

Identifying Student Errors Using Newman's Error Analysis in the Teaching Through Problem-Solving Approach

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Abstract

This study identifies the specific mathematical errors committed by learners exposed to the Teaching Through Problem-Solving (TTP) approach. While TTP is an active learning method that fosters deep understanding by presenting problems before formal solutions, there is a scarcity of research investigating how student errors manifest within this specific instructional model. Using Newman's Error Analysis (NEA), the researcher analyzed the written solutions of 32 Grade 7 students at Mindanao State University-Iligan Institute of Technology College of Education-Integrated Developmental School to categorize hurdles into five stages: reading, comprehension, transformation, process skills, and encoding. The findings reveal that Comprehending Error was the most frequent challenge in Problem 1 (34.375%), while Encoding Error emerged as the primary obstacle in Problem 2 (34.375%). These results suggest that while students generally possess strong fundamental literacy, they struggle with moving from literacy to mathematical interpretation and providing narrative closure to their solutions. By pinpointing these exact stages of failure, educators can develop targeted scaffolding and instructional strategies to address the root causes of student difficulties in student-centered environments.

Keywords: Teaching Through Problem-Solving; Newman Error Analysis; student errors; mathematics education; diagnostic tool.

1. Introduction

Mathematical problem-solving skills are a fundamental aspect of mathematics education and a crucial competency for students to develop (Kabael & Baran, 2023; Safrina et al., 2022). These skills involve the ability to formulate problems, identify relevant information, and develop logical problem-solving steps (Setiawan et al., 2023; Syafri et al., 2021). Effective mathematics education should encourage students to think critically, analyze problems, and devise appropriate problem-solving strategies (Kaitera & Harmoinen, 2022; Hasibuan et al., 2018).

In problem-solving, students commonly face challenges in understanding the problem context, translating verbal descriptions into mathematical expressions, and applying appropriate problem-solving strategies (Bacus & Guillena, 2023; Bibi et al., 2022).

Furthermore, difficulties in reading comprehension, lack of problem-solving skills, and sufficient time for additional support are also encountered by students (Sambo & Makgakga, 2024).

Traditional teaching methods contribute to these challenges particularly through misconceptions about mathematical concepts and misunderstandings in algebraic operations (Palupi et al., 2022; Mariawan & Parwati, 2018). Moreover, traditional teaching methods often fail to address the specific comprehension challenges faced by students when solving mathematical word problems (Orosco et al., 2011; Haerani et al., 2021). Traditional mathematics instruction often focuses on rote memorization, which frequently leads to the very errors this study seeks to analyze (Legarde, 2022).

Introducing a shift from this passive traditional method is crucial. Active learning like the Teaching Through Problem-Solving (TTP) fosters deeper mathematical understanding and reasoning. It is an educational method where problems are presented first to students before they introduce formal solution methods to learn, allowing students to become active investigators grappling complex tasks (Takahashi et al., 2013). Also, this makes teachers shift from lecturers to facilitators of mathematical “productive struggle” (Biccard, 2024). In addition, there is a consensus among researchers that the TTP approach has positive effects on students' problem solving skills and academic achievement (Acquandoh et al., 2022; Ahdhianto et al., 2020; Ali et al., 2010; Astriani et al., 2017). The TTP Approach has been found to enhance students' skills, crucial for successful problem-solving. Because TTP demands higher cognitive engagement, it provides a richer, more transparent landscape for observing how students think and, subsequently, where their logic falters which suggests essential data points revealing the depth of their conceptual understanding, not signs of failure (Roorda et al., 2024).

Since students are given the autonomy to solve problems in the TTP approach, a structured diagnostic tool like Newman's Error Analysis is necessary to systematically categorize the hurdles they encounter when left to their own mathematical devices. This Newman Error Analysis or NEA Model involves five types of errors namely: reading errors, comprehension errors, transformation errors, process skill errors, and encoding errors (Alhassora, 2017).

While there is abundant research documenting the types, frequencies, and causes of student errors across diverse problem-solving contexts, most of this research does not specifically investigate how errors manifest within the TTP model itself. The academic literature contains numerous studies analyzing errors using frameworks such as Newman Error Analysis, which categorizes errors into various stages (Hadiyanti & Manurung, 2025; Payung et al., 2025). These studies provide detailed taxonomies of error types, from conceptual errors to careless mistakes to procedural errors. Despite this robust body of research on student errors in problem-solving generally, there exists a notable scarcity of studies that specifically examine error manifestation within the TTP instructional model. The research literature on TTP implementation tends to focus on implementation challenges, teacher understanding, and overall effectiveness outcomes, rather than detailed analysis of the specific error patterns students exhibit when learning through this pedagogical approach (Roorda et al., 2024; Acquandoh et al., 2022; Ahdhianto et al., 2020; Ali et al., 2010; Astriani et al., 2017). Hence, this study identifies the errors committed by learners exposed under the TTP approach using the NEA Model. The findings of this study will help educators move beyond simply marking an answer wrong and instead allow them to provide targeted scaffolding based on the specific type of error identified. By systematically categorizing errors into cognitive and non-cognitive factors, educators can devise more appropriate teaching strategies that address the root causes of student difficulties (Ekasari & Putra, 2024; Patac & Patac, 2017).

