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Where functions go wrong: Analyzing students' misconceptions and errors through Newman's lens

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Abstract

Functions are a fundamental concept in mathematics, yet many students struggle with their operations and applications. This qualitative descriptive study investigated the types of mathematical errors committed by Grade 11 students from two senior high schools in Davao del Norte, Philippines, focusing on performing operations on functions and solving related problems. Ten purposively selected students identified as struggling in mathematics took a 10-item validated test, followed by interviews. Data were analyzed using Newman's Error Analysis, covering reading, comprehension, transformation, process skills, and encoding errors. Results showed persistent errors across all categories, with common difficulties in interpreting mathematical symbols, composing and operating functions, translating problems into equations, applying correct procedures, and accurately presenting final answers. Contributing factors included limited conceptual understanding, inadequate problem-solving practice, insufficient prior knowledge, and incomplete curriculum coverage. The study highlights the need for targeted instructional interventions to develop both conceptual and procedural fluency in functions, offering implications for teachers, curriculum designers, and policymakers aiming to improve mathematics learning outcomes.

Keywords**:** Conceptual understanding; functions; mathematics education; procedural fluency; student errors.

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1. INTRODUCTION

Mathematics operates through its rules, principles, concepts, and applications, and one of these areas is concerned with functions. Functions are mathematical building blocks for predicting natural disasters, diagnosing diseases, designing machines, understanding world economies, keeping airplanes in the air (Yigiter, 2016), and some relationships in real-life phenomena (Denbel, 2015). This is fundamental in mathematics and is emphasized across all levels. However, despite this, students' understandings are still ingrained with misconceptions, especially in operating and solving problems involving functions (Walde, 2017). The lack of fundamental mathematical knowledge at the secondary level has been identified as a problem and has become a serious issue in mathematics education (Pagaran et al., 2022).

Globally, students focusing on understanding errors and difficulties in learning mathematics, mainly functions and algebra, were studied over the past decade (Uegatani et al., 2024; Jupri et al., 2014; Nurhayati et al., 2017; Julius et al., 2018; Refugio et al., 2020; Winarso & Toheri, 2021; Rong & Mononen, 2022). However, no study shows any intervention in addressing the students' errors.

Meanwhile, in the Philippines, senior high school learners exhibited a weak understanding of polynomial, exponential, and logarithmic functions (Gurat, 2018). Students can only learn more sophisticated mathematical concepts by mastering these prerequisites. Students make mathematical, strategic, and logical errors in solving mathematical problems involving functions when they encounter learning difficulties in comprehending operations, rules, formulas, and procedures, and have limited exposure to substantial mathematical tasks.

From the studies above, the issues with students' performance in mathematics, primarily in the errors in operating and solving problems involving functions, are evident. Thus, this study will further explore students' errors using Newman's Error Analysis and develop an intervention that will address these errors. In the long run, this study will serve as a basis to improve students' understanding of the mentioned concept and their performance in general; that will serve as a guide for the curriculum specialist, administrator, and policymakers for the revision of current school rules and policies, regulations, and internal modalities that restrain teachers and students in the learning process, which will also ultimately improve the schools' performance.

1.1. Literature review

1.1.1. Performing operations on functions

Function operations are the procedures and rules to use and follow in solving functions. These include addition, subtraction, multiplication, division, and composition, for which there is a certain way to deal with each and where errors arise. Analyzing the operation of a function presents several challenges, each of which may be classified according to the nature of the error or difficulty encountered. Research conducted by Dewi et al. (2020) clearly stated that errors made by students when solving problems about functions seen from mathematical objects include (1) conceptual errors, namely, students making mistakes when concluding the value of a function, and students making mistakes in determining the method or steps to solve the function. Functions, for example, in questions of primitive forms, because students do not understand the limit properties of functions, (2) the main error is that students do not understand.

In the concept of determining the area of the proportional function area, students do not understand the concept of exponents, and students misinterpret the rules that apply to mathematical operations, (3) procedural errors, namely, students incorrectly answering the procedure, misunderstanding being tricked through the screen, and need to be corrected in the substitution process. This failure was caused by students needing help understanding the concepts, facts, and principles of the operation of function material. The relatively low ability of students to operate with function material can be attributed to several factors (Dewi et al., 2020).

1.1.2. Solving word problems involving functions

Students can make various errors while attempting to solve problems, which are classified into conceptual and procedural errors. Conceptual errors can be incorrect formulas, misinterpretations, inaccurate formula typing, or failure to write equations to answer. Meanwhile, there are seven types of procedural errors that students commonly make: inability to perform procedures such as drawing a line; failing to grasp the problem's purpose; incorrectly substituting variable values into formulas; mistakes brought on by a lack of proficiency with algebraic concepts; performing arithmetic operations incorrectly; and drawing conclusions without valid reasons (O'Connor & Norton, 2016).

