

A Predictive-Correlational Study of Error Patterns in the Four Fundamental Operations as Predictors of Mathematical Problem-Solving Performance Among Grade 6 Learners in Portlamon Elementary School, Division of Surigao del Sur: Basis for a Targeted Mathematics Intervention Program

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Date Submitted:
August 25, 2026

Date Accepted:
September 20, 2026

Date Published:
October 09, 2026

DOI:
10.5281/zenodo.23264212

ABSTRACT

This study examined error patterns in the four fundamental operations as predictors of mathematical problem-solving performance among Grade 6 learners at Portlamon Elementary School, Division of Surigao del Sur, as a basis for developing a targeted mathematics intervention program. A quantitative predictive-correlational research design was employed involving 31 Grade 6 learners with complete and valid responses. Researcher-made tests measured learners' performance and error patterns in addition, subtraction, multiplication, and division, as well as problem-solving performance across Grade 6 mathematics domains. Data were analyzed using weighted mean, standard deviation, rank ordering, Pearson product-moment correlation, and multiple linear

regression. Findings revealed very low overall performance in the four fundamental operations, with 58.55% accuracy, and low mathematical problem-solving performance at 38.39%. Multiplication obtained the highest accuracy, while division showed the weakest performance. The overall relationship between fundamental-operation performance and mathematical problem-solving was positive, moderate, and statistically significant ($r = .5972$, $p = .00039$). Subtraction, multiplication, and division were significantly related to problem-solving performance, whereas addition was not. Multiple regression further showed that the four operation-based indicators collectively significantly predicted mathematical problem-solving performance, $F(4, 26) = 3.790$, $p = .0148$, explaining 36.8% of the variance, although no individual operation emerged as a significant unique predictor. Based on these findings, a targeted mathematics intervention program was proposed, emphasizing division, subtraction, fraction and decimal computation, proportional reasoning, percentage applications, and multi-step problem solving to strengthen learners' foundational computational skills and mathematical problem-solving performance.

Keywords: *error patterns, fundamental operations, mathematical problem-solving, predictive-correlational study, mathematics intervention*

INTRODUCTION

Mathematical problem-solving performance is a crucial educational outcome because it reflects whether learners can interpret quantitative situations, select appropriate strategies, and use basic computations meaningfully in real contexts. In elementary mathematics, problem solving has been described as the heart of mathematics teaching and learning, while word-problem tasks require learners to read a situation, identify relevant quantities, determine an approach, and use computation to arrive at a

solution (Stevens et al., 2024; Suseelan et al., 2022). Moreover, mastery of computation in the four fundamental operations provides an important foundation for higher-level mathematics, including problem solving, making this dependent variable especially significant among upper-elementary learners (Nelson & Powell, 2018).

Globally, mathematical problem-solving performance remains a major learning concern. In PISA 2022, mean mathematics performance across OECD countries fell by almost 15 score points compared with 2018, which OECD equated to roughly three-quarters of a year of schooling lost, and 31% of students performed below Level 2 while only 69% reached at least Level 2 proficiency in mathematics (OECD, 2023a). These figures indicate that a substantial proportion of learners worldwide still struggle with the level of mathematical reasoning, modelling, and solution selection needed for successful problem solving in school and real-life settings.

The Asian and Southeast Asian context shows both high achievement and deep disparity. In PISA 2022, more than 85% of students in Singapore, Macao (China), Japan, Hong Kong (China), Chinese Taipei, and Estonia attained at least Level 2 proficiency in mathematics, and the share of top performers reached 41% in Singapore and 23% in Japan and Korea (OECD, 2023b). In contrast, SEA-PLM 2019 found that only 35% of Grade 5 learners across six participating Southeast Asian countries performed at Band 6 or above in mathematics, meaning that about two in three had not yet reached that level; the report also documented wide variation, with 1% to 57% of learners across countries showing mathematical proficiency comparable only to the first years of primary school (UNICEF & SEAMEO, 2020). These regional contrasts suggest that strong mathematical problem solving in Asia depends heavily on the quality of foundational numeracy developed in the primary grades.

The Philippine situation is particularly concerning. In PISA 2022, the Philippines posted an average mathematics score of 355 compared with the OECD average of 472, and only 16% of Filipino students attained at least Level 2 proficiency in mathematics, while almost no students reached Levels 5 or 6 (OECD, 2023b, 2023c). At the primary level, the Southeast Asia Primary Learning Metrics 2019 National Report of the Philippines stated that the country's average scores in reading, mathematics, and writing were below the average scores of the other participating countries, indicating persistent weaknesses in foundational and applied learning outcomes before secondary school (Department of Education et al., 2021). These national results underscore the urgency of studying mathematics performance earlier, particularly in areas closely linked to later problem solving, such as computational accuracy and error patterns in the four fundamental operations.

This concern is also evident in the Caraga and Surigao del Sur context. DepEd Caraga reported that the percentage of Grade 6 learners achieving at least "Proficient" in the National Achievement Test increased from 2.29% in School Year 2021–2022 to 20.61% in School Year 2023–2024; although this reflects improvement, it also means that most learners still remained below the proficient benchmark (Department of Education–Caraga Region, 2025). At the division level, the Schools Division of Surigao del Sur issued memoranda in 2024 on the administration of the Rapid Mathematics Assessment and on the analysis of Rapid Mathematics Assessment results with corresponding intervention planning, indicating continuing concern over foundational mathematics gaps among learners in the division (Department of Education–Division of Surigao del Sur, 2024a, 2024b). In a public elementary school such as Portlamon Elementary School, these regional and divisional realities make it necessary to examine whether weaknesses in basic operations are already affecting the mathematical problem-solving performance of Grade 6 learners.

In the present study, the predictor variable is error patterns in the four fundamental operations. Computation error analysis is important because it helps identify whether learner mistakes stem from procedural, conceptual, place-value, or operation-selection misunderstandings, and prior research has shown that computation mastery supports higher-level mathematical skills such as problem solving (Nelson & Powell, 2018). Likewise, mathematical problem solving depends not only on interpreting the text of a

problem but also on choosing and executing the correct computations once an approach has been selected (Stevens et al., 2024). Although previous studies have examined error patterns and mathematics problem solving, many have focused on third-grade learners with mathematics difficulty or on Grade 10 learners, and several have used descriptive or mixed-method approaches rather than testing operation-specific error patterns as predictors of problem-solving performance in a Grade 6 public elementary setting (Campanilla & Mendoza, 2024; Nelson & Powell, 2018). Suseelan et al. (2022) also noted that elementary mathematics problem-solving research commonly centers on arithmetic and representations, which further supports the relevance of studying foundational operations. Based on this pattern in the literature, empirical evidence remains limited on whether error patterns in addition, subtraction, multiplication, and division can significantly predict mathematical problem-solving performance among Grade 6 learners in Portlamon Elementary School, Division of Surigao del Sur. This gap justifies the present predictive-correlational study.

Literature Review Review of Related Literature and Studies

Error Patterns in the Four Fundamental Operations

Error patterns in the four fundamental operations refer to recurring and classifiable mistakes that learners commit while performing addition, subtraction, multiplication, and division. In this study, the variable is anchored on a researcher-made computation test designed to capture not only whether a response is correct or incorrect, but also the type of error reflected in the learner's answer choices. This view is consistent with the Philippine mathematics curriculum, which treats number and algebra competencies, operational fluency, and real-life problem solving as interconnected outcomes in Grades 4 to 6, and with error-analysis literature, which regards recurring wrong-operation, regrouping, miscalculation, place-value, and procedural mistakes as meaningful indicators of learner understanding rather than mere isolated failures (Department of Education, 2016, 2023; Lin et al., 2025; Nelson & Powell, 2018).

A major theoretical basis for studying computation errors is the distinction and interaction between conceptual knowledge and procedural knowledge in mathematics. Conceptual knowledge refers to understanding mathematical ideas, relationships, and principles, while procedural knowledge concerns the execution of rules, algorithms, and step-by-step processes. In arithmetic, learners may produce errors because they know a procedure superficially without understanding why it works, or because they partially understand a concept but cannot carry it out accurately in written computation. Hurrell (2021) argued that conceptual and procedural knowledge should not be treated as mutually exclusive because both are necessary and strengthen each other, while Nelson and Powell (2018) showed that common computational errors often reflect misunderstandings in either conceptual or procedural learning. For this reason, error patterns in basic operations may be interpreted as observable traces of deeper knowledge gaps rather than simple carelessness alone (Hurrell, 2021; Nelson & Powell, 2018).

Another important conceptual basis of computation errors is place value theory. Place value underlies multi-digit addition and subtraction, supports multiplication and division procedures, and serves as the numerical infrastructure for later work with decimals and fractions. Sari et al. (2021) emphasized that a profound understanding of place value is crucial for the development of arithmetic skills and successful basic operations, while also noting that weak place value understanding is a typical characteristic of children with mathematical learning difficulties. Similarly, Önal and Altiner (2021) stressed that place value learned incompletely in the primary years can negatively affect later mathematical learning because it is a prerequisite for many subsequent topics. Thus, many learner errors in the four operations may be traced to weak understanding of the decimal structure of numbers, digit value, bundling, regrouping, and the positional system itself (Önal & Altiner, 2021; Sari et al., 2021).

Error patterns in computation are also supported by the literature on arithmetic misconceptions and numeracy development. Misconceptions arise when learners hold incorrect or incomplete interpretations of mathematical symbols, operations, and relationships, and these misconceptions become visible when they repeatedly apply the same incorrect strategy across similar items. Lin et al. (2025) noted that the error-

analysis literature has identified recurring categories such as wrong operation, miscalculation, regrouping error, procedural error, and place-value error, while the DepEd mathematics curriculum frames operational fluency as part of broader numeracy and problem-solving development in Key Stage 2. From this perspective, studying error patterns in the four fundamental operations is justified because it allows the researcher to identify whether learner weaknesses are rooted in procedural execution, conceptual misconceptions, or foundational numeracy deficits that may later constrain problem-solving performance (Department of Education, 2016, 2023; Lin et al., 2025).