2. Literature Review

2.1 The Landscape of Mathematical Problem Solving

Problem-solving has emerged as a cornerstone competency in contemporary mathematics education, representing far more than the ability to perform calculations (Vidad & Quimbo, 2021). It encompasses the development of critical thinking, analytical reasoning, and the capacity to apply mathematical knowledge to real-world contexts (Ferreder et al., 2024). The significance of problem-solving skills in mathematics education cannot be overstated, particularly as societies increasingly prioritize competencies needed for the 21st century. For much of the 20th century, mathematics education operated within a procedural paradigm that emphasized mastering computational techniques and memorizing rules (Zhu, 2023). Traditional mathematics education focused on rote memorization and abstract procedures, following a predictable instructional pattern: present a rule, demonstrate the procedure, have students practice with similar problems, and assess through computational accuracy rather than engage learners in genuine exploration (Susanti, 2025; Nilimaa, 2023). Students learned to execute algorithms without necessarily understanding the mathematical principles underlying them (Mora & Reyes-Rodríguez, 2019). This methodology reflected certain foundational assumptions about learning: that understanding would develop naturally through repeated practice, that procedural fluency was a necessary prerequisite for conceptual understanding, and that mathematics could be effectively taught as a decontextualized body of techniques. The implicit message to students was unambiguous: "Learn the steps, apply them correctly, and you will succeed in mathematics." Engagement, curiosity, and meaningful application were secondary concerns at best (Omer et al., 2025).

Rather than viewing mathematics as a collection of disconnected procedures to memorize, conceptual understanding represents a different perspective that emphasizes grasping underlying principles, recognizing relationships between concepts, and comprehending why mathematical procedures work and when they should be applied (Susanti, 2025). A student possessing genuine conceptual understanding can: explain mathematical reasoning, transfer knowledge, recognize multiple pathways, connect representations, and engage in flexible problem-solving (Gilmore et al., 2017; O'Dwyer et al., 2015). Importantly, conceptual understanding does not eliminate procedural fluency as a goal; rather, it recognizes that procedural fluency is most robust and transferable when grounded in deep understanding (Gilmore et al., 2017).

There are multiple worldwide movements toward emphasizing conceptual understanding. Firstly, research from cognitive psychology and learning sciences demonstrated that students trained primarily in procedures struggle dramatically when encountering problem types that deviate from practiced patterns (Jonsson et al., 2014; Nguyen et al., 2020). Knowledge organized around procedures is fragile, context-dependent, and poorly transferable (Evans & Dietrich, 2022). In contrast, students with conceptual foundations can reason about novel situations and adapt their problem-solving approaches flexibly (Liljedahl et al., 2016).

Secondly, international assessments (TIMSS and PISA) revealed many students achieved procedural accuracy on routine computational tasks yet performed poorly on problem-solving, application, and reasoning items. This persistent gap between procedural competence and conceptual reasoning—even among high-performing students—motivated educators globally to reconsider fundamental instructional approaches (Eriksson et al., 2019; Kadijevich et al., 2023; Schulz, 2024). It became clear that the procedural pathway was not producing the mathematical thinking necessary for students to apply knowledge meaningfully beyond the classroom.

Lastly, contemporary instructional approaches emphasize positioning students as active mathematicians rather than passive recipients of transmitted procedures (Castillo et al., 2025). Problem-Based Learning, Inquiry-Based Learning, and project-based approaches all reflect a deep conviction that students develop more robust understanding when they must grapple with genuine problems, formulate their own questions, test hypotheses, and justify their reasoning (Hmelo-Silver et al., 2007; Johnsen et al., 2024). These pedagogies inherently prioritize conceptual understanding because students cannot simply memorize solutions; they must understand mathematical principles to solve problems they have never encountered in that exact form (Nisa et al., 2023).

It is indeed ideal to focus on conceptual understanding. However, word problems also pose significant challenges for students in mathematics education. Research consistently shows that linguistic interpretation, rather than arithmetic computation alone, drives much of this difficulty (Boonen et al., 2016).

Literature identifies word problems as among the most complex tasks in math curricula. A review by Daroczy et al. (2015) states that word problems demand processing linguistic elements unrelated to arithmetic, such as text complexity and semantic relations, which elevate difficulty beyond numerical operations. Successful solvers build mental models from text, while strugglers impulsively translate keywords and numbers, leading to errors independent of calculation skills (Pongsakdi et al., 2020). These provide a broad foundation for why a diagnostic study is necessary in the first place.