In a study conducted by Walde (2017), students need help with several difficulties, have incorrect notions, and have inaccurate concept representations concerning the concept of functions. The main limiting factors are the student's English language proficiency, a lack of conceptual background, and problems comprehending the meaning. Moreover, in a study conducted by Irham (2019) in Indonesia, he found that conceptual errors, algebraic operational errors, and comprehension of problem-solving instructions were shown to be systemic in low-ability students' problem-solving. Meanwhile, there are adding operations and concluding mistakes among the high-ability skills. Group learning, intense practice problems, and developing knowledge of the function operations could help, and high-ability students should work in a more conducive learning setting (Irham, 2019).

Furthermore, students' difficulties in learning functions can be attributed to several specific challenges, including the inability to: identify examples and non-examples of functions; articulate the formal definition of a function; determine its domain, codomain, and range; construct accurate arrow and Cartesian diagrams; compute the value of a function for a given variable; and formulate appropriate function equations (Muzaki & Kurniawan, 2020). Students' inability to learn the function was due to inappropriate methods and techniques of learning. Instead of understanding the concept of function, students memorize it, which makes it hard to solve mathematical problems involving functions. Moreover, it was also found that the students must be more capable of performing algebraic operations that lead to an incorrect solution and cannot translate real-life problems into an algebraic form.

1.2. Purpose of study

This study explores the challenges Grade 11 students face in understanding and applying functions, a foundational concept in mathematics. Despite the importance of functions in higher-level mathematics, research indicates persistent difficulties in performing operations and solving related problems, yet few studies systematically analyze the types of errors underlying these difficulties. The study aimed to investigate the nature and sources of errors committed by students when performing operations on functions and solving associated problems.

2. METHOD AND MATERIALS

This study employed a qualitative descriptive research design, which provides a straightforward account of participants' experiences without requiring deeper theoretical framing (Kim et al., 2017; Sandelowski, 2010). The focus was on identifying mathematical errors of Grade 11 students in General Mathematics competencies: performing operations on functions and solving function-related problems, using Newman's Error Analysis (NEA). A similar design was used by Triliana and Asih (2019) in analyzing probability-solving errors.

2.1. Participants

Ten struggling Grade 11 students from two senior high schools in Davao del Norte were selected through purposive sampling (Ritchie et al., 2013). As participants were minors, parental and student consent were obtained following ethical guidelines (Sanjari et al., 2014; Orb et al., 2001). A vernacular video explaining the study's purpose, objectives, and benefits was provided, along with an information sheet and consent form.

2.2. Data collection instrument

The instrument consisted of a validated 10-item multiple-choice test aligned with the competencies and NEA framework, reviewed by two mathematics teaching experts. After test administration, three students were interviewed individually, and responses were transcribed verbatim. Error analysis followed NEA's five stages: reading, comprehension, transformation, process skills, and encoding (White, 2010). Confidentiality and anonymity were assured throughout data collection and analysis.

3. RESULTS

3.1. Reading error

Reading error is the first stage of Newman's Error Analysis Model, which is defined by the ability of the learners to read the given mathematical problems and identify the sentences and mathematical symbols used (Abdullah et al., 2015). When the learners have difficulties reading the text, they will also struggle to comprehend what is being asked (Brown & Skow, 2016). In this section, reading errors of the learners are analyzed, and it is apparent that reading mathematics symbols remains a great concern.

Learners' response to the questionnaire and interview revealed their incapability in reading symbols such as parentheses "()", fraction bar "/", greater than or equal to "≥ ", pi "π", and are often confused to read "-" as either negative or minus. One of the learners does not know where to begin while reading the supplied problem, so she skips over the part where she is supposed to say $h(x) = x - 1$ and $d(x) = 7x + 3$ (h of x is equal to x minus 1 and d of x is equal to 7x plus 3). In addition, most of the learners are not familiar with the composition of functions and are not able to read $(f \circ g)(x)$, making them unable to proceed to the next stage of solving the given question. One of the learners claimed that this was because they were not taught by their teacher about the composition of functions, even though the competencies focused on this study should be tackled in the first week of the first quarter of the school year.

