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Analysis of Students' Errors in Solving Recurrence Relation Word Problems Based on Newman's Procedure

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Abstract

Although Newman's Error Analysis (NEA) has been widely applied to mathematical word problems, contextual recurrence relation problems in undergraduate Discrete Mathematics remain underexamined. This study analysed the types, frequencies, and characteristics of students' errors in solving a recurrence relation word problem using Newman's procedure. A qualitative descriptive approach with a document analysis design was employed, examining examination scripts from all 32 students enrolled in a Discrete Mathematics course through total sampling. Written responses to a single contextual savings problem were analysed using NEA-based coding, frequency tabulation, and qualitative description. Only one student (3.1%) produced a complete and correct response, while 59.4% failed before constructing a valid model. The largest decline in successful progression occurred at the comprehension stage. The most frequent error indicators were failure to interpret the result in context (43.8%) and failure to construct a recurrence model (28.1%). The findings suggest that the principal difficulties in this task concerned translating verbal information into mathematical models and interpreting mathematical results within the original context. The study contributes a task-specific account of modelling errors to NEA research in higher education. Instructional implications include explicitly linking temporal expressions to mathematical indices, incorporating contextual validation into assessment rubrics, and designing realistic contextual problems. Further research should triangulate written-response analysis with interviews to clarify the reasoning underlying the observed errors.

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Keywords: Newman's Error Analysis; Recurrence Relations; Discrete Mathematics; Mathematical Modelling; Word Problems.

INTRODUCTION

Discrete mathematics is a foundational course for prospective mathematics teachers and computing students because it develops reasoning about counting, logic, and iterative processes. Within this course, recurrence relations occupy a strategic position. A recurrence relation describes a quantity whose current value depends on its previous values, and it underpins later work on algorithms, sequences, and dynamic models. Nevertheless, students perceive discrete mathematics as difficult and weakly connected to the mathematics they already know (Magda & Gardner-McCune, 2025). Studies on counting and combinatorics also show that undergraduates and pre-service teachers often rely on keyword rules and familiar templates rather than on the structure of the problem (Marhami et al., 2026; Soto et al., 2022). When recurrence relations are presented in everyday contexts, such as weekly savings, students must coordinate verbal information, symbolic indices, initial conditions, and an algebraic solution method within a single task.

We argue that errors in contextual recurrence problems should be viewed as evidence of how students translate a situation into a mathematical representation, rather than as mere computational slips. Modeling research describes problem solving as a cycle. The cycle begins with understanding a real situation, continues with mathematization and mathematical work, and ends with interpretation and validation (Schukajlow et al., 2023). Systematic reviews show that the competencies required at each step can be distinguished and need to be fostered deliberately (Cevikbas et al., 2022). Validation in particular does not develop spontaneously, even when students work with concrete data (Geisler, 2023; Jablonski et al., 2023). The authenticity of the context also affects whether students draw on real-world knowledge (Schluter & Besser, 2024).

Understanding where students' reasoning breaks down in recurrence tasks is therefore conceptually urgent, because a correct closed-form solution can conceal a misunderstanding of what is actually being modeled. It is also empirically urgent, because lecturers need specific evidence to redesign instruction and assessment.

Newman's Error Analysis (NEA) is a widely used framework for locating such breakdowns. NEA classifies errors into reading, comprehension, transformation, process skills, and encoding errors. NEA studies at the school level consistently report that comprehension and transformation errors are critical, because errors at early stages propagate to later stages (Haerani et al., 2021; Zulyanty & Mardia, 2022). Studies at the secondary level have found that transformation errors, namely translating contextual information into a mathematical model, are the most frequent error type (Indriana et al., 2024; Sari et al., 2023; Sarwan et al., 2026; Sukmarini & Hermanto, 2021). A systematic literature review of NEA studies on word problems found errors at every stage, with encoding errors being the most common (Purba et al., 2026). Mathematical modeling studies likewise show that the greatest difficulty arises when real-world situations must be translated into mathematical form (Parandrengi & Hiltrimartin, 2023; Permata et al., 2025).

In higher education, NEA has been applied to logic (Husenti & Pratama, 2022), calculus (Ekasari & Putra, 2024; Suddin & Handayani, 2026), applied mathematics (Irianti et al., 2024), and statistics (Nuryati et al., 2022; Pinahayu et al., 2023). These studies generally report that process-skill errors dominate among undergraduates. This pattern differs from school-level findings, suggesting that the dominant error type depends on the nature of the task.