2.2 Teaching through Problem Solving (TTP) as a Pedagogical Framework

Teaching through problem-solving (TTP), as developed and promoted by Akihiko Takahashi based on Japanese mathematics education practices, is a student-centered approach where new concepts are introduced via challenging problems that students tackle independently before direct explanation (Roorda et al., 2024). Lessons begin with the teacher posing a carefully selected problem tied to the target concept, allowing 10-15 minutes for individual or small-group work while observing strategies. This is followed by *hataraku* (student work sharing) and *neriage* (whole-class discussion comparing solutions, identifying errors, and refining ideas), culminating in a summary that formalizes the concept (Hiroshi & Hiroshi, 2025).

Direct instruction follows a "I do, we do, you do" model: the teacher lectures to explain procedures first, models examples, then guides practice, emphasizing transmission of ready-made knowledge. TTP prioritizes struggle and comparison to foster insight, contrasting direct instruction's reliance on upfront clarity, which can reduce perseverance (Dubinsky & Hamid, 2024).

Several studies on teaching through problem-solving (TTP), show it promotes productive struggle by having students grapple with unsolved problems first, enhancing perseverance and sense-making before teacher guidance (Hourigan & Leavy, 2022; Roorda et al., 2024; Sionicio & Barbacena, 2021). A study in the Philippines where students engaged in metacognitive processes like planning strategies, monitoring, and evaluating solutions amid challenges, shifting cognitive responsibility as they independently tackled real-world problems before class discourse. TTP significantly boosted metacognitive awareness and academic performance, with reflection fostering deeper learning through struggle (Sionicio & Barbacena, 2021).

Literature highlights several challenges in implementing Teaching through Problem-Solving (TTP), particularly teachers' difficulties in monitoring independent student work to pinpoint where students get "stuck" without intervening prematurely. Novice TTP teachers find it hard to support without directing, leading to premature hints or demonstrations that undermine student autonomy and cognitive shift. Hourigan & Leavy (2022) report teachers' initial skepticism about extended struggle, fearing disengagement, especially for lower performers. Lesson Study helps via prediction and observation, but

elements like discussion phases remain tough, with calls for more support in targeting skills and practicing summaries. Roorda et al. (2024) found teachers valued student observations for TTP tools but needed rehearsal for identifying stuck points.

2.3 Newman's Error Analysis (NEA) as a Diagnostic Tool

The Newman Error Analysis (NEA) is a systematic framework used primarily in mathematics education to identify and categorize student errors in problem-solving. The methodology was developed by Anne Newman and is extensively applied to understand the root causes of difficulties students face in mathematical problem-solving, particularly with word problems (Ekasari & Putra, 2024).

The mechanics of Newman's Error Analysis involve a five-stage diagnostic procedure, which systematically breaks down the problem-solving process and allows for the identification of where an error occurs. These stages are: Reading Error which occurs when a student is unable to correctly read or decode the words in a problem, Comprehension Error where students can read the problem but fail to understand its overall meaning or the underlying mathematical concepts being tested, Transformation Error where students understand the problem but are unable to select the appropriate mathematical operations, formulas, or strategies required to solve it, Process Skill Error which occur when students correctly identify the necessary operations and methods but make mistakes during the execution of these procedures, and Encoding Error where students successfully perform all mathematical operations but fail to express their answer in the required or appropriate form (Triliana & Asih, 2019; Irianti et al., 2024; Mukminah & Riana, 2020; Utami, 2016; Syawali & Mulyawati, 2024).

Newman Error Analysis has been widely applied in educational research to diagnose learning difficulties across various mathematical topics and educational levels. The widespread adoption of Newman Error Analysis in educational settings is due to its utility in providing a structured way for teachers to identify specific areas where students struggle (Ekasari & Putra, 2024). By pinpointing the exact stage at which errors occur, educators can develop targeted interventions and instructional strategies to address these difficulties more effectively. Indeed, NEA is a valuable tool for diagnosing student errors in mathematics education. It focuses on a pedagogical framework for categorizing human cognitive and procedural mistakes in solving mathematical problems (Ekasari & Putra, 2024).

2.4. The Synthesis: Error Analysis in Student-Centered Environments

Newman Error Analysis (NEA) is a diagnostic tool widely employed in mathematics education research to categorize students' errors in problem-solving into five distinct stages. In addition, NEA has been widely applied across various mathematical topics and educational levels. Many studies utilize this systematic approach primarily in traditional educational settings to diagnose specific points of difficulty for students, thereby enabling educators to provide targeted interventions. Mostly the methodology for applying NEA in traditional settings typically involves qualitative descriptive research designs and researchers commonly administer written tests to students, often consisting of word problems, and then follow up with interviews to further probe the students' thought processes and identify the precise stage at which an error occurred (Noutsara et al., 2021; Siskawati et al., 2021; Irianti et al., 2024).

Furthermore, NEA is also partnered with various mathematical pedagogies which include higher order thinking skills including evaluating and creating skills, cooperative learning, independent learning, critical thinking, and analogical reasoning (Siskawati et al., 2021; Mardiyana, 2017; Mulyana et al., 2022; Hariri & Kania, 2025; Saleh et al., 2017). Despite the extensive use of NEA for diagnosing errors in traditional learning settings, there is no established body of peer-reviewed research that specifically applies

Newman Error Analysis within active learning or problem-based learning (PBL) environments, specifically the Teaching through problem solving (TTP). While these instructional approaches aim to enhance student engagement, critical thinking, and active learning, the literature does not yet document empirical studies reporting the systematic adaptation or validation of NEA within these structured pedagogical settings which suggests a potential gap in educational research. While we know TTP is good and NEA is a strong tool, we have not yet fully explored how the unique pressures of a TTP classroom and the errors students make.