In most of the events, participants exhibited confusion and difficulty in reading mathematical symbols. This suggests that they are unfamiliar with their usage, which hinders them from progressing to the next steps in solving problems. Difficulty in interpreting symbols indicates a lack of understanding of the problem itself. Many of the selected participants committed similar errors, particularly in reading symbols, a difficulty that stems from assigning vague or imprecise meanings to them. Consequently, these difficulties impede students' ability to construct an accurate conceptual representation of the problem and to discern the functional relationships involved. Such deficiencies in symbolic literacy increase their susceptibility to cognitive overload when transitioning to college-level mathematics.

According to Mulwa (2015), many students have trouble with the operation of functions because of the need to use mathematical terminology and associated ideas, and these ideas (i.e., mathematical symbols) are not often understood. Mathematical symbols obstruct students' grasp of mathematical concepts and their ability to offer answers to a given problem (Mutodi & Mosimege, 2021). These issues with reading and the usage of mathematical symbols also affect conceptual comprehension and mastery; thus, it is important to recognize and fix any pronunciation and reading errors (Vieira et al., 2024; Prakitipong & Nakamura, 2006; Chirume, 2012; Abdullah et al., 2015).

3.2. Comprehension error

Comprehension error refers to a student's ability to read a problem without fully understanding its intent or what is being asked (Abdullah et al., 2015). These errors may occur when students understand individual lexical items but fail to integrate them into a coherent representation of the problem or specific mathematical terms. They may also emerge when students struggle to extract relevant mathematical meaning from texts, graphs, tables, or other representational forms (BOSTES, 2016). Such deficiencies in comprehension often lead to downstream errors in the transformation, processing, and encoding stages (Abdullah et al., 2015).

In this study, participants exhibit difficulties in understanding the overall problem and some specific terms in the problem, such as the given function, composition, and volume. Most of the participants knew the operation was to be used but did not fully understand what functions to operate. For example, they know that they were asked to find the sum, but instead of saying that they are to find the sum of h(x) and d(x), the participant said the sum of x. Moreover, some participants do not understand what a composition of functions is and instead classify it as division.

Above all, the abovementioned difficulty is even more prevalent in the worded problems, especially in getting the context clues or key terms. In several instances, participants defaulted to everyday, non-mathematical meanings of technical vocabulary. For example, when asked to define *volume*, one participant associated it with sound rather than its geometric meaning, illustrating a semantic misalignment between colloquial and mathematical language. Such misunderstandings highlight the role of linguistic competence in mathematical comprehension and problem-solving efficacy.

Accordingly, most of the participants were able to comprehend the problem statement; they were unable to identify and apply the appropriate functional concept required for its solution, suggesting that the participants have trouble recalling the different types of functions, as well as their corresponding processes and concepts, which then makes it difficult for the participants to generate accurate solutions.

Siniguian (2017) mentioned that students who have difficulties in comprehending, translating problems into mathematical equations, and the inability to use correct mathematics imply a need for mastering mathematical concepts and formulas on the part of the mathematics learners to lessen errors in solving mathematical problems and in constructing mathematical equations in a well-developed manner to come up with the correct solution. Hence, the findings underscore that comprehension errors in mathematics are not merely a matter of reading ability but stem from deeper conceptual and linguistic gaps, necessitating targeted interventions that strengthen both mathematical language proficiency and conceptual mastery to reduce error incidence and enhance problem-solving performance.

3.3. Transformation error

Transformation error occurs when students comprehend the demands of the issue but fail to identify the mathematical operations involved (Abdullah et al., 2015). Students with a limited comprehension of the formula struggle when trying to determine which formula to use to solve the problem successfully (Mardiyana, 2017). Thus, transformation errors reflect a disconnect between problem comprehension and procedural knowledge, highlighting the need for strengthened conceptual–procedural integration in mathematics learning.

This study found that the students were able to read and understand the requirements needed for the question. Participants also demonstrated difficulties in the transformation process, as their solutions relied solely on addition and multiplication, overlooking the required subtraction operation. Responses revealed additional challenges, including difficulty in verbally articulating their solution process despite being able to represent it in writing. For instance, when asked how to solve the problem, a student would state "to add" without providing any rationale for the choice of operation.

Although participants could identify the appropriate operation for the given problem, they struggled to recall the procedure for solving it, often attributing their limited familiarity to prior exposure in class rather than genuine conceptual understanding. Moreover, two of the participants do not seemingly understand what the given word problem implies. One student specifically stated that they do not know how to solve it, hence, they do not have any answers for the given problem. This indicates that when a student cannot understand the problem, they also do not know how to derive the worded problem into a solution.