Research that specifically examines recurrence relations remains scarce. Existing studies have examined recursive thinking among secondary students (Nicchiotti et al., 2024), the formulation of recurrence relations from figural patterns by engineering students (Trigueros-Rodriguez & Montejo-Gamez, 2025), pattern generalization among pre-service teachers (Sjaastad & Lorange, 2026), and novices' mental models of recursion in programming (Kiesler, 2022). None of these studies has used NEA to examine how undergraduates move from a verbal recurrence situation to a solved and interpreted model. This gap forms the basis of the present study.

The novelty of this study lies in three aspects. First, it applies NEA to a linear homogeneous recurrence relation with constant coefficients presented as a contextual word problem, a task type rarely examined in NEA research. Second, it combines stage-based error frequencies with an analysis through the modeling cycle, so that errors can be interpreted both as procedural failures and as breakdowns in the translation between situation and model (Schukajlow et al., 2023). Third, it attends to anomalies that are often overlooked, including

similar answer patterns across students and the plausibility of the problem context itself (Hidayatullah & Csíkos, 2023; Kirkland & McNeil, 2021). The theoretical foundation combines NEA with the distinction between conceptual and procedural knowledge, which holds that the two forms of knowledge must be developed jointly rather than sequentially (Hurrell, 2021).

Accordingly, this study focuses on students' written responses to a contextual recurrence relation problem in a Discrete Mathematics examination. It aims to describe the distribution of students' achievement, determine the types and frequencies of errors at each stage of Newman's procedure, and characterize the error patterns and anomalies that explain why students failed to obtain and interpret the correct solution.

METHODS

This study employed a qualitative descriptive approach. Its purpose was to describe students' errors as they appeared in authentic written work, without manipulating any variable. The design was a document analysis of examination answer sheets, organized according to the five stages of Newman's procedure. This design suits the research objective, because NEA identifies the stage at which a student's solution first deviates from a correct path on the basis of written evidence of that deviation (Purba et al., 2026; Zulyanty & Mardia, 2022).

The participants were 32 students enrolled in a Discrete Mathematics course at a public university in Indonesia. Total sampling was applied: all answer sheets submitted for the recurrence relation item were included. Consequently, no selection bias was introduced at the sampling stage. Each answer sheet was coded from S01 to S32 according to its order.

The main instrument was an essay item in the course examination. The item read: *"Pak Udin saves money in a conventional bank. His savings this week equal four times his savings two weeks ago minus three times his savings last week. He made no initial deposit when he started saving, and in the first week he deposited one million rupiah. How much are his savings in week 15, disregarding the bank's interest?"* Let a_n denote the savings in week n (in millions of rupiah). The intended model is the recurrence relation in Equation (1).

$$a_n = 4a_{n-2} - 3a_{n-1}, \quad a_0 = 0,\ a_1 = 1 \qquad (1)$$

The characteristic equation and its roots are given in Equation (2). Applying the initial conditions yields the closed form and the requested value in Equation (3).

$$r^2 + 3r - 4 = 0 \;\Rightarrow\; (r+4)(r-1) = 0 \;\Rightarrow\; r_1 = 1,\; r_2 = -4 \qquad (2)$$

$$a_n = \frac{1-(-4)^n}{5}, \qquad a_{15} = \frac{1+4^{15}}{5} = 214{,}748{,}365 \qquad (3)$$

The answer sheets revealed that a parallel version of the item (Package B) had also been administered, in which the coefficient 4 was replaced by 10. Its solution is given in Equation (4). Each answer was assessed against the key of its own package. Thirteen students answered Package A and 16 answered Package B. The package of the remaining three students could not be identified because their responses contained no recognizable coefficient.

$$a_n = 10a_{n-2} - 3a_{n-1} \;\Rightarrow\; a_n = \frac{2^n-(-5)^n}{7}, \qquad a_{15} = 4{,}359{,}658{,}699 \qquad (4)$$

Data were collected from the answer sheets. A coding guide was developed from the NEA stages and operationalized into 17 indicators, as presented in Table 2. Trustworthiness was ensured in three ways: checking every coded error against the answer key, re-reading each sheet in full before assigning its final category, and recording every coding decision. Pages that were difficult to read were flagged for verification against the original sheets.

The analysis was conducted in four stages. First, each response was reduced to its key steps: model, characteristic equation, roots, constants, closed form, and final value. Second, each sheet was assigned to one of six achievement categories (A to F) based on the furthest step completed correctly. Third, each error was coded using the NEA indicators. A student could display more than one indicator, so indicator frequencies may exceed the number of students. Fourth, frequencies and percentages were tabulated and displayed (Tables 1 and 2; Figure 1), and representative excerpts were described qualitatively to characterize each error type.

