).

Causal Factors Behind Errors Based on Interview Data

Analysis of the eight interview sessions yielded four recurring themes that consistently emerged as underlying factors behind the error distributions described above. These four factors do not stand independently but are interconnected and mutually reinforcing.

First, an insufficiently solid prerequisite conceptual foundation. When the researcher posed questions about conceptually fundamental matters such as what a 'variable' means, or why the sign changes when a term is moved to the other side most students gave unconvincing responses. Some students defined a variable as 'a letter whose value is unknown' but then treated it like a name for an object rather than as a representation of a quantity. Integer operations, particularly those involving negative numbers, still frequently produced confusion. Weak prerequisite conceptual foundations like these directly impede the mastery of subsequent content that depends on them. Suraji et al. (2018) found a similar pattern: low conceptual understanding of SPLDV material was strongly correlated with poor problem-solving ability on the same material.

Second, the dominance of procedural learning without conceptual understanding. Nearly all interviewed students were unable to explain the reason behind the steps they performed. When asked 'Why does the sign change when you move a term to the other side?', the most common answer was a variation of 'That's just how it is' or 'My teacher said so'. Not one student responded with an explanation of the equality principle. This is not solely the students' fault; it reflects the type of instruction they received. Teaching that prioritizes speed and procedural completion without ensuring conceptual understanding produces extremely fragile knowledge: effective as long as the problem is exactly the same as what was practiced, but failing immediately at even the slightest variation (Rohmah & Sutiarso, 2018).

Third, minimal exposure to contextual problems in regular instruction. Six of the eight interviewed students acknowledged that word problems rarely appeared in everyday learning they tended to appear only before tests or exams. Two others added that when word problems were given, the teacher typically demonstrated the solution immediately without

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giving students time to attempt it independently first. This limited exposure has a direct consequence: students do not develop adequate schemas for solving contextual problems strategic frameworks that are automatically activated when reading a narrative-type problem. Without such schemas, every word problem feels like a new and unfamiliar encounter (Mauliddiana & Gozali, 2023; Firdaus & Ihsanudin, 2024).

Fourth, mathematical anxiety and its influence. Three of the eight students spontaneously used the words 'panic' or 'nervous' to describe their experience when facing problems with lengthy texts. Mathematical anxiety is not merely psychological discomfort it has real and measurable cognitive consequences. When a person is anxious, part of their working memory capacity is used to manage that anxiety itself, rather than to process information from the problem. This reduction in capacity most strongly affects processes requiring high attention, such as carefully reading a problem text and holistically processing information two processes that directly correspond to the reading and comprehension stages in the NEA framework. This provides a plausible explanation for why reading and comprehension errors tended to be higher among students who also expressed greater levels of anxiety in interviews (Ahzan et al., 2022).

Pedagogical Implications: From Findings to Action

The four causal factors identified, when combined with the error distribution patterns found, together point to one consistent conclusion: a fundamental shift in the orientation of algebra learning is needed from merely transmitting procedures towards building meaningful, durable, and flexibly applicable understanding across diverse contexts.

To address the dominance of transformation errors, teachers need to explicitly and structurally integrate mathematization activities into every learning session. These activities include habituating students to identify known and unknown quantities in mathematical form, comparing different ways of representing the same situation, and critically discussing why one representation is more appropriate than another. Contextual problems are not merely alternative assessment instruments they are the primary medium for practicing mathematization ability, which is at the core of algebraic thinking (Ratnasari et al., 2018; Jupri et al., 2014).

To address process skill errors stemming from memorized procedures without understanding, a consistent instructional approach is needed that places 'why' before 'how'. When teaching equation transposition, teachers should first build intuition about the equality principle for example, through a two-sided balance analogy before introducing procedural steps. After the procedure is learned, teachers need to actively encourage students to verify whether the equation remains equivalent after each step is performed, so that the procedure is not merely memorized but genuinely understood in terms of its operating principle (Rohmah & Sutiarso, 2018).

To reduce comprehension errors in contextual problems, teachers need to build a culture of mathematical reflection in the classroom. Questions such as 'What does the number you found mean?', 'Are all mathematically possible solutions also contextually plausible?', and 'How do you check whether your answer makes sense?' need to be asked routinely not just occasionally or only when facing certain problems. These reflective questions, if made part of classroom norms, will gradually build evaluative thinking habits that go beyond merely executing procedures (Suraji et al., 2018).

Finally, NEA itself can be adapted as a practical formative assessment tool in the classroom. Rather than recording 'correct/incorrect' or merely assigning a numerical score, teachers can use a simple rubric based on the five NEA categories to classify student errors on each test. This information can then be used to design more specific and targeted feedback: students who predominantly make transformation errors need mathematisation practice; students with many process skill errors need procedural reinforcement through understanding

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of principles; and so on. In this way, NEA is not merely a research tool, but also a practical instrument that can simultaneously improve the quality of assessment and learning (Singh et al., 2010; White, 2010).

4. CONCLUSION

This study successfully produced a comprehensive diagnostic map of eighth-grade students' error patterns in solving algebra problems using the Newman's Error Analysis framework. From the 328 errors identified through answer sheet analysis and in-depth interviews, transformation errors proved to be the most dominant (38.7%), followed by process skill errors (27.4%), comprehension errors (18.6%), encoding errors (10.2%), and reading errors (5.1%).

Comparison of error distributions across topics reveals that each algebra topic has a distinct error profile. Problems with high narrative content requiring conversion of information into mathematical form (SPLDV and Algebraic Operations) generated more transformation errors. Problems with long, sequential procedures (Linear Function and Algebraic Operations) produced more process skill errors. Problems requiring evaluation of the meaning of solutions in real-world context (Contextual Quadratic Equation) generated comprehension errors well above the average, even among students who procedurally solved the problem correctly. These findings confirm that NEA-based analysis must be conducted topic-specifically to yield truly actionable diagnostic information.

Behind the entire error distribution, four structural factors were identified as root causes: an insufficiently solid prerequisite conceptual foundation; the dominance of procedural learning without conceptual understanding; minimal exposure to contextual problems in regular instruction; and unaddressed mathematical anxiety. All four are interconnected in a cycle that is difficult to break without deliberately designed intervention. The implication for instructional practice is the need for a shift in orientation from procedure transmission towards the building of meaningful understanding connected to real-world contexts.

Further research is recommended in two directions. First, the development and testing of the effectiveness of NEA-based algebra learning modules that explicitly integrate mathematization activities, reflective questioning, and explanations of the principles behind every procedure. Second, similar research involving schools from more diverse contexts in terms of geographic location, accreditation status, and students' socio-economic backgrounds to explore how broadly these findings generalize and what contextual factors influence patterns of student errors in algebra.

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