3. Methodology

This study was conducted in Mindanao State University - Iligan Institute of Technology College of Education-Integrated Developmental School which is purposively chosen since it is a TTP Implementing School in Iligan City, Region X, Northern Mindanao, Philippines. There was an observation phase from the research setting which practices TTP approach and this will have a two-week duration. The observers of this phase are the researchers for the purpose of the observation phase is to verify only if the class indeed implements TTP approach and to know the lessons taught in order to construct the problem set. The interaction of the teacher and learners, communication between learners, and environment of the classroom are not part of the observation.

Moreover, the observed classroom consists of one (1) teacher with at least 1 year experience of teaching using TTP approach and a sample of 32 Grade 7 students ($n=32$), coded as S1 to S32, exposed and taught under the TTP approach by at least 1 quarter were the participants of the study. There are 102 grade 7 learner population from the research setting which is distributed into 3 sections. The study focuses on 1 section of Grade 7 learners which was purposively chosen as this section is handled by a TTP practicing teacher. Choosing all 32 learners in one section creates a homogenous and manageable group since they share a similar environment, schedule, and potentially similar experience. It also leads to consistent data, easier logistics, simplifies coordination, and helps in monitoring participant engagement and attendance. Also, it strengthens reliability of observation or interventions applied to that group and richer data in qualitative research due to collective experience (Ofori and Johnson, 2025; Weimer, 2011; Mugabi, 2024; Reddington and Cañada, 2006). The study focuses on Grade 7 learners as this is the stage where learners begin to engage deeply with inquiry and analysis (Bjørkvold & Blikstad-Balas, 2018). Moreover, grade 7 learners develop skills in problem identification and proposing solutions (Baitokayeva, L. (n.d.)). Research in this age group helps teachers understand their strategies, goals, and performance better.

The researchers in this phase observed the teaching-learning process and recorded the topics (1) special products and (2) division of polynomials. From this, a problem set was developed based on the lessons taught during the observation phase. This problem set is composed of two problems (co-created by the teacher implementer) and were not a multiple-choice type of test and it is specifically designed for students to use their problem-solving skills. The problem set consists of two problems, one for Special Products and one for Division of Polynomials. Further, the problem set was evaluated by 3 Mathematics practitioners (Proficient Teachers based on Philippine Professional Standards for Teachers) using a content validity index tool.

After the content validity of the problem set, it was administered to the students as a summative test at the end of the two-week observation. The duration of the test is 1 class hour. After the test, it was corrected by 3 mathematics teachers (Proficient Teachers based on Philippine Professional Standards for Teachers). In addition, inter-rater reliability was also done through percentage agreement.

The corrected test papers then underwent the descriptive qualitative content analysis using Newman's error analysis. Each solution of the students is dissected and scanned for

errors either reading/decoding, comprehending, transforming, processing, or encoding errors. After identifying the errors of each test paper, it was categorized based on the different types of errors of Newman's Error Analysis. Each response of a student per problem will be categorized to one or more types of errors as long as it fits the definition. Moreover, frequency of errors based on this analysis were also determined.

Hence, there were two (2) instruments utilized in this research study which are the problem set and error types from Newman Error Analysis (see appendix 1 and 2).

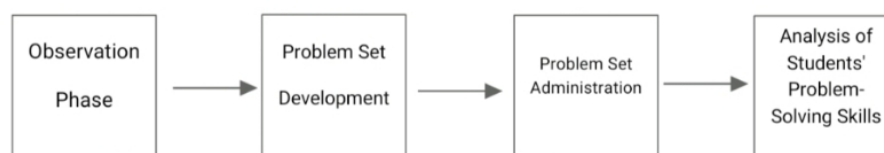


Figure 1. Data Gathering Procedure

4. Results and Discussion

Students' written solutions are analyzed using Newman's Error Analysis. This is utilized to consider the difficulties that the students experienced during the problem-solving. Newman's Error Analysis has 5 error types namely: Reading or Decoding, Comprehending, Transforming, Processing, and Encoding.

4.1. Learners' Summary of Errors in Problems 1 & 2

This section provides a comprehensive table and discussion of the errors committed by the learners from the special products problem and the division of polynomials problem.

Table 1. Summary of Errors in Problem 1 (Special Products)

Error	Number of Students	Percentage
Reading/Decoding	8	25%
Comprehending	11	34.375%
Transforming	10	31.25%
Processing	1	3.125%
Encoding	8	25%

Table 1 showcases the summary of percentage of learners who committed errors in problem 1. Based on the table, there are 8 out of 32 students (25%) who committed reading/decoding errors in problem 1. This means that reading/decoding error is relatively low among the participants. This suggests that the fundamental literacy of the class is relatively strong but a significant minority still stumble at this first stage.