RESULTS

The results are presented in four parts: students' overall achievement, the distribution of errors across Newman's stages, a description of the errors at each stage, and anomalous findings.

Overall Achievement

Only one of the 32 students (3.1%) solved the recurrence relation problem completely and correctly. Six students (18.8%) reached a correct closed form (categories A and B), whereas 19 students (59.4%) failed before constructing a valid model (categories D, E, and F). The distribution is presented in Table 1.

Table 1. Distribution of Students' Achievement Categories (n = 32)

Category	Package A	Package B	Unidentified	Total	%
A. Fully correct	1	0	0	1	3.1
B. Correct model and method, failed at the end	2	3	0	5	15.6
C. Partly correct, procedural error	2	5	0	7	21.9
D. Incorrect model	5	2	0	7	21.9
E. No recurrence approach	3	5	2	10	31.3
F. No solution attempted	0	1	1	2	6.3
Total	**13**	**16**	**3**	**32**	**100**

Category E was the largest group: about one third of the students did not recognize the problem as a recurrence relation. They replaced the recursive structure with a fixed additive pattern, for example 15 × Rp1 million = Rp15 million (S15, S16), or with proportional multiplication, for example 2 × 15 = 30 million (S02).

Categories C and D each contained seven students, but their patterns differed. Students in category D solved an incorrect model fluently. For example, S10 solved $r^2 - 4r + 3 = 0$ neatly and obtained M(15) = 21,523,360,000,000. Students in category C started with a correct model but slipped at a later technical step. The proportion of category C was higher in Package B (5 of 16) than in Package A (2 of 13), whereas the only fully correct answer came from Package A.

Distribution of Errors across Newman's Stages

Figure 1 shows the furthest stage that each student passed correctly. The sharpest decline occurred at the comprehension stage, where nine students stopped. Fourteen students passed the transformation stage, eight passed the process-skills stage, and only one passed the encoding stage.

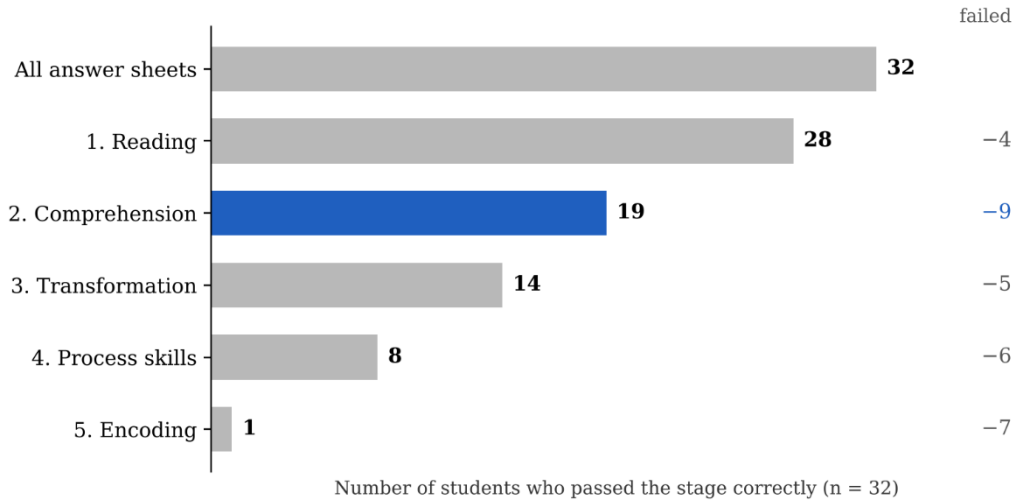


Figure 1. Number of Students Passing Each Stage of Newman's Procedure

Table 2 details the indicators coded at each stage. The three most frequent indicators were E4 (43.8%), T3 (28.1%), and T4 and E1 (21.9% each). None of the 14 students who obtained a final value through a recurrence approach related it back to the savings context. When the four transformation indicators are combined, transformation errors affected 23 students.