International literature consistently shows that learner errors in arithmetic are structured, recurring, and instructionally useful. In their systematic review, Lin et al. (2025) synthesized 17 studies with a total of 1,122 participants and found that research on mathematical error patterns has focused heavily on computational skills, with whole-number operations, fractions, and integer operations appearing most often. The review also pointed out that the field still lacks a unified framework for classifying mathematical errors, which makes comparison across studies difficult. Earlier but still foundational empirical work by Nelson and Powell (2018), involving 478 third-grade students, found that using the wrong operation was the most common identifiable error for all students, and that students with mathematics difficulty showed much greater variability in incorrect responses than typically achieving peers. Their results further showed that students with mathematics difficulty obtained an average score of 20.96 compared with 27.25 for typically achieving students, while error ratios for students with mathematics difficulty were generally above 52:100 compared with typically achieving students whose error ratios were typically below 43:100 (Lin et al., 2025; Nelson & Powell, 2018).

Asian studies likewise demonstrate that computation errors are strongly associated with weaknesses in place value and operational understanding. In Turkey, Sari et al. (2021) validated a developmental model of place value understanding using 437 students in Grades 2 to 4 and found through Rasch analysis that the remaining 33 items showed acceptable infit values ranging from .79 to 1.27, with item difficulties generally increasing according to the theorized hierarchy. They concluded that the model was appropriate for assessing place value understanding and structuring instruction. In another Turkish study, Önal and Altınar (2021) examined 171 learners aged 7 and 8 using a 25-item place value worksheet developed from the primary mathematics program, with expert-validated items showing content validity ratios of .60 and above. Their findings showed that younger children had lower correct response rates in key place value tasks, supporting the claim that incomplete place value understanding in the primary years can contribute to later computational mistakes. Together, these studies support the view that many arithmetic errors are rooted in foundational number structure and not only in weak memorization of rules (Önal & Altınar, 2021; Sari et al., 2021).

In the Philippine context, broad evidence also indicates persistent difficulties in foundational mathematics. Using three rounds of a nationally representative government-run household survey, Igarashi and Suryadarma (2023) examined foundational mathematics and reading skills among Filipino students in Grades 4 to 10 between 2003 and 2019 and found that foundational mathematics skills continued to decline across cohorts, with many higher-grade students still failing to master skills expected by Grade 3. This national trend is important because it suggests that weaknesses in basic operations are not merely classroom-level issues but part of a larger pattern of foundational mathematics underachievement. Such evidence strengthens the relevance of examining error patterns in addition, subtraction, multiplication, and division at the Grade 6 level, especially in public elementary settings where foundational skill gaps may accumulate over time (Igarashi & Suryadarma, 2023).

More localized Philippine studies point to similar concerns. Francisco et al. (2025) conducted a correlational study among 69 Grade VI learners of Barotac Nuevo Central Elementary School using a 60-item adapted standardized test and found that the learners' numeracy skills were only at the "beginning" level, with $M = 1.70$ and $SD = .523$, while academic performance in mathematics was significantly related to numeracy skills, $r(69) = .357, p = .003$. In Sorsogon, Fernandez and Benavides (2023) used a descriptive

design with a teacher-made test among 18 Grade 6 pupils and reported that learners performed very well in basic mathematical operations and interpretation of numbers but only satisfactorily in problem solving, suggesting that operational skill and higher-level application do not always develop at the same pace. These Philippine findings imply that while some learners can perform routine computation, operational mastery may still be fragile, uneven, or insufficiently transferable to broader mathematical performance (Fernandez & Benavides, 2023; Francisco et al., 2025).

Recent Philippine intervention studies also show that computation weaknesses in the basic operations can be improved when instruction directly targets the source of learner error. In Davao de Oro, Nalusay et al. (2024) used a quasi-experimental design with 42 Grade 6 students and found that multiplication automaticity improved from a low pretest level ($M = 6.14$, $SD = 2.07$) to a very high posttest level ($M = 19.48$, $SD = 1.09$), with a mean difference of -13.34 and a Wilcoxon value of 903.000. At the primary level, Vendicacion et al. (2025) employed a one-group pretest-posttest quasi-experimental design with 30 Grade 1 pupils and reported a statistically significant improvement in adding and subtracting numbers, with pretest and posttest means of 7.77 and 18.80, respectively, $p = .000$, and a large effect size of $r = -.875$. Although these studies focused on intervention rather than prediction, they reinforce the idea that recurring errors in the four operations are diagnosable and responsive to targeted remediation (Nalusay et al., 2024; Vendicacion et al., 2025).

Overall, the reviewed literature shows that error patterns in the four fundamental operations are meaningful indicators of learner thinking and are closely associated with foundational numeracy, place value understanding, computational fluency, and later mathematics performance. International and Asian research has already established that learners' errors are not random and that operation-specific mistakes can be classified and used diagnostically, while Philippine studies continue to document foundational numeracy weaknesses and the need for targeted support. However, the literature reviewed here still provides limited evidence on the predictive role of operation-specific error patterns among Grade 6 learners in a Philippine public elementary school context. This gap justifies examining addition, subtraction, multiplication, and division error patterns not only descriptively but also as possible predictors of mathematical problem-solving performance in the present study (Department of Education, 2016, 2023; Igarashi & Suryadarma, 2023; Lin et al., 2025; Nelson & Powell, 2018).

Addition. Addition is a basic arithmetic operation used to combine quantities or accumulate values, and it serves as one of the earliest foundations of formal numeracy development. In elementary mathematics, addition performance reflects not only the ability to arrive at correct sums but also the learner's understanding of place value, regrouping, number relationships, and alignment of digits in written work. When learners make repeated mistakes in addition, these errors often indicate deeper weaknesses in number sense and base-ten understanding rather than isolated carelessness alone (Department of Education, 2016; Jensen et al., 2024; Sari et al., 2021).

Common addition errors include place value mistakes, failure to regroup correctly, digit misalignment, and incorrect fact retrieval. These errors are especially important because addition is structurally linked to later work in subtraction, multiplication, division, fractions, decimals, and problem solving. When learners do not fully understand the value of digits in multi-digit numbers or the logic of carrying or regrouping, they may produce patterned errors that recur across tasks, making addition a useful diagnostic domain for identifying computational weaknesses in upper elementary mathematics (Hurrell, 2021; Önal & Altiner, 2021; Sari et al., 2021).

The literature shows that fluency in addition depends heavily on conceptual understanding of place value and on procedural control over regrouping. DepEd's mathematics curriculum for the elementary grades positions operational fluency as part of a broader goal of developing mathematical reasoning and problem solving, while more recent work on place value diagnosis argues that regrouping and the base-ten system are central constructs for understanding why learners succeed or fail in written computation. Thus, addition should be understood not merely as a memorized rule system but as an operation that reveals how

well learners understand number structure and written algorithms (Department of Education, 2016; Department of Education, 2023; Jensen et al., 2024).

Related studies further suggest that addition errors are often linked to conceptual-procedural imbalance. Hurrell (2021) argued that conceptual and procedural knowledge should work together in mathematics learning rather than be treated as competing domains, while Lin et al. (2025) noted in their systematic review that error analysis remains useful precisely because recurring errors often reveal what students do and do not understand about mathematical procedures and concepts. In this sense, addition errors such as incorrect carrying, skipped regrouping, or misaligned digits can be viewed as visible outcomes of incomplete numerical understanding (Hurrell, 2021; Lin et al., 2025).

Recent empirical studies continue to show that addition errors are patterned and measurable. Giri (2025), using a criterion-referenced test with 25 Class-V students, found that addition and subtraction errors could be systematically identified and categorized, supporting the usefulness of written error analysis for classroom diagnosis. Although the study focused on a small sample, it demonstrated that recurring operational mistakes are frequent enough to justify diagnostic attention in upper-elementary mathematics (Giri, 2025).

Additional evidence comes from Lin and Riccomini (2026), who examined error patterns in integer addition and subtraction among 160 seventh-grade students and found that students with mathematics difficulty made more errors than their peers on both operations. The study identified recurring conceptual and procedural mistakes, including sign misinterpretation and omission errors, showing that addition-related misunderstandings can remain persistent when earlier computational foundations are weak. While the content involved integers rather than whole numbers, the findings reinforce the broader idea that addition errors are often systematic and diagnostically meaningful (Lin & Riccomini, 2026).

Subtraction. Subtraction is the arithmetic operation used to determine difference, remove quantity, or compare values, and it requires learners to coordinate quantity, order, and place value simultaneously. In the upper elementary grades, subtraction performance reflects the learner's ability to apply regrouping accurately, align digits by place value, interpret numerical relationships correctly, and distinguish subtraction from related operations such as addition. Because subtraction draws heavily on place value and inverse reasoning, recurring errors often indicate fragile conceptual understanding and procedural control (Department of Education, 2016; Önal & Altiner, 2021; Sari et al., 2021).

Common subtraction errors include borrowing or regrouping mistakes, failure to decompose place values correctly, digit reversal, and procedural omission. These errors are especially consequential because subtraction is frequently embedded in multi-step and comparative word problems. When learners consistently subtract smaller digits from larger ones without regard to place value, omit regrouping steps, or misread the structure of the written problem, the resulting error patterns can signal both conceptual misunderstanding and weak control of algorithmic procedures (Giri, 2025; Hurrell, 2021).

Literature on subtraction emphasizes that regrouping competence is central to successful performance. Studies on place value understanding have shown that learners who do not adequately grasp how units can be composed and decomposed within the base-ten system are more likely to commit repeated subtraction mistakes. Jensen et al. (2024) argued that place value and regrouping are useful diagnostic constructs because they make learner difficulties visible, while Önal and Altiner (2021) noted that incomplete understanding of place value in the early grades can negatively affect subsequent computation learning (Jensen et al., 2024; Önal & Altiner, 2021).

Subtraction performance is also shaped by foundational numeracy barriers. In the Philippine context, national evidence indicates that many learners continue to struggle with foundational mathematics skills beyond the early grades, suggesting that difficulties in subtraction are part of a broader problem in basic numeracy development. Because subtraction requires flexible understanding of number relations and decomposition, it often becomes one of the first operations in which weak number sense, place value

confusion, and procedural gaps become highly visible (Department of Education et al., 2021; Igarashi & Suryadarma, 2023).

Empirical evidence shows that subtraction is often more error-prone than addition. Lin and Riccomini (2026), in a descriptive study involving 160 seventh-grade students, reported that all students struggled more with integer subtraction than addition and that students with mathematics difficulty displayed more severe misconceptions in subtraction. Key errors included sign misinterpretation, omission of signs, and misuse of the number line, suggesting that subtraction places heavier demands on conceptual control and rule application than addition does (Lin & Riccomini, 2026).