Due to poor comprehension of questions, particularly word problems, participants demonstrated limited ability to make reasonable assumptions and had little understanding of the problem context. This weakness was evident in their inability to accurately translate problem statements into corresponding mathematical equations, often resulting in the application of incorrect solution processes. Such errors also reflect a weak foundation in the operations of functions, as participants were unable to identify the relevant properties and operations needed to solve either equations or word problems. Consequently, the inability to transform a verbal statement into its mathematical equivalent serves as a clear indicator of inadequate problem understanding.

Overall, when the participants lack understanding, it will then imply that they cannot transform their worded sentences. They find it hard to understand since their knowledge about operations on functions only relies on basic operations such as adding and subtracting, and when they are presented with complicated problems, they cannot understand them.

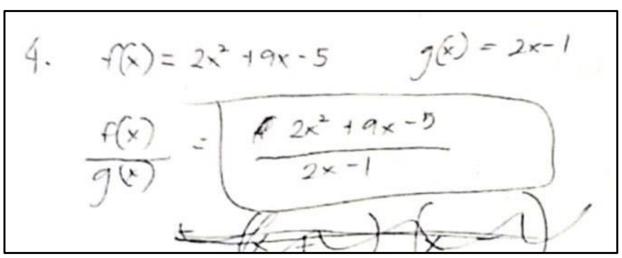
3.4. Process skills error

Process Skills error occurs when students are unable to execute the required procedure accurately (Abdullah et al., 2015; Brown & Skow, 2016). In problem solving, such errors often stem from deficiencies in language fluency and conceptual understanding (Prakitipong & Nakamura, 2006). Effective problem solving requires that students fully grasp the meaning of the question to process it mathematically and arrive at the correct solution (Abdullah et al., 2015). In this study, process skills errors were observed in both problem-solving tasks and exercises involving operations on functions.

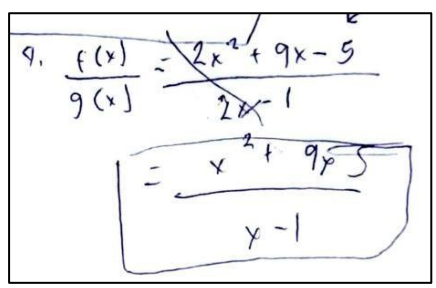
As observed in Figures 1 (a, b, c, d), participants have difficulties in dividing functions. One of the learners provided a blank solution because she did not know how to answer the given item. Participants struggle in finding the factors of $2x^2 + 9x - 5$ as they have misconceptions in canceling values of the numerator and the denominator. In Figure 1.4, the participant derived the correct solution; however, the steps he took were not the standard way of solving, that is, applying long division or the synthetic method.

Figure 1

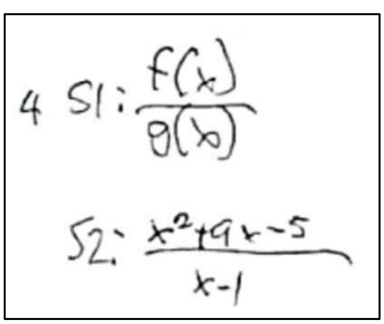
Difficulties in dividing functions

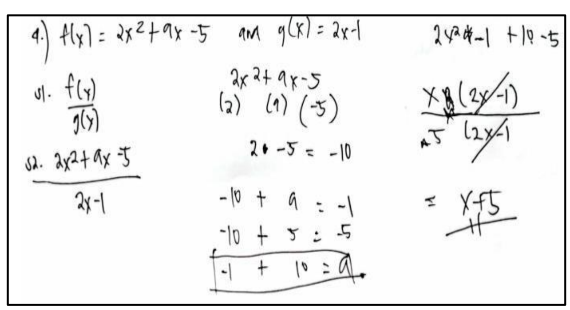


a



b



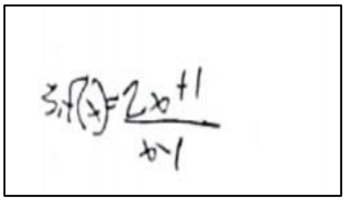


d

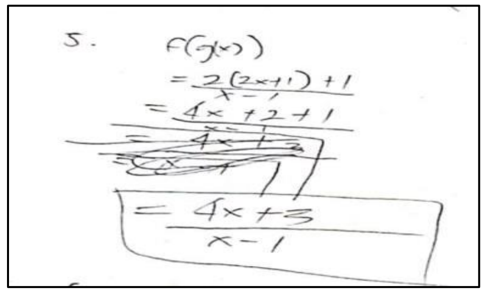
As observed in Figure 2 (a, b, c, d), the learners exhibited errors in performing function composition, particularly in executing the correct procedural steps and accurately substituting values. As observed in most of the participants' solutions, they only substituted the value of x in the numerator of f(x) with g(x) and neglected to perform the substitution in the denominator. As one of the participants said, they were not taught how to operate compositions of functions with rational functions. She added that she is only used to solving the composition of functions in a polynomial form. Figure 2a presents no solution. Participant claimed that she has no idea what operation is being performed.