Table 2. Frequency of Errors by Newman Stage and Indicator (n = 32)

Newman stage	Code	Error indicator	f	%
Reading	R1	Misreading coefficients or mixing numbers from the other package	4	12.5
Comprehension	K1	Incorrect initial condition (a_0 = 1 million)	4	12.5
	K2	Interpreting "two weeks ago" as multiplication by 2 or as 2^n	4	12.5
	K3	Assuming a fixed deposit or a linear pattern	6	18.8
Transformation	T1	Swapped coefficients or indices, or wrong signs in the relation or characteristic equation	5	15.6
	T2	Using the model of the other package	2	6.3
	T3	No recurrence relation constructed	9	28.1
	T4	Inaccurate notation (missing subscripts, "r^3", "= 40", misuse of sigma)	7	21.9
Process skills	P1	Index substitution error during iteration	3	9.4
	P2	Treating the index *n* as an exponent	1	3.1
	P3	Incorrect factorization of the characteristic equation	3	9.4
	P4	Sign or operation error when determining constants	2	6.3
	P5	Errors in computing large powers or final arithmetic	5	15.6

Newman stage	Code	Error indicator	f	%
Encoding	E1	Computing the wrong term (a_{10} instead of a_{15})	7	21.9
	E2	Stopping before obtaining a_{15}	6	18.8
	E3	Lost negative sign or inconsistent units	4	12.5
	E4	No interpretation of the result in context	14	43.8

Description of Errors at Each Stage

Reading errors. Four students misread the coefficients. S02 and S03 wrote "2 × savings two weeks ago", and S02 then computed 2 × 15 = 30 million. S05 and S30 wrote $a_n + 4a_{n-1} - 15a_{n-3} = 40$, although neither the number 15 nor the term a_{n-3} appears in the problem.

Comprehension errors. Errors at this stage appeared in three patterns. The first pattern concerned the initial condition. The statement that the first-week deposit was one million was encoded as a_0 = 1 million (S07, S10, S12, S15), while the information that there was no initial deposit was ignored. The second pattern was reading the phrase "two weeks ago" as an operation. S07 and S12 wrote $4a_n \cdot 2^n - 3a_n$ and $(3a_n)^n$, then divided by x^n to obtain meaningless expressions such as $x^n = -\frac{20}{3}$. The third pattern was replacing the recursive structure with a linear pattern. S15 computed week three as 4(1 million) − 3(1 million) = 1 million, concluded that the savings increase by one million each week, and reported 15 million. Similarly, S23 computed 7 million for week two and 13 million for week three, then extrapolated this constant difference to obtain 85 million.

Transformation errors. The most characteristic error was swapping the coefficients of a_{n-1} and a_{n-2}, for example $a_n = 4a_{n-1} - 3a_{n-2}$ or $T_n = 10T_{n-1} - 3T_{n-2}$ (S06, S10, S32). This model yields $r^2 - 4r + 3 = 0$ with roots 1 and 3, after which the procedure was carried out correctly. S32 obtained $a_n = ½(3^n - 1)$ and a_{15} = 7,174,453, a value consistent with the incorrect model. S01 wrote the relation correctly but formed the characteristic equation $r^2 - 4r + 3 = 0$ instead of $r^2 + 3r - 4 = 0$.

Notational weaknesses (T4) also appeared in three forms. Some students omitted subscripts, for example writing $4_{n-2} - 3_{n-1}$ (S08, S20, S26). Others wrote the characteristic equation as "$r^3 + 2r - 10$" (S17–S19). In addition, sigma notation was used to denote a single term (S22).

Process-skill errors. S01 set up the relation correctly but swapped the indices during iteration. The student computed $a_2 = 4a_1 - 3a_0 = 1$ instead of $4a_0 - 3a_1 = -3$, which produced a spurious pattern (0, 1, 1, 1, …). S04 determined the constants $c_1 = \frac{1}{5}$ and $c_2 = -\frac{1}{5}$ correctly but then substituted *n* into the relation as an exponent, obtaining $a_0 = 4^{-2} - 3^{-1}$.

Other technical errors were also found. S08 factored $x^2 + 3x - 4$ as $(x + 2)(x - 2)$. S24 and S25 wrote $7c_2 = -1$ as $7c_2 = 1$. S31 computed 4^{15} as 17,716,256, even though the closed form obtained was correct.

Encoding errors. Seven students computed a_{10}, although the item asked for a_{15}, and reported $\frac{2^{10}-5^{10}}{7} = -1{,}394{,}943$ as the final answer. Six students stopped before obtaining a value. S26 even reached 30,517,610,893/7, only one division away from the correct answer.

Units were also handled inconsistently. S06 repeatedly multiplied rupiah values and obtained 66,532,204,609,013,600,000, while S18 and S24 dropped the negative sign.