Similarly, Giri (2025) documented patterned errors in addition and subtraction among upper-elementary learners using a criterion-referenced test. The study highlighted how repeated subtraction mistakes can be identified through item-level analysis, making the operation useful for diagnostic and remedial purposes. Although the study was classroom-based and modest in scale, it supports the idea that subtraction difficulties are observable, classifiable, and relevant to school-based intervention planning (Giri, 2025).

Multiplication. Multiplication is commonly introduced as repeated addition, array-based reasoning, grouping, or scaling, but successful multiplication performance in later elementary grades also requires mastery of place value, fact retrieval, partial products, and algorithmic sequencing. Thus, multiplication errors are not limited to incorrect products; they may also reflect misunderstandings about the structure of multi-digit multiplication, the meaning of zero as a placeholder, or the relationship between the factors and the product (Alanazi, 2024; Department of Education, 2016).

Common multiplication errors include wrong multiplication facts, omission of place values in multi-digit computation, misapplication of partial products, and procedural sequencing problems. These errors matter because multiplication underpins fraction operations, proportional reasoning, percent, and many forms of mathematical problem solving. If learners treat multiplication only as memorization of tables without understanding the structure of the algorithm or the meaning of groups and scaling, they are more likely to show recurring computation errors in both routine and applied tasks (Alanazi, 2024; Nalusay et al., 2024).

The literature on multiplication emphasizes the importance of both fact fluency and conceptual understanding. Alanazi (2024) pointed out that learners often hold misconceptions such as treating multiplication as a process that always makes numbers larger, while also showing weak use of mental strategies and standard written methods. In addition, the curriculum expects multiplication to be used flexibly in whole numbers, decimals, fractions, and real-life applications, meaning that multiplication performance should be viewed as part of a larger network of numerical and problem-solving competencies rather than as a stand-alone skill (Alanazi, 2024; Department of Education, 2016).

Related literature also shows that multiplication errors often emerge when place value and algorithmic meaning are weak. The systematic review by Lin et al. (2025) found that whole-number operations and rational number computation are frequent sites of recurring learner error, while Jensen et al. (2024) showed that diagnosing difficulties through place value and regrouping can help uncover why written procedures fail. These insights suggest that multiplication errors should be interpreted not simply as failures of memorization but as signs of incomplete numerical structure and weak procedural integration (Jensen et al., 2024; Lin et al., 2025).

Recent Philippine evidence underscores the importance of multiplication automaticity at the Grade 6 level. Nalusay et al. (2024) used a quasi-experimental design with 42 Grade 6 students and analyzed the data using means and the Wilcoxon Signed Rank Test. They found that multiplication automaticity was low at pretest ($M = 6.14$, $SD = 2.07$) but became very high at posttest ($M = 19.48$, $SD = 1.09$), with a mean difference of -13.34, Wilcoxon value of 903.000, and $p = .000$. These results indicate that multiplication errors and fluency problems are both measurable and responsive to targeted support (Nalusay et al., 2024).

Alanazi (2024) likewise examined the common errors and misconceptions of 96 Saudi Grade Five students in multiplication and division using both quantitative and qualitative methods. The written test results showed substantial error rates in tasks involving multiplication and division by multiples of 10 and in the use of standard algorithms, supporting the conclusion that many learners lacked secure understanding of multiplication concepts, properties, and written procedures. Such findings strengthen the view that multiplication difficulties are not isolated to recall of facts alone but also involve place value, strategy use, and algorithmic understanding (Alanazi, 2024).

Division. Division is the arithmetic operation used to partition, share, or determine how many times one quantity is contained in another, and it is conceptually tied to multiplication as its inverse. Strong division performance requires learners to understand grouping, repeated subtraction, quotient meaning, remainder interpretation, and the alignment of steps in written algorithms. Because division is structurally complex, learner errors often reflect deeper misunderstandings about number relations and operational meaning (Alanazi, 2024; Department of Education, 2016).

Common division errors include incorrect quotient placement, misuse or misinterpretation of remainders, skipping procedural steps, and failure to align numbers correctly in long division or related written methods. Learners may also show misconceptions such as believing that division always makes numbers smaller or that smaller numbers cannot be divided by larger ones, misconceptions that can later affect work with fractions, decimals, and percent. For this reason, division performance is often used as a sensitive indicator of whether earlier arithmetic concepts have been fully internalized (Alanazi, 2024; Sugawara, 2026).

Pedagogical literature on division stresses the importance of teaching it through multiple models, such as partitive sharing and quotative grouping, rather than through rules alone. Alanazi (2024) emphasized that multiplication and division understanding develops from earlier knowledge of addition and subtraction but should not be reduced to them. Instead, learners need to understand division as a distinct operation with its own conceptual structures and problem situations. This conceptual grounding is especially important because division frequently appears in proportion, fraction simplification, and contextualized problem solving (Alanazi, 2024).

Related research also shows that division difficulties are frequently connected to comprehension, transformation, and process errors. Sugawara (2026), in a study of Grade 6 learners' misconceptions about division of whole numbers, highlighted the importance of diagnostic assessment in uncovering conceptual gaps that ordinary classroom scoring may miss. Although the study used a qualitative case-study design, its findings are still valuable in showing that division errors are often systematic and linked to weak understanding of mathematical language, place value, and process skills (Sugawara, 2026).

Empirical work on multiplication and division at the primary level further supports the diagnostic importance of division. Alanazi (2024), using a mixed-method design with 96 Grade Five students, found common errors in both mental and standard algorithms for multiplication and division, with many students showing limited understanding of symbols, concepts, and properties. The study's written test data revealed substantial incorrect response rates in tasks involving division by 10 and related whole-number operations, indicating that division remains a persistent area of misconception even among upper-elementary learners (Alanazi, 2024).

More recent work by Sugawara (2026) focused specifically on Grade 6 learners and reported three dominant error types in division of whole numbers: transformation errors, comprehension errors, and processing skill errors. Although the design was interpretivist and qualitative, the use of a two-tier multiple-choice diagnostic test shows that division difficulties can be systematically classified and traced to specific conceptual and procedural problems. This is directly relevant to school-based mathematics research because it supports the use of diagnostic tools in identifying dominant division error patterns for intervention planning (Sugawara, 2026).

Dominant Error Patterns Across the Four Fundamental Operations. Dominant error patterns refer to the most frequent or recurring mistakes committed by learners across a set of arithmetic tasks. In mathematics assessment, these patterns are useful because they reveal which misconceptions or procedural gaps are most stable and widespread in a group of learners. Rather than treating each wrong answer as unrelated, error-pattern analysis identifies regularities in learner thinking and links them to numerical concepts such as place value, regrouping, operation selection, fact retrieval, and symbolic understanding (Lin et al., 2025; Nelson & Powell, 2018).

Viewing arithmetic mistakes as dominant patterns is consistent with diagnostic assessment and with current curricular emphasis on mathematical reasoning and targeted support. The MATATAG curriculum explicitly highlights the importance of strong mathematical knowledge and understanding for developing critical problem solvers, while error-analysis research argues that recurring mistakes can serve as starting points for individualized or small-group remediation. Thus, identifying dominant error patterns is not merely descriptive; it also has direct instructional value (Department of Education, 2023; Jensen et al., 2024; Lin et al., 2025).

Prior literature has identified several recurring categories of arithmetic error. These include place value errors, regrouping or borrowing errors, operational sign confusion, incomplete or skipped steps, fact retrieval errors, digit misalignment, and broader conceptual misunderstandings about the meaning of operations. Lin et al. (2025) found in their review that whole-number and fraction computation tasks often elicited repeated categories of error, while Jensen et al. (2024) showed that place value and regrouping are especially useful for diagnosing individual differences in written computation. Together, these studies support the classification system often used in school-based error analysis (Jensen et al., 2024; Lin et al., 2025).

These categories are also visible in Philippine and international classroom studies. Giri (2025) highlighted recurrent addition and subtraction mistakes among upper-elementary learners, while Alanazi (2024) documented misconceptions in multiplication and division such as misunderstanding symbols, weak mental strategies, and incorrect use of standard algorithms. Such patterns suggest that although each arithmetic operation has unique demands, many learner mistakes can still be grouped into broader error families that cut across operations and thus become useful predictors of later mathematics performance (Alanazi, 2024; Giri, 2025).

Empirical studies have repeatedly shown that some error types occur more often than others. Nelson and Powell (2018), in their analysis of 478 third-grade students, reported that using the wrong operation was the most common identifiable error for all students, and that students with mathematics difficulty showed greater variability and higher error ratios than typically achieving peers. Their findings support the view that dominant errors can be quantified and compared across groups, making error analysis suitable for both descriptive and inferential research (Nelson & Powell, 2018).

Lin et al. (2025) also concluded from 17 reviewed studies involving 1,122 participants that error analysis in mathematics has focused strongly on computational tasks and that common errors recur across operations and content areas. The review argued that although there is not yet a fully unified framework for classifying all mathematical errors, recurring patterns are sufficiently consistent to support diagnosis and targeted instruction. This body of evidence justifies the use of dominant error patterns as a measurable variable in the present study (Lin et al., 2025).

Mathematical Problem-Solving Performance

Mathematical problem-solving performance refers to the learner's ability to understand a mathematical situation, represent the relevant relationships, select or construct an appropriate solution strategy, carry out the necessary computations, and verify the reasonableness of the answer. In the elementary grades, this performance is typically observed through contextualized tasks involving whole numbers, fractions, decimals, money, ratio and proportion, percent, and multi-step situations. The construct is aligned with both the DepEd curriculum and broader mathematics assessment frameworks that regard

problem solving as a central expression of mathematical proficiency rather than a separate or optional skill (Department of Education, 2016; Department of Education, 2023; OECD, 2023).

In this study, mathematical problem-solving performance is anchored on a researcher-made test based on Grade 6 mathematics competencies and on established views of problem solving as a process of interpreting, planning, solving, and checking. This is consistent with mathematics education literature, which treats performance in problem solving as dependent on both conceptual understanding and computational accuracy, especially when learners work with word problems and contextual applications. Thus, mathematical problem-solving performance may be understood as a comprehensive indicator of how learners use mathematics meaningfully in school tasks (Stevens et al., 2024; Vessonen et al., 2025).

One foundational basis of mathematical problem solving is Polya's view that successful solution requires understanding the problem, devising a plan, carrying out the plan, and looking back. Although developed earlier, this framework remains influential because it aligns closely with current views of problem solving as a strategic and reflective mathematical process. Contemporary mathematics frameworks continue to echo this logic by emphasizing reasoning, representation, modelling, and evaluation in solving real-world problems (OECD, 2023; Stevens et al., 2024).