Figure 2

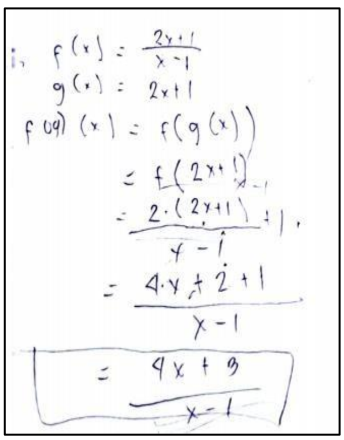
Errors in performing function composition

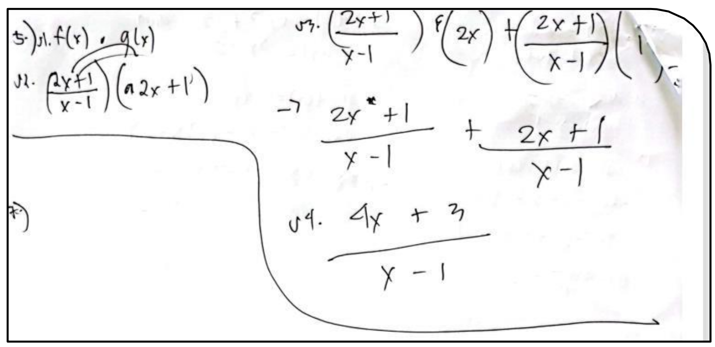


a



c



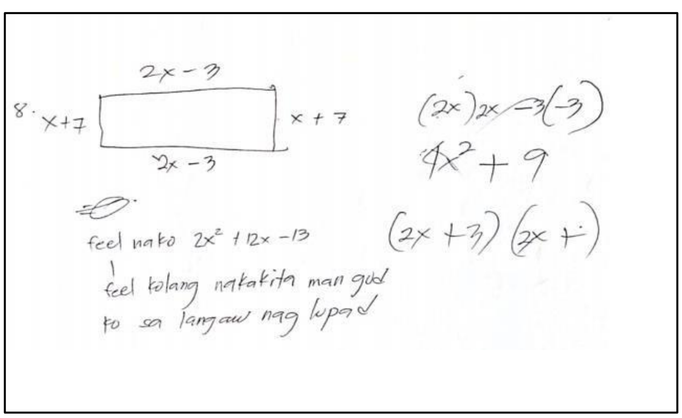


b

d

Figure 3

Errors in showing the complete solution or the process of arriving at the correct answer



In addressing word problems, most participants were unable to present a solution due to unfamiliarity with this problem type. As noted by Participant 1, word problems had not been introduced in their classes, resulting in an inability to process and solve such tasks. Participant 5 reported a similar experience to Participant 1, adding that the topic was not covered in class because the examination period was approaching. In worded problems involving geometry, most participants have errors in showing the complete solution or the process of arriving at the correct answer (see figure 3) because they cannot recall the definition of the area of a shape and volume of a solid, and their corresponding formulas. Similarly, the solution of other participants was blank. Participant 1 stated that her understanding of Geometry was underdeveloped due to the modular learning setup implemented during the COVID-19 pandemic.

The basic education mathematics framework aims to develop critical thinking and problem-solving skills among elementary and high school learners. They are expected to have a solid foundation of necessary concepts and life skills (TIMSS, 2019). However, in this analysis, it is apparent that the important mathematics concepts that learners should acquire in their basic education were not evident among the participants. In addition, as Participants 1 and 5 reported that their teacher was unable to cover the topics on function composition and solving word problems involving functions, despite these being scheduled for discussion during the first week of the semester. Consequently, they were unable to develop familiarity with such problems, resulting in process skills errors. This suggests a continued reliance on teacher-led instruction despite the learner-centered orientation of the current curriculum. Teachers play a major role in students' understanding of mathematics, as their methods of imparting knowledge assist in assimilation (Li et al., 2024).

According to Naing & Nyein (2018), learners must have mathematics process skills, especially in problem-solving skills and logical reasoning, to apply their skills to new situations in their life and work. As supported by the Department of Education, Filipino learners must be holistic citizens who are competent, skilled, and values-driven lifelong learners and future employees (TIMSS, 2019). Given that mathematics is learned not only in high school but also in college, correcting the process skills errors of the students in mathematics is imperative.