Two anomalies were found. First, five answer sheets (S05, S17, S18, S19, and S30) showed identical patterns, down to their errors. They wrote the relation as $a_n + 3a_{n-1} - 10a_{n-2} = 40$ and the characteristic equation as $r^3 + 3r - 10 = 0$. They also wrote $2c_1 + 5c_2 = 1$ but solved it as $2c_1 - 5c_2 = 1$. All five reported −1,394,943, which is actually the value of a_{10}. S05 and S30 answered Package A but used the roots 2 and −5 from Package B. This pattern is reported as an indication requiring confirmation, not as a conclusion.

Second, both packages produce a negative balance in week two ($a_2 = -3$ million), and the sign alternates in subsequent weeks. The value of a_{15} is also unrealistic for personal savings, namely Rp214.7 trillion in Package A and Rp4,359 trillion in Package B. No student commented on these anomalies.

DISCUSSION

The main finding of this study is that students' greatest obstacle was not the algorithm for solving recurrence relations but two-way translation: from text to model and from the result back to the context. Eighteen students (56.3%) failed at one of the stages from reading to transformation, and the largest drop occurred at the comprehension stage.

In this task, comprehension errors took a specific form. Students had to map the temporal phrases "last week" and "two weeks ago" onto the indices n − 1 and n − 2. Students

who failed tended to take one of three routes. Some read the phrase as an arithmetic operation (K2), some swapped the position of the coefficients (T1), and others abandoned the recursive structure in favor of a more familiar linear pattern (K3, T3).

These three routes indicate that the concept of an index as a marker of relative time had not yet been formed. Initial-condition errors (K1) reinforce this interpretation. Students who wrote a_0 = 1 million did not distinguish the state before saving from the first week, even though this distinction determines the entire particular solution.

The pattern in category D reveals a further layer. Students such as S10 and S32 executed the solution algorithm (characteristic equation, roots, general solution, constants) without checking whether the model reproduced the given data. Had a_2 been computed by hand, the model error would have been apparent immediately. Conversely, S04 obtained the correct constants but returned to the recursive relation with negative exponents, indicating that the function of the closed form was not understood. In both cases, procedural competence was present, but conceptual understanding of what the procedure represents was absent.

The dominance of comprehension and transformation errors is consistent with school-level NEA studies. These studies report that errors at early stages propagate to later stages (Haerani et al., 2021; Zulyanty & Mardia, 2022), and that translating contextual information into a mathematical model is the most frequent difficulty (Indriana et al., 2024; Sari et al., 2023; Sarwan et al., 2026; Sukmarini & Hermanto, 2021). The finding also parallels comprehension errors among students translating word problems (Aurelia et al., 2024) and modeling errors among pre-service teachers and secondary students (Parandrengi & Hiltrimartin, 2023; Permata et al., 2025).

However, this finding differs from most undergraduate NEA studies, which identify process-skill errors as the dominant type (Ekasari & Putra, 2024; Irianti et al., 2024; Pinahayu et al., 2023; Suddin & Handayani, 2026). The difference can be explained by the nature of the task. In calculus, statistics, or differential equation problems, the model is usually given or easily recognized, so errors concentrate on executing the procedure. In a contextual recurrence problem, the model must be constructed from a verbal description of relations across time, which shifts the difficulty to the comprehension and transformation stages.

This interpretation is supported by three bodies of research. First, undergraduates and pre-service teachers apply counting techniques without justification when the structure

of a discrete problem is unfamiliar (Marhami et al., 2026; Soto et al., 2022). Second, engineering students formulate recurrence relations more successfully when they analyze differences between terms using numerical and pictorial representations (Trigueros-Rodríguez & Montejo-Gámez, 2025). Third, notational difficulties (T4) are consistent with findings that understanding of mathematical language and symbols is closely related to mathematical literacy (Kusmaryono et al., 2024). Pre-service teachers, too, can produce symbolic generalizations without being able to explain the underlying structure (Sjaastad & Lorange, 2026). In addition, the index-swapping error (P1) resembles the difficulty novice programmers have in tracing the flow of control across recursive calls (Kiesler, 2022).

From the perspective of the modeling cycle (Schukajlow et al., 2023), almost all students stopped before the interpretation and validation stages. Computing a_{10} instead of a_{15} (E1) indicates that the question was not re-read. The absence of any comment on negative savings (E4) indicates that the context was treated as decoration rather than as a source of meaning.

This is consistent with several lines of evidence. Validation does not occur spontaneously (Geisler, 2023). The looking-back stage is the weakest part of students' problem solving (Salim et al., 2026). Even primary school students set aside real-world knowledge when solving word problems (Hidayatullah & Csíkos, 2023; Kılıç & Şahinkaya, 2022). The high rate of encoding errors agrees with the systematic review by Purba et al. (2026) and with evidence that question design influences students' sense-making (Kirkland & McNeil, 2021). In this study, a problem whose correct answer is itself unrealistic gave students little reason to validate their results.