A second basis comes from mathematical modelling and schema-based views of problem solving. The PISA mathematics framework describes mathematical literacy as the capacity to formulate, employ, and interpret mathematics in a variety of contexts, which means that learners must move beyond simple computation and understand how mathematical structures map onto real situations. Similarly, schema-based perspectives on word-problem solving argue that learners perform better when they can recognize the underlying structure of a problem and connect it to appropriate operations. These perspectives are highly relevant to Grade 6 mathematics, where word problems often require combining understanding of context with accurate computational execution (OECD, 2023; Vessonen et al., 2025).

Curriculum standards also provide an important conceptual basis. The MATATAG mathematics curriculum states that learners need strong mathematical knowledge and understanding to become mathematically proficient and critical problem solvers, while the K to 12 curriculum guide organizes Grade 6 competencies around number and algebra topics that culminate in contextualized performance tasks and real-life applications. These official frameworks support the view that mathematical problem-solving performance is not just test performance on verbal problems but a curriculum-based expression of mathematical reasoning and application (Department of Education, 2016; Department of Education, 2023).

International literature consistently identifies mathematical word-problem solving as a demanding but teachable area of elementary mathematics. Vessonen et al. (2025), in a systematic review and meta-analysis of 115 reports involving 20,456 students from six continents, found that mathematical word-problem-solving interventions had a strong positive average effect on elementary schoolers' problem-solving skills, with $g = 0.95$ across 425 effect sizes. This large meta-analytic result supports the view that problem-solving performance is both an essential learning outcome and a domain in which learner difficulties can be substantially improved through focused instruction (Vessonen et al., 2025).

Asian studies also report that problem-solving performance in elementary mathematics improves when instruction explicitly targets reasoning and structured solution processes. In Thailand, Kinasoon et al. (2025) used a randomized control group pretest-posttest design to examine decimal arithmetic problem-solving skills among Grade 5 students. The experimental group ($n = 34$) significantly outperformed the control group ($n = 35$) at posttest, with means of 12.91 and 4.37, respectively, $t = 9.02$, $p < .05$, and Cohen's $d = 2.16$. Within the experimental group, scores rose from a pretest mean of 1.94 to a posttest mean of 12.91, with $t = 21.77$, $p < .05$, and Cohen's $d = 3.37$. These findings show that decimal-based problem solving is measurable and highly responsive to structured teaching approaches (Kinasoon et al., 2025).

In the Philippine context, recent studies likewise show that mathematics problem-solving performance remains a critical concern at the elementary level. De la Victoria (2024) employed a quasi-experimental design with 29 Grade 6 learners and found that the pretest mean of 13.97 increased to a

posttest mean of 44.48 after collaborative learning was introduced, with computed $t = 6.634$ exceeding the critical t of 1.824. Similarly, Bacosa et al. (2025) reported that in their study of One Word Problem a Day, the control group improved from a mean of 15.78 to 24.22, while the experimental group improved from 14.61 to 29.49, with both paired-sample t -tests indicating significant gains at $p < .005$. Together, these studies suggest that elementary learners' problem-solving performance is often initially limited but can improve significantly when instruction is designed to scaffold strategy use and mathematical reasoning (Bacosa et al., 2025; De la Victoria, 2024).

Problem-solving performance in Grade 6 mathematics is also closely aligned with the content strands emphasized in the Philippine curriculum. The Grade 6 curriculum includes solving problems involving fractions and mixed numbers, decimals and money, ratio and proportion, and percent applications such as discount, interest, and commission, all of which require learners to integrate conceptual understanding with procedural accuracy. Because these domains often appear in real-life or multi-step tasks, performance in problem solving can be viewed as a curriculum-valid indicator of whether learners can apply foundational computations meaningfully and flexibly (Department of Education, 2016).

Recent studies on specific domains reinforce this view. Pereda Lorient et al. (2025), in a quantitative experimental study of 73 fifth-grade students, found significant improvement in learning outcomes for fractions and decimal numbers in both personalized and non-personalized instructional conditions, with noteworthy differences favoring personalized instruction for fractions. Cahyaningsih et al. (2025) likewise reported that, among 38 elementary students from nine schools, the experimental group exposed to problem-based learning in fractions achieved a mean increase of 33.25 points compared with 7.78 points in the control group, with $p < .001$ and Cohen's $d = 3.47$. These findings indicate that fraction- and decimal-related problem solving remains difficult for many learners, but that strong instructional support can substantially improve performance (Cahyaningsih et al., 2025; Pereda Lorient et al., 2025).

Ratio, proportion, and other applied topics such as percent also present significant cognitive demands because they require multiplicative reasoning and correct interpretation of relationships rather than direct computation alone. Arenas-Peñaloza et al. (2024) found that primary learners solving ratio tasks often showed difficulty in interpreting verbal problems, applying arithmetic procedures correctly, and understanding the concept of ratio itself. Although that study was more process-oriented than statistical, its findings are consistent with the curricular expectation that learners need strong foundational operations and mathematical language in order to succeed in proportional and percent-based problem solving. This makes mathematical problem-solving performance a highly suitable dependent variable in the present study (Arenas-Peñaloza et al., 2024; Department of Education, 2016).

Fractions and Mixed Numbers. Fractions and mixed-number problem solving refers to the learner's ability to interpret, represent, and solve mathematical situations involving part-whole relationships, equivalent fractions, improper fractions, mixed numbers, and operations on fractions in contextualized tasks. In the K to 12 Mathematics Curriculum Guide, fractions are part of the Grade 4 to 6 numbers and number sense strand, and by the end of Grade 6 learners are expected to demonstrate understanding of fractions, decimals, ratio and proportion, percent, and integers as applied in critical thinking and problem solving. Thus, performance in this component reflects not only procedural skill but also the ability to use rational numbers meaningfully in real-life situations (Department of Education [DepEd], 2016).

The literature consistently identifies fractions as one of the most difficult domains in elementary mathematics because learners often struggle with equivalence, magnitude, symbolic representation, and operations involving unlike denominators and mixed numbers. Sirajuddin et al. (2025) noted that many elementary students have difficulty connecting symbolic and visual representations of fractions, while Pereda Lorient et al. (2025) argued that fraction learning remains a central target for personalized mathematics instruction because weaknesses in this area constrain later achievement. These patterns

suggest that fraction problem solving depends heavily on conceptual understanding, visual representation, and flexible reasoning rather than memorization alone (Pereda Lorient et al., 2025; Sirajuddin et al., 2025).

Recent quantitative studies show that fraction problem-solving performance is measurable and responsive to instruction. In Indonesia, Cahyaningsih et al. (2025) used a quasi-experimental design with 38 elementary learners from nine schools and found that the experimental group improved from a mean pretest score of 45.67 to a posttest mean of 78.92, or a gain of 33.25 points, whereas the control group improved only from 46.34 to 54.12, or 7.78 points; the posttest difference was significant, $t(36) = 7.23$, $p < .001$. Likewise, Sirajuddin et al. (2025), in a quasi-experimental study with 120 fifth-grade learners from four public schools in Makassar, found that the experimental group's fraction understanding score rose from 45.2 to 77.8, while the control group improved from 44.7 to 60.3; the treatment effect was significant, $F(1,117) = 56.48$, $p < .001$, partial $\eta^2 = 0.15$, and fraction problem-solving accuracy increased by 32.6 percentage points in the experimental group compared with 15.4 points in the control group. These findings confirm that fraction and mixed-number problem solving remains difficult for many learners but can improve substantially under structured instruction (Cahyaningsih et al., 2025; Sirajuddin et al., 2025).

Decimals and Money. Decimals and money problem solving refers to the learner's ability to solve contextualized mathematical situations involving decimal notation, place value to the tenths and hundredths, peso-and-centavo relationships, and real-life computations such as totals, change, comparisons, and combinations of prices. In the curriculum, money is treated as an applied context within number and measurement, while decimals are explicitly included within the Grade 4 to 6 progression of numbers and number sense. Accordingly, this component reflects the practical use of decimal understanding in everyday financial situations, making it an important indicator of applied mathematical proficiency in upper elementary mathematics (DepEd, 2016).

The literature shows that decimal and money problem solving is often challenging because learners must coordinate place value understanding, symbolic precision, and contextual reasoning. Decimals require learners to interpret the base-ten system across whole numbers and fractional parts, while money problems add contextual demands such as quantity comparison, budgeting, and reasonableness of answers. Pereda Lorient et al. (2025) emphasized that decimals remain a significant target for personalized mathematics learning, and Wiedenhöfer (2025) argued that financial numeracy in mathematics should go beyond basic calculation toward thoughtful decision-making in realistic monetary contexts. Together, these studies suggest that success in decimal and money problems depends on both accurate computation and the meaningful application of mathematical ideas to real-life financial situations (Pereda Lorient et al., 2025; Wiedenhöfer, 2025).

Empirical studies likewise indicate that decimal-based problem solving can be improved through focused instruction. Pereda Lorient et al. (2025), working with 73 fifth-grade learners, found significant gains in both fractions and decimals, with the control group improving in decimals from $M = 6.07$, $SD = 2.49$ to $M = 7.19$, $SD = 2.53$, $t(35) = 5.11$, $p < .001$, $d = 0.85$, and the experimental group improving from $M = 5.88$, $SD = 2.44$ to $M = 7.09$, $SD = 2.65$, $t(36) = 6.10$, $p < .001$, $d = 1.00$. In Thailand, Kinasoon et al. (2025) used a randomized control group pretest-posttest design with Grade 5 learners and found that the experimental group outperformed the control group in decimal arithmetic problem solving, with posttest means of 12.91 and 4.37, respectively, $t = 9.02$, $p < .05$, and Cohen's $d = 2.16$. These studies support the importance of including decimals and money as a distinct component of mathematical problem-solving performance (Kinasoon et al., 2025; Pereda Lorient et al., 2025).

Ratio and Proportion. Ratio and proportion problem solving refers to the ability to compare quantities, interpret multiplicative relationships, and determine equivalent relations in contextual tasks. This component goes beyond additive reasoning because learners must recognize that two quantities are related multiplicatively and that equivalent ratios preserve a constant relationship. In Grade 6 mathematics, ratio

and proportion is one of the major competencies under numbers and number sense, making it a core domain of upper-elementary mathematical problem solving (DepEd, 2016).