3.5. Encoding error

Encoding error is the fifth stage of Newman's Error Analysis, which is characterized as a student's failure to write the answers accurately, their inability to demonstrate the accuracy of the answer, or their failure to write the answer's conclusion (Fitriani et al., 2018). An encoding error occurred because students were not accustomed to writing conclusions after each work on math problems, let alone to checking the truth of answers. Because the students believed that the most important thing was that they got answers from the given mathematical problem (Fitriani et al., 2018).

Most students have arrived at the wrong answer due to a careless error in procedure, which includes adding integers and adding integers with unlike signs. Furthermore, the results show that participants have just randomly selected the letter of their answer, failing to show the procedure for deriving the correct answer. Mostly, the participants were able to encircle the answer based only on what was near their answer. They finalize their answers without reviewing why none of their solutions and final answers are in the options. Most participants are just guessing their answer based on their conceptualization.

4. DISCUSSION

In most cases, participants committed careless and procedural errors. Although most participants comprehended the problem statement, they were unable to identify and apply the appropriate functional concept required for its solution. For instance, Participant 1 understood the problem but failed to obtain the correct answer due to a careless error in adding integers. Similarly, Participant 2 derived the correct solution but encircled an incorrect option, also classified as a careless error. Such recurring mistakes suggest difficulties in recalling the different types of functions along with their corresponding processes and concepts, thereby hindering the participants' ability to arrive at accurate solutions.

As previously noted, most of the participants have committed careless and procedural errors. Consequently, when students have accurately read and grasped the problem but have chosen not to seek solutions, this is considered careless. Because the student had never found the problem and worked on a problem similar to that, carelessness arose. Although they were aware that the notion of different functions should be applied, the students had trouble deciding how to approach the problem; therefore, they ultimately decided against solving it (Fitriani et al., 2018). The findings, therefore, revealed that most participants made mistakes when attempting to solve mathematical conundrums involving different types of functions; thus, an intervention is needed.

A majority of students arrived at incorrect answers due to procedural carelessness, including computational errors in adding integers and combining integers with unlike signs. Furthermore, results indicate that some participants appeared to select their answers at random, without demonstrating the procedural steps necessary to derive the correct solution. In most cases, the participants can encircle the answer based only on what is near their answer. They finalize their answers without reviewing why none of their solutions and final answers are in the options. More often than not, the participants are just guessing their answer based on what they feel is right and encircle the answers randomly.

Furthermore, Students experienced difficulty in solving the problem due to forgetting fundamental mathematical operations and properties, including the rules for signed numbers and key principles such as the distributive property of equality. Participants have shown the procedure in which they derived the answer of $6x^3+2x^2-3x^1-1$ instead of $6x^3+2x^2-3x-1$. This mistake can be classified as a careless error. The results also show the misconception of participants regarding math symbols and the application of symbols, and the basic methods and properties to solve the problem. In addition, it was also shown that students have no background in world problems, which gives difficulty in answering the problem.

5. CONCLUSION

This study revealed that Grade 11 students face persistent and multi-layered difficulties in performing operations on functions and solving related problems, as analyzed through Newman's Error Analysis framework. Errors were evident at all five stages: reading, comprehension, transformation, process skills, and encoding, stemming from limited conceptual understanding, weak procedural fluency, inadequate exposure to problem-solving tasks, and insufficient mastery of mathematical symbols and language. Contributing factors included incomplete curriculum coverage, lack of problem-solving practice, and reliance on rote learning. These findings highlight a pressing need for targeted instructional strategies that integrate conceptual clarity with procedural mastery, ensuring that students can both understand and apply function concepts effectively.

To address these gaps, it is recommended to strengthen symbolic and conceptual literacy, provide varied and contextualized problem-solving practice, adopt scaffolded instruction for complex topics, integrate formative error analysis to monitor misconceptions, offer targeted professional development for teachers, and ensure complete curriculum coverage and alignment to support the development of both conceptual and procedural fluency in learning functions.

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Approval: The study adheres to the ethical guidelines for conducting research.

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REFERENCES

Abdullah, A. H., Abidin, N. L. Z., & Ali, M. (2015). Analysis of students' errors in solving Higher Order Thinking Skills (HOTS) problems for the topic of fractions. *Asian Social Science*, *11*(21), 133. https://www.researchgate.net/profile/Abdul-Abdullah-7/publication/282602742_Analysis_of_Students'_Errors_in_Solving_Higher_Order_Thinking_Skills_HOTS_Problems_for_the_Topic_of_Fraction/links/56279a3f08aed9017d45fdea/Analysis-of-Students-Errors-in-Solving-Higher-Order-Thinking-Skills-HOTS-Problems-for-the-Topic-of-Fraction.pdf

BOSTES. (2016). Error analysis: Mathematics K–6 support document for students with special education needs.