The similarity of answer patterns across five sheets cannot be interpreted with certainty from written data alone. Nevertheless, it signals a risk to the validity of the error analysis, because errors originating from a common source would inflate certain indicator frequencies. Research on academic dishonesty shows that such patterns are common in examinations and require both preventive design and confirmation procedures (Noorbehbahani et al., 2022).

Theoretically, these findings extend NEA research by showing that the dominant error stage among undergraduates depends on whether the model is given or must be constructed. They also show that NEA becomes more informative when combined with the

modeling cycle and with the distinction between conceptual and procedural knowledge (Hurrell, 2021).

Practically, there are three implications. First, instruction should explicitly train the translation of temporal phrases into indices, for example by requiring students to compute the first three terms by hand before seeking a closed form. This step also serves as a model check, in line with approaches that build recursive thinking through narrative and step-by-step construction (Nicchiotti et al., 2024). Second, assessment rubrics should award credit for validation, such as checking a_0 and a_1 against the closed form and interpreting the result in context (Cevikbas et al., 2022; Jablonski et al., 2023). Third, contextual problems should be designed so that their results are plausible, or their implausibility should be made an intentional topic of discussion (Schlüter & Besser, 2024). A savings problem that yields negative balances risks teaching students that the context need not be trusted.

This study has three limitations. First, the data consisted only of written responses, so the causes of errors were inferred rather than confirmed. Interviews with representatives of each category are needed, particularly categories D and E and the students who showed similar answer patterns. Second, the two packages differ in arithmetic difficulty, so comparisons between them are descriptive. Third, coding was performed by a single coder. Future research is recommended to involve a second coder and report inter-coder reliability. Future studies should also compare tasks in which the recurrence model is given with tasks in which it must be constructed, and test instructional interventions that target index mapping and validation.

CONCLUSION

Students' ability to solve a contextual recurrence relation problem was low. Only one of 32 students (3.1%) answered completely and correctly, and six students (18.8%) reached a correct closed form. Errors were concentrated at the comprehension and transformation stages, where students had to map temporal phrases onto indices and determine initial conditions. Encoding errors were also prominent. No student interpreted the result in context (43.8%), and a considerable proportion computed the wrong term (21.9%). Overall, the main obstacle was not the solution algorithm but two-way translation between the situation and the model.

This study contributes to research on Newman's Error Analysis by showing that, in higher education tasks requiring model construction, comprehension and transformation errors outweigh the process-skill errors that dominate tasks with a given model. It also demonstrates the value of interpreting NEA results through the modeling cycle and of reporting anomalies in both student responses and problem design.

Future research should triangulate written errors with interviews, involve more than one coder, and compare recurrence tasks with a given model and with a model to be constructed. Lecturers are advised to train index mapping explicitly, require hand computation of initial terms as a model check, include validation in assessment rubrics, and design contextual problems with realistic outcomes.

REFERENCES

Aurelia, D., Ekawati, R., & Arifin, S. (2024). Primary students' comprehension errors in translating math problems. *Edumatica: Jurnal Pendidikan Matematika, 14*(3), 213–230. https://doi.org/10.22437/edumatica.v14i3.38814

Cevikbas, M., Kaiser, G., & Schukajlow, S. (2022). A systematic literature review of the current discussion on mathematical modelling competencies: State-of-the-art developments in conceptualizing, measuring, and fostering. *Educational Studies in Mathematics, 109*(2), 205–236. https://doi.org/10.1007/s10649-021-10104-6

Ekasari, A., & Putra, D. J. (2024). Error analysis of learners' problem-solving abilities in mathematics courses: A Newman error analysis (NEA) approach. *Jurnal Pendidikan Sains, 12*(1), 44–49. https://doi.org/10.17977/2442-3904.1019

Geisler, S. (2023). Mathematical modelling with experiments: Students' sense of validation and its relevance. *Rivista di Matematica della Università di Parma, 14*(2), 265–280. https://www.rivmat.unipr.it/vols/2023-14-2/03-geisler.html

Haerani, A., Novianingsih, K., & Turmudi, T. (2021). Analysis of students' errors in solving word problems viewed from mathematical resilience. *JTAM (Jurnal Teori dan Aplikasi Matematika), 5*(1), 246–253. https://doi.org/10.31764/jtam.v5i1.3928