Moreover, there are 11 out of 32 students (34.375%) who committed comprehending errors in problem 1 while having 8 previously in reading/decoding error. This shift indicates that their primary obstacle in problem 1 is moving from literacy to interpretation (Ekasari & Putra, 2024). Also, there are 10 out of 32 students (31.25%) who committed transforming errors in problem 1. This suggests that nearly a third of the students are getting stuck at the conceptual selection phase which means they know what the problem says but they do not know how to mathematicize it (Ahzan et al., 2022).

Furthermore, there is 1 student (3.125%) who committed a processing error in problem 1. This indicates that only 1 student unfortunately stumbled in the mathematical procedure and the rest of the students who successfully passed the transforming error also passed the processing error. In addition, there are 8 out of 32 students (25%) who

committed encoding errors in problem 1. This signifies that learners probably view that “calculating correctly” is the end of the task and it is enough (Prameshti et al., 2024).

Table 2. Summary of Errors in Problem 2 (Division of Polynomials)

Error	Number of Students	Percentage
Reading/Decoding	3	9.375%
Comprehending	2	6.25%
Transforming	0	0%
Processing	2	6.25%
Encoding	11	34.375%

Based on Table 2, only 3 students (9.375%) have reading/decoding errors in problem 2. Moreover, only 2 students (6.25%) have comprehending errors with 3 reading errors previously. This indicates that the linguistic hurdle was largely removed in problem 2 which is likely to have accessible language, familiar vocabulary, or context that the students find more relatable.

In problem 2, no student (0%) had transforming errors. This is significant since it suggests that the mathematical pathway was immediately obvious. There was no confusion whether to add, subtract, multiply, or divide. Previously, all students chose a correct math strategy in problem 2 (0% transforming error) and only 2 failed to perform the calculation (6.25% have processing errors). However, 11 students (34.375%) have encoding errors which is the greatest amount of errors in problem 2.

4.2 Sample Errors from Problems 1 & 2

The following figures are samples of the five errors of the Newman’s Error Analysis committed by the learners. Each figure is explained what type of error is committed and how it occurred in each figure.

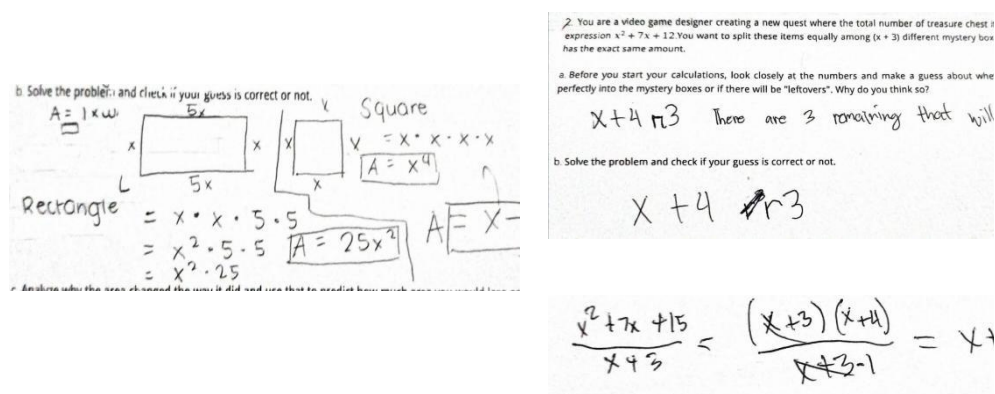


Figure 2. Samples of Reading/Decoding Error

Figure 2 showcases some examples of Reading/Decoding Error from S32 (left) and S12 (right). Reading/decoding error is committed when learners misread or misrepresent values from the problem. On the left image, the reading/decoding error happened when the learner wrote $5x$ instead of $x+5$. This is an example of a misrepresentation of data since multiplication was used instead of addition. On the right image, the answer of the student is $x+4$ with a remainder of 3. This is because the learner calculated $x^2 + 7x + 15$ instead of $x^2 + 7x + 12$ which is a clear sign of reading/decoding error.

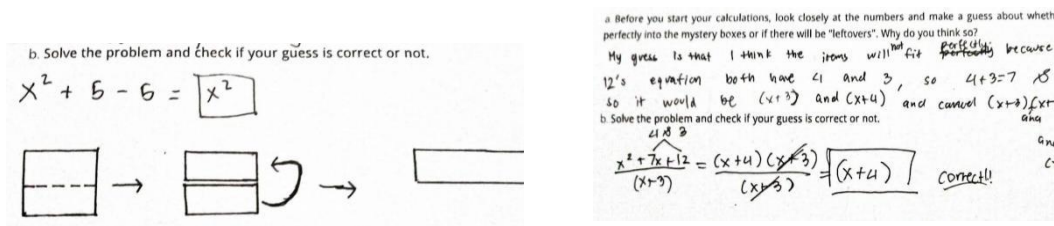


Figure 3. Samples of Comprehending Errors

Figure 3 showcases some examples of Comprehending Error from S31 (left) and S17 (right). Comprehending error is committed when learners fail to understand or comprehend the problem that they are solving. On the left image, the error happened when the learner wrote $x^2 + 5 - 5$. This suggests that the learner failed to comprehend that the 5 meter adjustment is to be added and subtracted on the sides and not on the area itself. The learner was able to read and decode that there are 5 meters being added and subtracted but misinterprets the question's intent. On the right image, the learner predicted that the items will not fit perfectly suggesting that there will be leftovers. The calculation is correct but the student reiterated that the initial guess was “correct” signifying that $x+4$ is the remainder which is contextually incorrect. These logical inconsistencies are examples of comprehending errors.