The literature describes ratio and proportion as a demanding domain because it requires multiplicative reasoning, flexible representation, and the ability to distinguish additive from proportional relationships. Arenas-Peñaloza et al. (2024) showed that primary learners often struggle to understand ratio conceptually and to connect verbal situations with appropriate mathematical representations, while Nelson et al. (2020) argued in their review that proportional reasoning interventions for students with learning difficulties remain underinvestigated despite the importance of the skill from Grades 5 to 9. These findings suggest that ratio and proportion problem solving is cognitively complex and often develops more slowly than routine arithmetic competence (Arenas-Peñaloza et al., 2024; Nelson et al., 2020).

Quantitative evidence supports the instructional importance of ratio and proportion. Ergene and Karaboğaz (2024) examined 56 seventh-grade students and found that learners taught through the flipped classroom model performed better on the Proportional Reasoning Test than those taught through curriculum-based instruction, with the experimental group also showing more correct and fewer incorrect solution strategies. In addition, Nelson et al. (2020) synthesized nine intervention studies on learners with learning disabilities or mathematics difficulty from Grades 5 to 9 and reported effect sizes ranging from $g = -0.10$ to 1.87 and $\text{Tau-U} = 0.88$ to 1.00 , indicating that proportional reasoning performance can improve meaningfully under well-designed intervention, although the evidence base is still limited. These findings support the inclusion of ratio and proportion as a major domain in mathematical problem-solving performance (Ergene & Karaboğaz, 2024; Nelson et al., 2020).

Percent, Discount, Interest, and Commission. Percent, discount, interest, and commission problem solving refers to the ability to solve real-life mathematical problems involving percentages and simple financial applications. It includes interpreting percent as “per hundred,” translating between fractions, decimals, and percents, and applying percentage reasoning to situations involving price reduction, earnings, or simple finance-related contexts. In the Grade 6 curriculum, percent is explicitly identified as part of the numbers and number sense competencies expected of learners by the end of the grade level, which makes it a relevant and curriculum-based indicator of mathematical problem-solving performance (DepEd, 2016).

The literature indicates that percentage reasoning is conceptually demanding because learners must coordinate part-whole reasoning, proportional thinking, and flexible representation across fractions, decimals, and percentages. Joutsenlahti and Perkkilä (2024) examined percentage mastery among Finnish students in Grades 7 to 9 and highlighted the importance of multiple representations in expressing mathematical thinking about percent. In a related way, Wiedenhöfer (2025) argued that financial numeracy in school mathematics should involve not only basic arithmetic but also meaningful decision-making in authentic money-related situations. These perspectives suggest that percentage-based problems, especially those involving discount or interest, require more than mechanical substitution into formulas; they require learners to reason about quantities, rates, and context (Joutsenlahti & Perkkilä, 2024; Wiedenhöfer, 2025).

Recent studies also show that percentage-based and financial problem solving can be improved through explicit instruction. Joutsenlahti and Perkkilä (2024) analyzed data from 1,112 Finnish students in Grades 7 to 9 and found that mastery of percent and its representations could be examined systematically across school levels, underscoring percent as a measurable area of mathematical competence. In the Philippine context, a 2025 intervention study on simple interest among 58 Grade 7 learners reported a pretest mean of 36.44% and a posttest mean of 82.8%, with a significant pretest-posttest difference, $t(57) = 11.9, p < .001$, and Cohen’s $d = 1.57$. Although the latter study was conducted at Grade 7, it remains relevant because simple financial applications such as interest and discount extend the percentage reasoning expected in late elementary and early junior high school (Joutsenlahti & Perkkilä, 2024; Salili et al., 2025).

Multi-Step Problems. Multi-step problems are mathematical tasks that require two or more connected operations, decisions, or solution stages before a final answer can be obtained. These problems are more cognitively demanding than single-step tasks because learners must interpret the situation, determine the sequence of operations, hold intermediate results in mind, and monitor whether the emerging solution remains reasonable. Within the curriculum, this kind of performance reflects the application of mathematical knowledge in problem solving, reasoning, and decision-making in real-life contexts, making it an appropriate culminating indicator of Grade 6 mathematical performance (DepEd, 2016; OECD, 2023).

The literature shows that multi-step problem solving places substantial demands on comprehension, planning, working memory, and strategy use. Stevens et al. (2024) argued that successful word-problem solving depends not only on mathematical knowledge but also on the ability to understand the language of the problem and connect it to an appropriate solution path. In a large meta-analysis, Vessonen et al. (2025) emphasized that mathematical word problems are an important yet demanding area for elementary learners, particularly when tasks require multiple operations or greater cognitive coordination. These findings indicate that multi-step problems should be treated as a distinct domain of mathematical problem-solving performance rather than as a simple extension of routine computation (Stevens et al., 2024; Vessonen et al., 2025).

Empirical evidence confirms the difficulty of multi-step problem solving while also showing that it can improve under targeted instruction. Vessonen et al. (2025) synthesized 115 reports involving 20,456 students and found that mathematical word-problem-solving interventions had a strong positive average effect on elementary schoolers' problem-solving skills, $g = 0.95$. In the Philippines, De la Victoria (2024) reported that Grade 6 learners exposed to collaborative learning improved from a pretest mean of 13.97 to a posttest mean of 44.48, with computed $t = 6.634$, while Bacosa et al. (2025) found that students exposed to One Word Problem a Day improved more strongly than those under conventional instruction, with the experimental group's mean rising from 14.61 to 29.49 compared with 15.78 to 24.22 in the control group. These findings support the view that multi-step mathematical problem solving is difficult but highly teachable, and thus deserves separate analysis in studies of learner performance (Bacosa et al., 2025; De la Victoria, 2024; Vessonen et al., 2025).

Relationship Between Error Patterns in the Four Fundamental Operations and Mathematical Problem-Solving Performance

The relationship between error patterns in the four fundamental operations and mathematical problem-solving performance is grounded in the idea that solving word problems requires both conceptual understanding and accurate execution of computations. Word-problem solving involves reading and interpreting a mathematical situation, selecting the correct operation, constructing a number sentence or equation, and carrying out the needed computation to arrive at a correct answer. When learners commit recurring errors in addition, subtraction, multiplication, or division, these weaknesses can increase cognitive load, disrupt the solution process, and reduce the likelihood of successful problem solving. Thus, computation errors are not merely procedural slips; they can also interfere with mathematical reasoning and application in contextualized tasks (Mao et al., 2025; Pongsakdi et al., 2020; Stevens et al., 2024).

Several studies provide quantitative evidence that computational skill is significantly associated with mathematical problem-solving performance. Nob and Pañares (2025), using a quantitative design with 240 students selected through simple random sampling, found a strong overall positive correlation between computational skills and word-problem solving performance, $r = .74, p = .001$. More specifically, arithmetic skills showed $r = .68, p = .002$; number sense, $r = .62, p = .004$; and mathematical fluency, $r = .65, p = .003$. Their multiple regression analysis further showed that arithmetic skills were the strongest predictor of word-problem performance, with $\beta = .47, p = .001$, while the full model was also significant, $R = .85, R^2 = .72$, adjusted $R^2 = .71, F = 45.60, p = .001$. These findings strongly support a predictive link between foundational computation and problem-solving success (Nob & Pañares, 2025).

Similar results appear in studies that controlled for other relevant variables. Lariviere et al. (2025) examined 325 third-grade students with mathematics difficulty using unconditional quantile regression and ordinary least squares regression, and reported that computation skill significantly predicted word-problem performance even when language variables and emergent bilingual status were controlled, with $\beta = .33$, $SE = .05$, $p < .001$; bivariate correlation between computation skill and word-problem performance was $r = .39$. Likewise, Sury and Pilchin (2025), using separate multiple regression models for fourth graders ($N = 41$) and eleventh graders ($N = 43$), found that arithmetic fluency significantly predicted applied math problem-solving in both groups. In fourth grade, arithmetic fluency had $B = 0.06$, $\beta = .49$, $t = 2.46$, $p = .02$, and the model explained 30.8% of the variance, $F(3, 37) = 5.48$, $p = .003$. In eleventh grade, arithmetic fluency remained significant with $B = 0.03$, $\beta = .39$, $t = 2.50$, $p = .02$, while the model explained 44.6% of the variance, $F(3, 39) = 10.48$, $p < .001$. These findings indicate that computation-related variables often remain significant even in multivariate models of problem solving (Lariviere et al., 2025; Sury & Pilchin, 2025).

Not all studies show a uniformly significant relationship between computation and all forms of problem solving. Tolar et al. (2012), in a longitudinal study of 261 students assessed from the beginning of Grade 3 through the end of Grade 5, found that computation significantly affected initial performance only for low-complexity word problems, but not for high-complexity word problems. Their growth-model results showed that computation had a significant coefficient of 2.2 for initial low-complexity performance, but only 0.6 for high-complexity performance, which was not significant. They also reported that neither computation nor language significantly predicted growth in word-problem solving over time. This suggests that as problem-solving tasks become more complex, basic computation alone may not be sufficient to explain performance differences (Tolar et al., 2012).

Some studies point to a mixed or context-dependent relationship. Pongsakdi et al. (2020), working with 891 fourth-grade students in Finland, found that word-problem performance on both easy and difficult items was related to both arithmetic skills and text comprehension. However, their group comparisons showed that students who were poor in text comprehension but skillful in arithmetic performed significantly better than those who were skillful in text comprehension but poor in arithmetic only on easy word problems. For difficult word problems, the difference between these two groups was not significant, $p = .14$. This indicates that arithmetic skills matter, but their impact may weaken or become conditional when problem complexity increases and language demands become heavier (Pongsakdi et al., 2020).

A similar pattern appears in developmental and mediation studies. Sury and Pilchin (2025) found that in fourth grade, the indirect effect of reading comprehension on applied math problem-solving through arithmetic fluency was significant, $p = .01$, with a bootstrapped 95% CI [0.01, 0.05], accounting for 59.3% of the total effect. However, in eleventh grade, the indirect effect through arithmetic fluency was not significant, $p = .23$, 95% CI [-0.01, 0.04]. In another line of evidence, Mao et al. (2025) found that among 206 Grade 4 and 5 students with mathematics difficulty, fewer than 14% showed consistent error patterns across computation and word problems, even though miscalculation, regrouping, and wrong operation were frequent in both domains. This suggests that while basic-operation errors are relevant to problem solving, the relationship is not always direct or uniform, because additional demands such as schema selection, comprehension, and representation also shape performance (Mao et al., 2025; Sury & Pilchin, 2025).