Hidayatullah, A., & Csíkos, C. (2023). Students' responses to the realistic word problems and their mathematics-related beliefs in primary education. *Pedagogika, 150*(2), 21–37. https://doi.org/10.15823/p.2023.150.2

Hurrell, D. P. (2021). Conceptual knowledge or procedural knowledge or conceptual knowledge and procedural knowledge: Why the conjunction is important to teachers. *Australian Journal of Teacher Education, 46*(2), 57–71. https://doi.org/10.14221/ajte.2021v46n2.4

Husenti, N., & Pratama, A. M. I. (2022). Analisis Kesalahan Materi Logika dengan Metode Newman pada Mahasiswa Program Studi Teknik Informatika UMG. *Jurnal Pendidikan Informatika dan Sains, 11*(2), 88–101. https://doi.org/10.31571/saintek.v11i2.2845

Indriana, I., Pathuddin, P., Lefrida, R., & Alfisyahra, A. (2024). Newman's error analysis: The students' errors in solving word problems of proportion. *Edumatika: Jurnal Riset Pendidikan Matematika, 7*(1), 45–57. https://doi.org/10.32939/ejrpm.v7i1.3642

Irianti, N. P., Barr, F. D., Nurasiah, L., & Irsal, N. A. (2024). Error analysis in solving applied mathematics problems based on the Newman procedure. *Inteligensi: Jurnal Ilmu Pendidikan, 7*(1), 110–117. https://doi.org/10.33366/ilg.v7i1.5883

Jablonski, S., Barlovits, S., & Ludwig, M. (2023). How digital tools support the validation of outdoor modelling results. *Frontiers in Education, 8*, Article 1145588. https://doi.org/10.3389/feduc.2023.1145588

Kiesler, N. (2022). Mental models of recursion: A secondary analysis of novice learners' steps and errors in Java exercises. In *Proceedings of the 33rd Annual Workshop of the Psychology of Programming Interest Group (PPIG 2022)*. Psychology of Programming Interest Group. https://ppig.org/papers/2022-ppig-33rd-kiesler/

Kılıç, Ç., & Şahinkaya, N. (2022). Examining primary school students' performance in solving problems requiring realistic considerations. *Malikussaleh Journal of Mathematics Learning, 5*(1), 19–25. https://ojs.unimal.ac.id/mjml/article/view/7191/0

Kirkland, P. K., & McNeil, N. M. (2021). Question design affects students' sense-making on mathematics word problems. *Cognitive Science, 45*(4), Article e12960. https://doi.org/10.1111/cogs.12960

Kusmaryono, I., Aminudin, M., Ubaidah, N., & Chamalah, E. (2024). The bridging understanding of language and mathematical symbols between teachers and students: An effort to increase mathematical literacy. *Infinity Journal, 13*(1), 251–270. https://doi.org/10.22460/infinity.v13i1.p251-270

Magda, D., & Gardner-McCune, C. (2025). Students' thoughts on discrete mathematics: Insights for practice and implications for future research. In *Proceedings of the 56th ACM Technical Symposium on Computer Science Education V. 1* (pp. 736–741). Association for Computing Machinery. https://doi.org/10.1145/3641554.3701948

Marhami, M., Dasari, D., Suryadi, D., & Juandi, D. (2026). Epistemological obstacles in combinatorics as praxeological gaps among pre-service mathematics teachers. *Jurnal Elemen, 12*(3), 710–723. https://doi.org/10.29408/jel.v12i3.35192

Nicchiotti, B., Donatiello, A., & Bianco, G. (2024). A narrative approach to foster the construction of recursive thinking in high school students. *Education Sciences, 14*(4), Article 350. https://doi.org/10.3390/educsci14040350

Noorbehbahani, F., Mohammadi, A., & Aminazadeh, M. (2022). A systematic review of research on cheating in online exams from 2010 to 2021. *Education and Information Technologies, 27*(6), 8413–8460. https://doi.org/10.1007/s10639-022-10927-7

Nuryati, N., Purwaningsih, S. S., & Habinuddin, E. (2022). Analysis of errors in solving mathematical literacy analysis problems using Newman. *International Journal of Trends in Mathematics Education Research, 5*(3), 299–305. https://doi.org/10.33122/ijtmer.v5i3.164

Parandrengi, M. J., & Hiltrimartin, C. (2023). Students' errors in solving climate change context mathematical modeling problems. *Jurnal Elemen, 9*(2), 388–402. https://doi.org/10.29408/jel.v9i2.11422