Brown, J., & Skow, K. (2016). Mathematics: Identifying and Addressing Student Errors. The Iris Center.

Chirume, S. (2012). How does the use of mathematical symbols influence the understanding of mathematical concepts by secondary school students?. *International Journal of Social Sciences & Education*, *3*(1). https://www.academia.edu/download/32190767/Paper-05.pdf

Denbel, D. G. (2015). Functions in the Secondary School Mathematics Curriculum. *Journal of Education and Practice*, *6*(1), 77-81. https://eric.ed.gov/?id=EJ1083845

Dewi, S. D. A. S., Roza, Y., & Maimunah, M. (2020). Faktor penyebab siswa tidak dapat menyelesaikan soal materi limit fungsi aljabar. *Jurnal Penelitian Dan Pengkajian Ilmu Pendidikan: E-Saintika*, *4*(2), 134.

Fitriani, H. N., Turmudi, T., & Prabawanto, S. (2018). Analysis of students' errors in mathematical problem solving based on Newman's error analysis. In *International Conference on Mathematics and Science Education*, 3(1), 791-796. http://download.garuda.kemdikbud.go.id/article.php?article=891270&val=13975&title=Analysis%20of%20students%20error%20in%20mathematical%20problem%20solving%20based%20on%20Newmans%20error%20analysis

Gurat, M. (2018). Exploring students' image concept of mathematical functions through error analysis. https://philpapers.org/rec/GURESI

Irham. (2019). Conceptual Errors of Students in Solving Mathematics Problems on the Topic of Function. Advances in Social Science, Education, and Humanities Research.

Julius, E., Abdullah, A. H., & Suhairom, N. (2018). Attitude of students towards solving problems in algebra: A review of Nigerian secondary schools. *IOSR Journal of Research & Method in Education*, *8*(1), 26-31.

Jupri, A., Drijvers, P., & van den Heuvel-Panhuizen, M. (2014). Student difficulties in solving equations from an operational and a structural perspective. *Mathematics Education*, *9*(1), 39-55. https://dspace.library.uu.nl/handle/1874/303417

Kim, H., Sefcik, J. S., & Bradway, C. (2017). Characteristics of qualitative descriptive studies: A systematic review. *Research in nursing & health*, *40*(1), 23-42. https://onlinelibrary.wiley.com/doi/abs/10.1002/nur.21768

Li, R., Cevikbas, M., & Kaiser, G. (2024). Mathematics teachers' beliefs about their roles in teaching mathematics: orchestrating scaffolding in cooperative learning. *Educational Studies in Mathematics*, *117*(3), 357-377. https://link.springer.com/article/10.1007/s10649-024-10359-9

Mardiyana, M. (2017). Error analysis of problem solving using the Newman stage after applying cooperative learning of the TTW type. In *AIP Conference Proceedings* (Vol. 1913, No. 1). AIP Publishing. https://pubs.aip.org/aip/acp/article-abstract/1913/1/020028/744644

Mulwa, E. C. (2015). Difficulties encountered by students in the learning and usage of mathematical terminology: A critical literature review. *Journal of Education and Practice*, *6*(13), 27-37. https://eric.ed.gov/?id=EJ1080447

Mutodi, P., & Mosimege, M. (2021). Learning mathematical symbolization: Conceptual challenges and instructional strategies in secondary schools. *Bolema: Boletim de Educação Matemática*, *35*, 1180-1199. https://www.scielo.br/j/bolema/a/nHVdpBMTykbcxB4MM7rPD8c/

Muzaki, A., & Kurniawan, A. (2020). Analysis of Students' Ability In Solving Relation and Functions Problems Based on Learning Indicators. In *Journal of Physics: Conference Series, 1464*(1), 012027. https://iopscience.iop.org/article/10.1088/1742-6596/1464/1/012027/meta

Naing, N. T., & Nyein, H. (2018). An Investigation into the Mathematics Process Skills of the Middle School Students. J. Myanmar Acad. Arts Sci.