Overall, the literature generally supports a significant correlational and predictive link between foundational computation and mathematical problem-solving performance. Studies consistently show that stronger arithmetic skills, number sense, and fluency are associated with better performance in word problems and applied mathematics, and several regression studies indicate that these variables significantly predict problem-solving outcomes. At the same time, the evidence also shows that the relationship is not absolute. In more difficult or linguistically demanding problems, the contribution of basic computation may become weaker, indirect, or shared with other factors such as text comprehension, vocabulary, and schema knowledge. Therefore, the literature supports the importance of examining error patterns in the four

fundamental operations as predictors of mathematical problem-solving performance, while also recognizing that the strength of this relationship may vary depending on task complexity and learner characteristics (Lariviere et al., 2025; Nob & Pañares, 2025; Pongsakdi et al., 2020; Tolar et al., 2012).

Targeted Mathematics Intervention Program

Mathematics intervention programs are structured, data-driven support mechanisms designed to address identified learning gaps through focused instruction that supplements regular classroom teaching. In intervention literature, these programs are typically characterized by systematic teaching, deliberate attention to mathematical language, the use of concrete and semi-concrete representations, and instructional decisions informed by assessment data rather than by general remediation alone. In the updated elementary mathematics practice guide, systematic instruction, precise mathematical language, visual representations, explicit word-problem instruction, and timed fluency-building activities are all treated as evidence-based components of effective mathematics intervention, while recent review evidence likewise emphasizes that effective elementary interventions intentionally combine conceptual understanding and procedural fluency (Bognar et al., 2025; Fuchs et al., 2021; Prediger et al., 2025).

The literature further suggests that targeted mathematics interventions are most effective when they are built from diagnostic information about what learners specifically do not understand. In the scoping review by Bognar et al. (2025), 44 experimental studies were analyzed, and the authors found 27 instructional characteristics grouped into nine thematic units, with an average of seven characteristics used per intervention; they concluded that effective elementary mathematics interventions should foster conceptual understanding and procedural fluency through problem solving, active learning, mathematical games, cooperative and individual learning, and the use of manipulatives and visualizations. At the same time, they observed that many interventions rarely addressed students' common errors directly, which is especially relevant to the present study because the proposed program is intended to emerge from diagnosed error patterns in the four fundamental operations. Likewise, Fuchs et al. (2021) and Prediger et al. (2025) indicate that targeted intervention is strengthened when teachers use formative assessment, explicit instructional materials, and small-group supplemental teaching to address specific foundational weaknesses such as place value, multiplication meaning, and core arithmetic concepts (Bognar et al., 2025; Fuchs et al., 2021; Prediger et al., 2025).

Quantitative intervention studies provide concrete support for the effectiveness of targeted remediation in computation and foundational numeracy. In Pangasinan, Carranza and De Guzman (2025) used a quasi-experimental pretest-posttest design involving 30 Grade 7 learners identified as struggling in mathematics and found that the mean score increased from 11.23 in the pretest to 23.07 in the posttest. Their paired-samples test showed a mean difference of -11.83, $t(29) = -18.044$, $p = .000$, indicating a statistically significant improvement after the conceptual understanding intervention. In a more computation-specific Philippine study, Nalusay et al. (2024) evaluated a 15-day intervention for Grade 6 learners' multiplication automaticity and found that the pretest mean of 6.14 ($SD = 2.07$) increased to a posttest mean of 19.48 ($SD = 1.09$), with a mean difference of -13.34, Wilcoxon value of 903.000, and $p = .000$. These studies are highly relevant because they show that skill-specific interventions can substantially improve foundational mathematics performance when they directly target identified learner weaknesses (Carranza & De Guzman, 2025; Nalusay et al., 2024).

Evidence also supports the effectiveness of interventions that target mathematical problem solving more directly. In Thailand, Kinason et al. (2025) used a randomized control group pretest-posttest design with Grade 5 learners and found that the experimental group ($n = 34$) outperformed the control group ($n = 35$) in decimal arithmetic problem solving at posttest, with means of 12.91 and 4.37, respectively, $t = 9.02$, $p < .05$, and Cohen's $d = 2.16$. Within the experimental group, scores increased from a pretest mean of 1.94 to a posttest mean of 12.91, $t = 21.77$, $p < .05$, with Cohen's $d = 3.37$. In the Philippines, De la Victoria (2024) employed a quasi-experimental pretest-posttest design with 29 Grade 6 learners and found that the weighted mean increased from 13.97 to 44.48, with a computed t value of 6.634 exceeding the critical value

of 1.824, indicating a significant post-intervention improvement. These findings show that carefully structured instructional strategies can improve not only computation but also problem-solving performance in upper-elementary mathematics (De la Victoria, 2024; Kinasoon et al., 2025).

At the broader evidence level, intervention research strongly supports targeted mathematics support for elementary learners. In their systematic review and meta-analysis, Vessonen et al. (2025) synthesized 115 reports involving 20,456 students from Grades 1 to 6 and found that mathematical word-problem-solving interventions had a strong positive average effect on problem-solving outcomes, with $g = 0.95$ across 425 effect sizes. Their multiple meta-regression also showed that fidelity of implementation, dosage and frequency, dependent measure type, and study quality moderated intervention effectiveness. This large-scale evidence suggests that a targeted mathematics intervention program is most likely to be effective when it is intentionally designed, consistently implemented, and aligned to the exact skill deficit it is meant to address (Vessonen et al., 2025).

Taken together, the literature suggests that the proposed targeted mathematics intervention program in the present study should be diagnostic, focused, and progressive in structure. As an inference from the reviewed studies, the program should begin with learner profiling based on dominant error patterns in addition, subtraction, multiplication, and division; cluster learners according to shared difficulties; and then provide small-group or skill-specific sessions that combine systematic instruction, clear mathematical language, concrete and semi-concrete representations, guided problem solving, and progress monitoring. The findings of Carranza and De Guzman (2025), De la Victoria (2024), Kinasoon et al. (2025), Nalusay et al. (2024), and Vessonen et al. (2025), read alongside the recommendations of Fuchs et al. (2021), Bogнар et al. (2025), and Prediger et al. (2025), support a program that does not treat all low performers the same, but instead connects computation diagnosis to targeted remediation and then to higher-order problem solving. This makes the current study's proposed output both literature-grounded and responsive to the actual learning needs that will be revealed by the error-pattern data (Bognar et al., 2025; Fuchs et al., 2021; Prediger et al., 2025; Vessonen et al., 2025).

Synthesis of the Literature and Research Gap

The reviewed literature consistently shows that learners' errors in addition, subtraction, multiplication, and division are not random but recurring and classifiable. Across studies, the most common patterns include wrong operation, place value errors, regrouping or borrowing mistakes, incomplete procedures, fact retrieval errors, and conceptual misconceptions about the meaning of operations. International review evidence indicates that error analysis studies have focused heavily on computation and that whole-number operations remain a major site of persistent learner difficulty, while classroom-based studies on addition and subtraction and on multiplication and division likewise show patterned errors that can be used for diagnosis and remediation. In the Philippine context, the broader trend of declining foundational mathematics skills reinforces the importance of examining these basic-operation errors among upper-elementary learners (Alanazi, 2024; Giri, 2025; Igarashi & Suryadarma, 2023; Lin et al., 2025; Nelson & Powell, 2018).

The literature on mathematical problem-solving performance shows that elementary learners often experience substantial difficulty across the major Grade 6 content domains, particularly fractions and mixed numbers, decimals and money, ratio and proportion, percent-related tasks, and multi-step problems. Studies on fractions and decimals indicate that learners struggle when they must coordinate symbolic understanding, magnitude, place value, and contextual interpretation, while studies on ratio and percent suggest that multiplicative reasoning and flexible representation are especially demanding. Research on multi-step word problems further shows that problem-solving performance depends not only on computational skill but also on comprehension, planning, and strategic execution. At the same time, intervention studies and meta-analytic evidence show that performance in these domains can improve substantially when instruction is targeted and well structured (Arenas-Peñaloza et al., 2024; Cahyaningsih

et al., 2025; Joutsenlahti & Perkkilä, 2024; Kinasoon et al., 2025; Pereda Loriente et al., 2025; Vessonen et al., 2025).

Across international, Asian, and Philippine studies, the general pattern is that stronger computation and arithmetic-related skills are associated with better mathematical problem-solving performance. Recent Philippine evidence found a strong positive association between computational skills and word-problem solving, while studies from the United States and Finland show that computation and arithmetic skills significantly contribute to word-problem performance even when language-related variables are also considered. These findings support the theoretical expectation that learners who commit fewer and less severe errors in the four fundamental operations are more likely to perform well in mathematical problem solving because they can devote more cognitive resources to understanding the task structure and selecting solution strategies (Lariviere et al., 2025; Nob & Pañares, 2025; Pongsakdi et al., 2020; Stevens et al., 2024).

The literature is consistent in showing that foundational arithmetic matters for problem solving, but it is not fully uniform in how strong or direct that relationship is. Studies generally agree that learners with stronger arithmetic fluency and fewer operation-level errors perform better in mathematical word problems, yet some evidence suggests that this relationship weakens when problems become more linguistically complex or cognitively demanding. For example, some findings indicate that computation predicts initial or lower-complexity problem solving more clearly than high-complexity problem solving, while others show that arithmetic works together with text comprehension, vocabulary, or problem schema knowledge rather than acting alone. Thus, the literature supports the importance of basic operations, but it also suggests that the relative contribution of each operation or skill may vary across tasks and learner groups (Lariviere et al., 2025; Pongsakdi et al., 2020; Sury & Pilchin, 2025; Tolar et al., 2012).

Several gaps emerge from the reviewed literature. First, many studies examine general mathematics achievement, numeracy, or problem-solving performance, but fewer focus specifically on error patterns in the four fundamental operations as a distinct analytical variable. Second, there remains limited predictive-correlational evidence involving upper-elementary learners, especially Grade 6 learners, because much of the existing work focuses either on younger children, students with diagnosed mathematics difficulty, or intervention outcomes rather than prediction. Third, relatively few studies bring together all four operations and multiple Grade 6 problem-solving domains in one framework. Fourth, the Philippine studies reviewed tend to emphasize intervention or general numeracy performance rather than localized predictive analysis in public elementary school settings. Finally, although intervention studies are abundant, fewer programs are explicitly grounded in diagnostic error data that can directly inform targeted remediation design (Bognar et al., 2025; Carranza & De Guzman, 2025; De la Victoria, 2024; Lin et al., 2025; Prediger et al., 2025).