Figure 4. Samples of Transforming Errors

Figure 4 showcases some examples of Transforming Error from S24 (left) and S26 (right). A transforming error is committed when the learner uses a wrong formula or strategy to solve the problem despite reading and understanding the problem correctly. On the left image, the learner multiplied -5 and 5 directly which does not fit the specific logic of the word problem. The learner chose a wrong math strategy. On the right image, the student correctly reads and comprehends that sides are being added or subtracted. However, the formula that was used is for volume and not for area. The student thinks that it is the formula for the area.

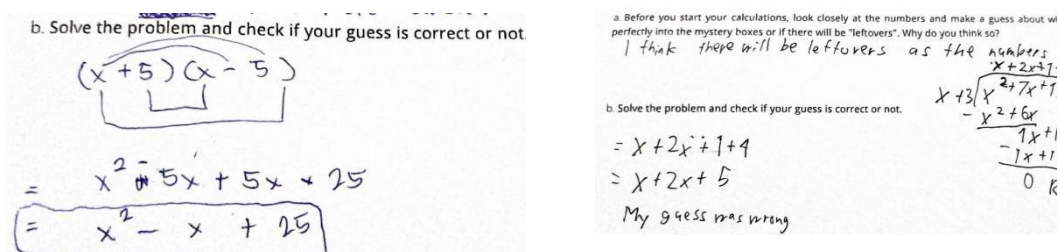


Figure 5. Samples of Processing Errors

Figure 5 showcases some examples of Processing Errors from S10 (left) and S13 (right). A processing error is committed when the formula or strategy is correct but the process of the solution contains an error. On the left image, the learner successfully

understands, decodes, and selects the correct solution which is FOIL Method. Even having a correct setup, the learner still ended up with a wrong answer because the computational and technical accuracy of the learner faltered ($-5x + 5x = x$). On the right image, the learner also fails to perform the calculation accurately. The learner thought that the x in the quotient will just be multiplied to the x in the divisor and the learner added $2x$ to the quotient to separately multiply to 3 in the divisor to produce $6x$. The learner knows basic operations but failed in this long method setup.

a. Before you calculate anything, make a guess whether you think the new rectangular garden is the same amount of area as your original square garden. Why do you think so?
 I claim the garden will have the same amount of area because you are an amount yet adding it back.

b. Solve the problem and check if your guess is correct or not.

change d to $x+5$ to $x-5$ $\rightarrow (x+5)(x-5)$
 $A = (x)^2$ $A = ?$ $(x+5)(x-5) = (x)^2 - 25$
 $= x^2$ $A = (L)(w)$ $A = x^2 - 25$

b. Solve the problem and check if your guess is correct or not.

$x+3 \overline{) x^2+7x+12}$
 x^2+3x
 $4x+12$
 $4x+12$
 0

Figure 6. Samples of Encoding Errors

Figure 6 showcases some examples of Encoding Error from S11 (left) and S16 (right). An encoding error is committed when learners do not justify or fail to provide a narrative closure on their solutions despite having correct answers. On the left image, the error happened when the learner boxed the answer x^2-25 , which is correct, but failed to provide a narrative closure whether there is a realization that the initial claim was wrong. Hence, fails to express the final answer completely. On the right image, the learner also arrives at the correct answer but a similar issue is encountered.

4.3 Implication of Errors towards the Learners' Performance and TTP Approach

The data from the Newman Error Analysis of Problem 1 reveals critical insights into student performance and provides a clear roadmap for implementing TTP approach. In terms of student performance, the low percentage of reading and processing errors indicates that the learners possess adequate foundational literacy and basic computational skills. However, the performance bottlenecks occur during the intermediate stages, specifically in comprehension (34.375%) and transformation (31.25%). This demonstrates that while students can read the words and execute calculations, a significant portion struggles to bridge the gap between language and mathematical modeling—failing to interpret the problem's context or select the correct mathematical operations. Additionally, the 25% encoding error rate suggests a superficial understanding of problem-solving, where students prematurely stop after calculating without verifying if their final answer actually addresses the original question.