Permata, J. I., Budiarto, M. T., & Fuad, Y. (2025). Analysis of error in mathematical modeling problems: An exploratory study of middle school students. *Edelweiss Applied Science and Technology, 9*(7), 947–959. https://doi.org/10.55214/25768484.v9i7.8773

Pinahayu, E. A. R., Awaaludin, A. A. R., Adnyani, L. P. W., Mariko, S., Mulyani, N., & Yono, S. (2023). Analisis Kesalahan Mahasiswa dalam Menyelesaikan Soal Distribusi Sampling Beda Dua Proporsi Berdasarkan Prosedur Newman. *Jurnal Pendidikan Tambusai, 7*(2), 9191–9198. https://jptam.org/index.php/jptam/article/view/7714

Purba, P. P. N., Sihite, M. A., Hutagalung, E. E., & Al Fath, A. M. (2026). Analisis Kesalahan Siswa dalam Menyelesaikan Soal Cerita Matematika Berdasarkan Tahapan Newman: Systematic Literatur Review. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 11*(2), 241–253. https://www.journal.unpas.ac.id/index.php/pendas/article/view/45403

Salim, L. F., Noverli, M. F., & Kartika, H. (2026). Stage-specific patterns in students' statistical problem solving: A qualitative analysis through Pólya's framework. *Jurnal Didactical Mathematics, 8*(2), 469–490. https://ejournal.unma.ac.id/index.php/dm/article/view/19208

Sari, N. R., Asyari, S., & Darwis M., M. (2023). Analisis Kesalahan dalam Menyelesaikan Masalah Numerasi Aljabar dengan Menggunakan Prosedur Newman pada Siswa Kelas XI SMA. *Issues in Mathematics Education, 7*(2), 120–138. https://ojs.unm.ac.id/imed/article/view/51347

Sarwan, S., Fineldi, R. J., & Panjaitan, M. A. (2026). Analysis of student errors in solving algebra problems: A Newman's error analysis perspective. *Journal on Mathematics Education Research, 7*(1), 148–159. https://doi.org/10.17509/j-mer.v7i1.885

Schlüter, D., & Besser, M. (2024). Assessing authenticity in modelling test items: Deriving a theoretical model. *Frontiers in Education, 9*, Article 1343510. https://doi.org/10.3389/feduc.2024.1343510

Schukajlow, S., Kaiser, G., & Stillman, G. (2023). Modeling from a cognitive perspective: Theoretical considerations and empirical contributions. *Mathematical Thinking and Learning, 25*(3), 259–269. https://doi.org/10.1080/10986065.2021.2012631

Sjaastad, J., & Lorange, C. A. (2026). Pre-service teachers using an app to generalize figural patterns through figural reasoning. *LUMAT: International Journal on Math, Science and Technology Education, 14*(1), Article 2. https://doi.org/10.31129/LUMAT.14.1.2856

Soto, O., Siy, K., & Harel, G. (2022). Promoting a set-oriented way of thinking in a U.S. high school discrete mathematics class: A case study. *ZDM – Mathematics Education, 54*(4), 809–827. https://doi.org/10.1007/s11858-022-01337-7

Suddin, S., & Handayani, R. (2026). An analysis of students' errors based on Newman's error analysis in solving partial derivative problems in calculus. *MATH-EDU: Jurnal Ilmu Pendidikan Matematika, 11*(1), 27–38. https://jurnal.unimor.ac.id/index.php/JIPM/article/view/10926

Sukmarini, M. A., & Hermanto, H. (2021). Error analysis in answering system of linear equations with two variables questions based on Newman indicator. *International Journal on Teaching and Learning Mathematics, 4*(1), 15–25. https://doi.org/10.18860/ijtlm.v4i1.14180

Trigueros-Rodríguez, E., & Montejo-Gámez, J. (2025). Formulación de relaciones de recurrencia utilizadas por estudiantes de ingeniería para la identificación de patrones. In M. Burgos Navarro, M. C. Cañadas Santiago, J. M. Marbán Prieto, & I. Polo-

Blanco (Eds.), *Investigación en educación matemática XXVIII* (pp. 445–452). Sociedad Española de Investigación en Educación Matemática. https://www.seiem.es/acta/actas-xxviii-seiem-melilla-2025/

Zulyanty, M., & Mardia, A. (2022). Do students' errors still occur in mathematical word problem-solving?: A Newman error analysis. *Al-Jabar: Jurnal Pendidikan Matematika, 13*(2), 343–353. https://doi.org/10.24042/ajpm.v13i2.13519