The present study addresses these gaps by examining error patterns in addition, subtraction, multiplication, and division not only descriptively but also as predictors of mathematical problem-solving performance among Grade 6 learners in a specific Philippine public elementary school context. By linking operation-level error patterns with performance in fractions and mixed numbers, decimals and money, ratio and proportion, percent-related tasks, and multi-step problems, the study extends prior literature that has often treated these areas separately. Moreover, by situating the inquiry in Portlamon Elementary School, Division of Surigao del Sur, the study contributes localized evidence that can inform a targeted mathematics intervention program grounded in actual learner errors rather than general remediation assumptions. In this way, the study is both empirically necessary and practically relevant for strengthening mathematics instruction in the elementary grades (Bognar et al., 2025; DepEd, 2016; Lin et al., 2025; Vessonen et al., 2025).

Theoretical Framework

For this study, three theories provide a strong foundation for explaining the variables and their possible relationship: error patterns in the four fundamental operations and mathematical problem-solving performance. These theories help clarify how learners' understanding of basic operations may shape the

kinds of errors they commit and, in turn, influence how successfully they solve mathematical problems. Specifically, the study is anchored on Skemp's Theory of Relational and Instrumental Understanding, Pólya's Theory of Mathematical Problem Solving, and Cognitive Load Theory. (Herheim, 2023; Santos-Trigo, 2024; Sweller, 1988, 2024).

The first is Skemp's Theory of Relational and Instrumental Understanding by Richard R. Skemp (1976/1978). This theory explains that mathematical learning may take two forms: instrumental understanding, which refers to knowing rules and procedures without understanding the reasons behind them, and relational understanding, which refers to knowing both what to do and why it works. In the present study, error patterns in addition, subtraction, multiplication, and division may be interpreted through this lens because repeated computational mistakes often suggest that learners are relying on procedures mechanically rather than understanding number relationships, place value, regrouping, and operation meaning conceptually. Thus, the theory supports the assumption that dominant error patterns are not merely accidental mistakes but possible indicators of weak relational understanding in the four fundamental operations. (Herheim, 2023; Skemp, 1978).

The second is Pólya's Theory of Mathematical Problem Solving by George Pólya (1945). Pólya explained that effective problem solving proceeds through four phases: understanding the problem, devising a plan, carrying out the plan, and looking back. In the present study, mathematical problem-solving performance is understood in this way because Grade 6 learners must first comprehend the problem situation, determine the appropriate operation or set of operations, perform the required computations accurately, and then verify whether the answer is reasonable. This theory supports the idea that successful problem solving depends not only on understanding the context of the problem but also on correctly selecting and executing basic operations. When learners show recurring errors in the four fundamental operations, these errors may disrupt the carrying out and checking stages of problem solving, thereby lowering performance. (Pólya, 1945/2014; Santos-Trigo, 2024).

The third is Cognitive Load Theory by John Sweller (1988). This theory explains that working memory has limited capacity when processing new information, while long-term memory stores knowledge and schemas that support efficient performance. In the present study, this theory is relevant because learners who have weak mastery of the four fundamental operations may use excessive mental effort just to complete basic computations, leaving fewer cognitive resources available for understanding, planning, and monitoring mathematical problem solving. In contrast, learners with stronger foundational skills can retrieve basic procedures more efficiently and devote more attention to the higher-order demands of solving the problem itself. Thus, Cognitive Load Theory helps explain why frequent operation-level errors may be associated with lower mathematical problem-solving performance. (Sweller, 1988, 2024).

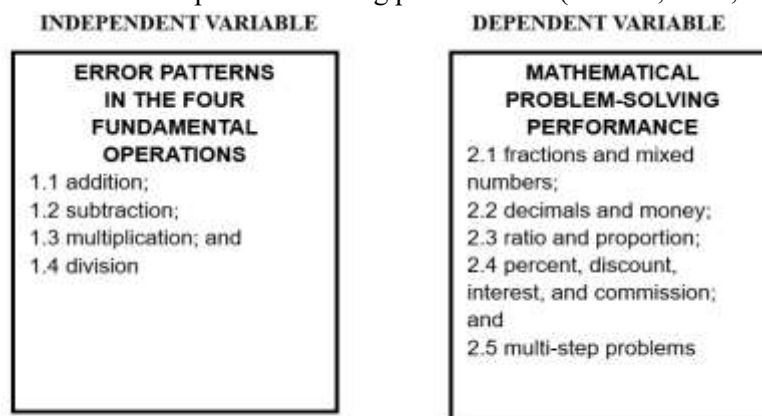


Figure 1. *Schematic Diagram of the Study*

Taken together, these theories provide a coherent basis for the study. Skemp's theory explains how recurring errors in the four fundamental operations may reflect weak conceptual and procedural understanding. Pólya's theory explains how mathematical problem-solving performance depends on learners' ability to understand, plan, execute, and evaluate solutions, all of which require correct use of basic operations. Cognitive Load Theory explains why weaknesses in computation can interfere with higher-level problem solving by consuming limited working-memory resources. Therefore, these theories jointly support the assumption that error patterns in the four fundamental operations can meaningfully predict the mathematical problem-solving performance of Grade 6 learners and provide a sound basis for the development of a targeted mathematics intervention program. (Herheim, 2023; Pólya, 1945/2014; Santos-Trigo, 2024; Sweller, 1988, 2024).

Statement of the Problem

This study aims to determine whether error patterns in the four fundamental operations predict the mathematical problem-solving performance of Grade 6 learners in Portlamon Elementary School, Division of Surigao del Sur.

Specifically, it seeks to answer the following questions:

1. What is the error pattern performance of the Grade 6 learners in the four fundamental operations in terms of:
 - 1.1 addition;
 - 1.2 subtraction;
 - 1.3 multiplication; and
 - 1.4 division?
2. What is the level of mathematical problem-solving performance of the Grade 6 learners in areas of:
 - 3.1 fractions and mixed numbers;
 - 3.2 decimals and money;
 - 3.3 ratio and proportion;
 - 3.4 percent, discount, interest, and commission; and
 - 3.5 multi-step problems?
3. Is there a significant relationship between error patterns in the four fundamental operations and the mathematical problem-solving performance of Grade 6 learners?
4. Which of the error patterns in the four fundamental operations significantly predict the mathematical problem-solving performance of Grade 6 learners?
5. What can be proposed based on the findings of the study?

METHODS

Research Design

This study employed quantitative research, which was appropriate because it involved gathering numerical data and analyzing them statistically to describe learner performance, identify patterns of error, examine relationships among variables, and generate prediction-based findings. Quantitative research is commonly used when variables are measured through instruments and the resulting numbered data are analyzed objectively through statistical procedures (Bhandari, 2023b; Creswell & Creswell, 2018).

More specifically, the study used a predictive-correlational research design. Correlational research examines the degree of association between two or more variables without manipulating them, making it a nonexperimental form of quantitative research. In predictive studies, regression analysis is used to explain variability in an outcome variable and to forecast or predict its value based on one or more predictor variables. Thus, a predictive-correlational design was appropriate when the intent was not only to determine whether variables were related, but also to test whether a predictor variable significantly explained or

predicted a criterion variable (Bhandari, 2023a; Creswell & Creswell, 2018; Statistical, Economic and Social Research and Training Centre for Islamic Countries [SESRIC], 2015).

In this study, the design was used to determine the performance of Grade 6 learners in the four fundamental operations in terms of addition, subtraction, multiplication, and division, and the level of mathematical problem-solving performance in terms of fractions and mixed numbers, decimals and money, ratio and proportion, percent, discount, interest, and commission, and multi-step problems. The correlational component was used to test whether a significant relationship existed between error patterns in the four fundamental operations and mathematical problem-solving performance, while the predictive component was used through regression analysis to determine which of the operation-based error patterns significantly predicted mathematical problem-solving performance (Department of Education [DepEd], 2016; SESRIC, 2015).

The use of a predictive-correlational design was justified by the nature and objectives of the study. The investigation did not involve any intervention, treatment, or manipulation of learners' computation errors or problem-solving performance. Instead, it described the current status of the variables, examined their statistical association, and tested whether error patterns in the four fundamental operations predicted the dependent variable. Since the study intended to generate school-based quantitative evidence and prediction-oriented findings rather than establish direct cause-and-effect relationships, the predictive-correlational design was the most appropriate methodological choice (Bhandari, 2023a, 2023b; Creswell & Creswell, 2018).

Research Locale

This study was conducted in Portlamon Elementary School, which is situated in the Caraga Region (Region XIII) in the northeastern part of Mindanao. Caraga is composed of five provinces—Agusan del Norte, Agusan del Sur, Surigao del Norte, Surigao del Sur, and Dinagat Islands—and includes Butuan City as its regional center. As a regional administrative unit in Mindanao, Caraga served as the broader educational and geographic context of the study.

Within Caraga, the study was specifically located in the Province of Surigao del Sur. The province maintains its official seat in Tandag City, where the provincial government is based, and the Schools Division of Surigao del Sur also holds office in Tandag City. This established the provincial and divisional context of the study and situated Portlamon Elementary School within the administrative jurisdiction of the Department of Education—Schools Division of Surigao del Sur.

At the municipal level, the study was conducted in the Municipality of Hinatuan, one of the municipalities of Surigao del Sur. Hinatuan is a coastal municipality composed of several barangays and serves as the immediate municipal setting of the study. Its geographic and administrative characteristics made it an appropriate local context for a school-based study on mathematics performance among elementary learners.

More specifically, the study was undertaken in Barangay Portlamon, where Portlamon Elementary School is located. The school is part of Hinatuan North District under the Schools Division of Surigao del Sur. Since the respondents of the study were the Grade 6 learners of this school, Portlamon Elementary School served as the direct and specific locale of the investigation.



Figure 2. *Maps of the Philippines and Municipality of Hinatuan*

Respondents of the Study

The respondents of this study were the Grade 6 learners of Portlamon Elementary School, Division of Surigao del Sur, who participated during the conduct of the study. Based on the encoded dataset used for analysis, the respondents consisted of all Grade 6 learners officially enrolled in the school during the data-gathering period, with a total population of thirty-one (31) learners. The learners themselves served as the respondents because the major variables of the study—error patterns in the four fundamental operations and mathematical problem-solving performance—were measured through researcher-made multiple-choice tests administered directly to them. Their responses provided the primary data needed to determine performance in the four fundamental operations, the level of mathematical problem-solving performance, the relationship between the variables, and the predictive influence of error patterns on mathematical problem-solving performance.