When viewed through the lens of the TTP approach, this error profile underscores the necessity of moving away from traditional, rote-learning instruction toward a structured problem-solving framework. According to Roorda et al. (2024), TTP relies heavily on *Neriage* (orchestrated classroom discussion), which is precisely what is needed to address the high comprehension and transformation errors. Instead of simply providing formulas, a TTP lesson would present this problem as a catalyst for independent thinking, forcing students to grapple with the context and share their varied mathematical interpretations. By publicly comparing different student-generated ideas on the board, the teacher can guide the 34.375% who struggle with comprehension to see how language translates into mathematical relationships, and help the 31.25% struggling with transformation learn how to "mathematize" a real-world scenario.

Furthermore, the high incidence of encoding errors directly implies that the "summary" phase of TTP (*Matome*) must be heavily emphasized in the classroom (Roorda

et al., 2024). In TTP, a lesson does not end when a calculation is complete; rather, the climax of the lesson involves reflecting on what was learned, connecting the mathematics back to the problem's context, and formulating a generalized takeaway. By explicitly integrating *Matome*, teachers can shift the students' mindset away from the misconception that "calculating correctly is the end of the task." Instead, it trains them to view mathematical writing and final verification as an essential, concluding component of the problem-solving process, thereby directly targeting and reducing the encoding errors observed in the data.

The data from Problem 2 reveals a starkly different student performance profile compared to the first problem, offering unique implications for TTP approach. In terms of student performance, the near-absence of reading (9.375%), comprehension (6.25%), and transformation errors (0%) indicates that the problem's context was highly accessible and the mathematical pathway was immediately obvious to the learners. The primary bottleneck shifts entirely to the final stage, where a substantial 34.375% of the class committed encoding errors. This high frequency of encoding errors, contrasted with zero transformation errors and low processing errors, proves that while students easily understood the task and successfully executed the arithmetic, they overwhelmingly failed to formally state, contextualize, or label their final answers correctly.

For the TTP approach, this specific error distribution implies that the problem used may have lacked the productive struggle necessary to stimulate deep mathematical thinking (Anhalt et al., 2018). When a problem has a 0% transformation error rate, it functions more as an exercise or a routine word problem rather than a true "problem", which requires a task where the solution method is not immediately obvious. In a TTP classroom, if the mathematical strategy is instantly apparent to everyone, the independent solving phase yields identical, routine methods rather than diverse student-generated ideas (Takahashi et al., 2013). Consequently, the orchestration of the classroom discussion loses its depth because there are no conflicting strategies or misconceptions to compare, debate, and synthesize on the blackboard.

To address the massive spike in encoding errors through TTP, the teaching implications must focus heavily on the *Matome* (summing up) and *Naiseitsu* (reflection) stages of the lesson (Roorda et al., 2024). Because the students view the completion of the calculation as the end of their cognitive effort, the teacher must use the *Matome* phase to establish a classroom norm that a mathematical solution is incomplete without its contextual conclusion. During the whole-class reflection, the teacher can deliberately showcase student work on the board that includes proper units, labels, and final sentences, contrasting it with work that leaves the answer as a bare, unencoded number. This trains students to understand that in problem-solving, the final mathematical statement must loop back and directly answer the real-world question posed, thereby systematically eliminating the encoding habits observed in this data.

5. Findings

Under the Teaching through Problem-Solving (TTP) Approach, the learners are not excused from committing errors. The analysis of the written mathematical solutions of the thirty-two Grade 7 students using Newman's Error Analysis (NEA) reveals distinct, context-dependent error profiles across the two assessment problems, offering critical insights into how learning difficulties manifest within a Teaching Through Problem-Solving (TTP) environment. In Problem 1, which focused on Special Products, comprehending error emerged as the most frequent error in Problem 1 and Processing Error emerged as the least frequent. In addition, the students demonstrated adequate foundational literacy and basic computational skills, as evidenced by relatively low rates in Reading/Decoding errors (25%) and Process Skill errors (3.125%). However, severe performance bottlenecks emerged during the intermediate cognitive stages, with 34.375%

of the class committing Comprehending errors and 31.25% committing Transforming errors. This indicates that while the majority of learners could successfully decode the literal words and execute algebraic operations, nearly a third of the class struggled to bridge the gap between language and mathematical modeling, failing to interpret the problem's underlying context or determine how to "mathematize" the real-world scenario into correct mathematical expressions. Furthermore, an Encoding error rate of 25% was observed, suggesting a superficial perception of problem-solving where students prematurely halt their cognitive efforts immediately after obtaining a numerical result without validating if their final answer properly addresses the original question.

In contrast, the diagnostic data from Problem 2, which assessed the Division of Polynomials, Encoding errors emerged as the most frequent error and no student committed a Transformation error. The data also reveals a starkly inverted error distribution that underscores how the nature of a task alters student performance. For this problem, linguistic hurdles were largely absent, resulting in exceptionally low Reading/Decoding errors (9.375%) and Comprehending errors (6.25%). Most notably, the Transforming error rate dropped to 0%, proving that the required mathematical pathway was instantly obvious and that students experienced zero confusion regarding which arithmetic operation to select. With procedural execution also remaining highly successful—leaving only a 6.25% Process Skill error rate—the primary bottleneck shifted entirely to the final stage of problem-solving, where a substantial 34.375% of the class committed Encoding errors. This indicates that a lot of students are able to read/decode, comprehend, transform, and process however they were not able to reflect or check on their answers on why or what they are solving in the first place that is why a lot committed encoding errors. In other words, while students easily understood the task and successfully executed the polynomial long division or factoring algorithms, they overwhelmingly failed to formally state, properly label, or contextually wrap their final answers to align with the real-world situation posed in the problem text.