Nurhayati, D. M., Herman, T., & Suhendra, S. (2017). Analysis of secondary school students' algebraic thinking and math-talk learning community to help students learn. In *Journal of Physics: Conference Series, 895*(1), 012054. https://iopscience.iop.org/article/10.1088/1742-6596/895/1/012054/meta

O'Connor, B. R., & Norton, S. (2016). Investigating Students' Mathematical Difficulties with Quadratic Equations. *Mathematics Education Research Group of Australasia*. https://eric.ed.gov/?id=ED572345

Orb, A., Eisenhauer, L., & Wynaden, D. (2001). Ethics in qualitative research. *Journal of Nursing Scholarship*, *33*(1), 93-96. https://sigmapubs.onlinelibrary.wiley.com/doi/abs/10.1111/j.1547-5069.2001.00093.x

Pagaran, G. M., Loremas, M. L., Gultiano, J. D., & Etcuban, J. O. (2022). Mathematics performance of senior high school students in blended learning amidst the COVID-19 pandemic. *Journal of Positive School Psychology*, *6*(6), 10593-10613.

Prakitipong, N., & Nakamura, S. (2006). Analysis of the mathematics performance of grade five students in Thailand using the Newman procedure. *Journal of International Cooperation in Education, 9*(1), 111-112.

Refugio, C. N., Bulado, M. I. E. A., Galleto, P. G., Dimalig, C. Y., Colina, D. G., Inoferio, H. V., & Nocete, M. L. R. (2020). Difficulties in Teaching Senior High School General Mathematics: Basis for Training Design. *Cypriot Journal of Educational Sciences*, *15*(2), 319-335. https://eric.ed.gov/?id=EJ1252659

Ritchie, J., Ormston, R., McNaughton Nicholls, C., & Lewis, J. (2013). Qualitative research practice: A guide for social science students and researchers. https://www.torrossa.com/gs/resourceProxy?an=5017584&publisher=FZ7200

Rong, L., & Mononen, R. (2022). Error analysis of students with mathematics learning difficulties in Tibet. *Asian Journal for Mathematics Education*, *1*(1), 52-65. https://journals.sagepub.com/doi/abs/10.1177/27527263221089357

Sandelowski, M. (2010). What's in a name? Qualitative description revisited. *Research in nursing & health*, *33*(1), 77-84. https://onlinelibrary.wiley.com/doi/abs/10.1002/nur.20362

Sanjari, M., Bahramnezhad, F., Fomani, F. K., Shoghi, M., & Cheraghi, M. A. (2014). Ethical challenges of researchers in qualitative studies: The necessity to develop a specific guideline. *Journal of medical ethics and history of medicine*, *7*, 14. https://pmc.ncbi.nlm.nih.gov/articles/PMC4263394/

Siniguian, M. T. (2017). Students' difficulty in solving mathematical problems. *International Journal of Advanced Research in Engineering and Applied Sciences*, *6*(2), 1-12.

TIMSS. (2019). Philippines: IEA.

Triliana, T., & Asih, E. C. M. (2019). Analysis of students' errors in solving probability based on Newman's error analysis. In *Journal of Physics: Conference Series, 1211*(1), 012061. https://iopscience.iop.org/article/10.1088/1742-6596/1211/1/012061/meta

Uegatani, Y., Otani, H., Shirakawa, S., & Ito, R. (2024). Real and illusory difficulties in conceptual learning in mathematics: comparison between constructivist and inferentialist perspectives. *Mathematics Education Research Journal*, *36*(4), 895-915. https://link.springer.com/article/10.1007/s13394-023-00478-6

Vieira, A. P. A., Peng, P., Antoniuk, A., DeVries, J., Rothou, K., Parrila, R., & Georgiou, G. (2024). Internalizing problems in individuals with reading, mathematics, and unspecified learning difficulties: A systematic review and meta-analysis. *Annals of Dyslexia*, *74*(1), 4-26. https://link.springer.com/article/10.1007/s11881-023-00294-4

Walde, G. S. (2017). Difficulties of the concept of function: The case of general secondary school students of Ethiopia. *International Journal of Scientific & Engineering Research*, *8*(4), 1-10. https://www.researchgate.net/profile/Getinet-Seifu/publication/316644105_Difficulties_of_concept_of_function_The_case_of_general_secondary_school_students_of_Ethiopia/links/59098171aca272f658fc02b5/Difficulties-of-concept-of-function-The-case-of-general-secondary-school-students-of-Ethiopia.pdf

White, A. L. (2010). Numeracy, Literacy, and Newman's Error Analysis. *Journal of Science and Mathematics Education in Southeast Asia*, *33*(2), 129-148. https://eric.ed.gov/?id=EJ970194

Winarso, W., & Toheri, T. (2021). An analysis of students' errors in learning mathematical problem solving: The perspective of David Kolb's theory. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, *12*(1), 139-150. https://dergipark.org.tr/en/pub/turkbilmat/article/753899

Yigiter, I. (2016). Applications of Functions in Daily Life. https://tinyurl.com/3ere7k8c