When synthesized through the lens of the TTP pedagogical framework, these contrasting error profiles provide clear, actionable implications for instructional design and classroom orchestration. The high frequencies of comprehension and transformation hurdles in Problem 1 demonstrate the essential need to maximize the *Neriage* (orchestrated classroom discussion) phase of a TTP lesson. Rather than resorting to traditional instruction that directly feeds formulas to students, educators must use these complex tasks to spark independent struggle, subsequently utilizing the blackboard during *Neriage* to publicly compare diverse student-generated ideas and explicitly guide learners on how textual relationships transform into algebraic models. Conversely, the 0% transformation error rate in Problem 2 reveals that the task lacked the necessary productive struggle required to stimulate high cognitive engagement, causing the problem to function as a routine computational exercise rather than a true problem. This deprives the TTP environment of diverse, conflicting student strategies to debate and synthesize. Ultimately, the pervasive presence of Encoding errors across both problems (25% and 34.375%) proves that students hold a systemic misconception that calculating a number is the absolute end of a mathematical task. To directly combat this habit, teachers must heavily reinforce the *Matome* (summing up) and *Naiseitsu* (reflection) stages of TTP by deliberately showcasing student work that includes proper labels and narrative units, thereby establishing a firm classroom norm that a mathematical solution is fundamentally incomplete without its contextual conclusion.

6. Conclusion

This research concludes that even under the Teaching Through Problem-Solving (TTP) approach, students remain susceptible to a variety of mathematical errors that can be systematically categorized using Newman's Error Analysis (NEA). The data demonstrates a shift in error patterns depending on the problem context; for instance, students struggled significantly more with Comprehending Errors in Problem 1 (34.375%) compared to Problem 2 (6.25%), indicating that linguistic hurdles and interpretation are major barriers in certain problem types. Conversely, Encoding Errors were prevalent in both tasks, reaching 34.375% in Problem 2, which signifies a tendency among learners to view "calculating correctly" as the end of the task rather than providing complete narrative or contextual closure. It also suggests that once students correctly transform a problem, they are generally capable of executing the required mathematical procedures. Ultimately, the study highlights that while TTP promotes productive struggle and active investigation, students require targeted scaffolding particularly at the comprehension and encoding stages to fully bridge the gap between procedural accuracy and meaningful mathematical communication.

7. References

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Appendix 1

Problem Set

1. Imagine you have a square garden with a side length of x meters, and you decide to change its shape by making one side 5 meters longer and the other side 5 meters shorter to form a rectangle.

a. Before you calculate anything, make a guess whether you think the new rectangular garden will have more, less, or the same amount of area as your original square garden. Why do you think so?

b. Solve the problem and check if your guess is correct or not.

c. Analyze why the area changed the way it did and use that to predict how much area you would lose or gain if you had changed the sides by 10 meters instead of 5.

2. You are a video game designer creating a new quest where the total number of treasure chest items is given by the expression $x^2 + 7x + 12$. You want to split these items equally among $(x + 3)$ different mystery boxes so that every box has the exact same amount.

a. Before you start your calculations, look closely at the numbers and make a guess about whether the items will fit perfectly into the mystery boxes or if there will be "leftovers". Why do you think so?

b. Solve the problem and check if your guess is correct or not.

c. Imagine you decided to increase the total treasure items to $x^2 + 7x + 15$ while keeping the mystery boxes at $(x + 3)$. Analyze how this small change would affect the outcome and explain what will happen to the content of the mystery boxes.

Appendix 2

Newman's Error Analysis

Newman's Error Analysis

Error type	Likely indicators	Suggested strategies for students
Reading/decoding	- Responses that show little or no engagement with the task - Responses that are consistent with an obvious misreading - Responses consistent with unfamiliarity with technical terms	Refer to, or create, a glossary of new words and their meaning in maths
Comprehending	- Responses showing only a superficial engagement with the task - Responses consistent with a different (but related) question from the one being asked	- Ask yourself 'what do I have to find out or show?' - Draw a diagram - Restate the problem in your own words
Transforming	- Responses consistent with a different (but related) question from the one being asked - Responses consistent with the right numbers being used but with the wrong operations (or in the wrong order)	- Guess and check - Make a list or table - Look for a pattern - Make the numbers simpler - Experiment or act it out - Be patient: most problems are not solved quickly nor on the first attempt
Processing	- Arithmetic errors - Procedural errors - Incomplete solutions	If one approach isn't working try a different one
Encoding	- Incomplete solutions - Responses that require some mathematical skill but which don't answer the question asked	- Does the answer make sense? - Have I answered the question fully?