The study employed purposive sampling in identifying the target population, specifically the Grade 6 learners of Portlamon Elementary School who matched the objectives and variables of the study. Following this, total enumeration was applied, wherein all identified Grade 6 learners were included in the data-gathering process. The final number of respondents consisted of those who participated in the test administration and submitted complete and valid responses, as reflected in the encoded dataset used for statistical analysis. In this case, all thirty-one (31) Grade 6 learners were included in the final dataset.

To ensure the validity and relevance of the data, inclusion criteria were applied. Only learners who were officially enrolled as Grade 6 pupils of Portlamon Elementary School, were present during the administration of the instruments, accomplished the researcher-made tests, and submitted complete and valid responses were included in the study. Learners who did not belong to the identified grade level or who

would have submitted incomplete responses were to be excluded from the final dataset. However, based on the actual data gathered, all identified Grade 6 learners were included in the analysis.

The respondents were required to accomplish two structured, researcher-made multiple-choice tests: one on error patterns in the four fundamental operations and another on mathematical problem-solving performance. Only complete and valid responses were encoded and included in the statistical analysis. The population and sample distribution of the respondents are presented in Table 1.

Table 1. *Respondents of the Study*

Respondents	Population	Sample
Grade 6 Learners of Portlamon Elementary School	31	31
Total Learner-Respondents	31	31

Note. The respondents were identified through purposive sampling, specifically the Grade 6 learners of Portlamon Elementary School, with total enumeration applied to the identified group. The table reflects the Grade 6 population distribution based on the final encoded dataset used in the study.

Research Instrument

This study utilized two researcher-made, adapted, and contextualized multiple-choice tests designed to gather quantitative data on the two major variables of the study: error patterns in the four fundamental operations and mathematical problem-solving performance. Structured objective tests were appropriate for this investigation because the learners' responses could be converted into numerical scores and analyzed statistically in an objective and standardized manner. In this study, the instruments were presented as learner test booklets with fixed response options so that all respondents answered under the same conditions and scoring rules (Bhandari, 2023).

The instrument consisted of two parts. Part I measured Error Patterns in the Four Fundamental Operations in terms of addition, subtraction, multiplication, and division. Part II measured Mathematical Problem-Solving Performance in terms of fractions and mixed numbers, decimals and money, ratio and proportion, percent, discount, interest, and commission, and multi-step problems. The final instrument contained 40 items, with 20 items for Error Patterns in the Four Fundamental Operations and 20 items for Mathematical Problem-Solving Performance. Each item was presented in multiple-choice format with four options, one correct answer, and three distractors. Responses were scored using 1 point for each correct answer and 0 point for each incorrect answer, then encoded and processed through an automated scoring workbook where raw scores, percentages, and interpretations were computed. The content coverage of both parts was aligned with the Grade 6 mathematics competencies in the K to 12 Mathematics Curriculum Guide and the problem-solving emphases reflected in the PISA mathematics framework (Department of Education [DepEd], 2016; OECD, 2023).

The Error Patterns in the Four Fundamental Operations component of the instrument was developed from the Grade 6 mathematics competencies on whole numbers, decimals, fractions, and mixed numbers in the K to 12 Mathematics Curriculum Guide. Its distractors were deliberately constructed to reflect recurring computation errors commonly discussed in mathematics error-analysis literature, such as fraction-related errors, decimal alignment or decimal placement errors, wrong method, basic fact errors, operation misconception, place value errors, incomplete procedures, and related computation mistakes. These source bases provided the conceptual foundation for organizing the items and the distractor logic of the error-pattern test used in the study (DepEd, 2016; Lin et al., 2025; Nelson & Powell, 2018).

The Mathematical Problem-Solving Performance component of the instrument was likewise based on the Grade 6 mathematics competencies in the K to 12 curriculum, particularly those involving fractions and mixed numbers, decimals and money, ratio and proportion, percent-related applications, and multi-step problems. The organization of the problem-solving test was further informed by the PISA 2022 mathematics framework, which emphasizes the processes of formulating, employing, and interpreting mathematics in

contextualized situations. These sources served as the conceptual basis for constructing the test items so that the instrument would measure not only procedural calculation but also the learners' ability to understand and solve mathematical problems meaningfully (DepEd, 2016; OECD, 2023).

As a researcher-made and contextualized instrument, the two tests were structured by directly aligning each item with the variables, indicators, and domains stated in the Statement of the Problem and the Table of Specifications. The content coverage of the instrument was therefore anchored on recognized curriculum and assessment frameworks and localized to the Grade 6 mathematics competencies relevant to the actual learners of Portlamon Elementary School. This alignment helped ensure that the items were relevant to the respondents, appropriate to the study locale, and consistent with the constructs intended to be measured in the investigation (DepEd, 2016; OECD, 2023).

For reliability, the accomplished tests from the 31 Grade 6 learner-respondents were subjected to internal consistency analysis using Cronbach's alpha. Based on the actual dataset of the study, the computed alpha coefficients were .728 for the Error Patterns in the Four Fundamental Operations test, .580 for the Mathematical Problem-Solving Performance test, and .784 for the combined instrument. These results suggested stronger internal consistency for the error-pattern test and the overall instrument than for the problem-solving test, and they provided empirical evidence on the dependability of the scores generated by the tools. The use of Cronbach's alpha as an index of internal consistency was consistent with accepted instrument-development practice in educational research (Taber, 2018).

After finalization, the instruments were administered to the 31 Grade 6 learners of Portlamon Elementary School who served as the respondents of the study. Only complete and valid responses were encoded in the automated scoring workbook and used for the statistical analysis. Thus, the research instruments used in this study may be considered researcher-made, adapted, contextualized, curriculum-aligned, and reliability-tested, making them appropriate for gathering the data needed to answer the research problems.

Data Gathering Procedure

This study observed a systematic pre-data collection phase to ensure that the gathering of quantitative data was ethical, organized, and aligned with school protocols. First, the researcher prepared and finalized the two researcher-made multiple-choice tests on error patterns in the four fundamental operations and mathematical problem-solving performance, ensuring that the items were clear, grade-level appropriate, and aligned with the Grade 6 Mathematics competencies in the K to 12 curriculum and the problem-solving domains reflected in the study instrument. The researcher also prepared the parental consent and learner assent procedures, coding sheet, and automated scoring workbook to facilitate confidentiality, orderly data processing, and accurate statistical treatment. Second, the researcher secured the necessary permissions from the Schools Division Superintendent and the school administration of Portlamon Elementary School before the conduct of the study. Coordination was then made with the school head, the Grade 6 adviser, and other concerned personnel regarding the schedule of administration and the most feasible manner of distributing and retrieving the test instruments without disrupting regular school activities (Bhandari, 2023b; Department of Education [DepEd], 2016; OECD, 2023).

During the actual data gathering, the researcher implemented the informed consent and assent procedures and administered the research instruments in a manner that respected the rights of the respondents and the normal operations of the school. The Grade 6 learners were oriented regarding the purpose of the study, the voluntary nature of participation, and the confidentiality of their responses. Only those who participated and submitted complete responses were included. The two tests were then administered to all Grade 6 learners covered by the study, and the respondents were given sufficient time to answer the instruments independently. After completion, the accomplished answer sheets were retrieved and checked for completeness and legibility to minimize missing or unusable data. Since the study used

standardized objective tests, the administration of the instruments was carried out in a consistent manner for all respondents (Bhandari, 2023b, 2023c).

To protect confidentiality and comply with data privacy principles, the researcher used a coding system rather than the names of the respondents in encoding and processing the data. The accomplished test papers were handled only for research purposes, and access to the responses was limited to those directly involved in the study. This procedure was consistent with the Data Privacy Act of 2012, which protects personal information and requires that personal data be secured and processed responsibly. Only the information necessary for the analysis of error patterns in the four fundamental operations and mathematical problem-solving performance was retained in the dataset (Republic of the Philippines, 2012).

After retrieval of the accomplished tests, the researcher proceeded with data encoding, cleaning, and verification. The responses were entered into the automated scoring workbook, which generated raw scores, percentages, interpretations, operation-level results, problem-solving domain scores, and error-code tallies based on the established scoring scheme. The researcher then checked the dataset for completeness, invalid entries, duplicated responses, and possible encoding errors. Only complete and valid responses were retained for the final statistical analysis. This process was important in ensuring the integrity of the data and the accuracy of the descriptive, correlational, and regression results generated from the study (Bhandari, 2023b, 2023c).

Finally, the cleaned dataset was subjected to statistical treatment aligned with the Statement of the Problem. Descriptive statistics were used to determine the performance of the Grade 6 learners in the four fundamental operations and the level of their mathematical problem-solving performance across the identified domains. Correlational analysis was then used to determine whether a significant relationship existed between error patterns in the four fundamental operations and mathematical problem-solving performance, while regression analysis was employed to determine which of the operation-based error patterns significantly predicted mathematical problem-solving performance. The results were summarized and reported in aggregate form to preserve confidentiality and to present school-based quantitative evidence on the mathematics performance of the Grade 6 learners of Portlamon Elementary School (Bevans, 2023; Bhandari, 2023a, 2023c).

Statistical Treatment

To answer Research Question 1 on the performance of the Grade 6 learners in the four fundamental operations in terms of addition, subtraction, multiplication, and division, weighted mean and standard deviation were used. The weighted mean was applied to determine the average performance of the learners in each operation and in the overall test, while the standard deviation was used to describe the variability or spread of the scores. Rank ordering was also applied to identify the highest and lowest areas of performance among the four fundamental operations based on the computed mean scores (Anthony, 2024; Siedlecki, 2020).

To answer Research Question 2 on the level of mathematical problem-solving performance of the Grade 6 learners in terms of fractions and mixed numbers, decimals and money, ratio and proportion, percent, discount, interest, and commission, and multi-step problems, weighted mean and standard deviation were likewise used. Rank ordering was also employed to determine the highest and lowest domains of mathematical problem-solving performance according to the computed mean scores. These descriptive statistics were appropriate because the study first sought to describe the level and relative standing of the learners' performance in each problem-solving domain before examining relationships and prediction (Anthony, 2024; Siedlecki, 2020).

To answer Research Question 3 on the significant relationship between error patterns in the four fundamental operations and the mathematical problem-solving performance of Grade 6 learners, the Pearson product-moment correlation coefficient (Pearson r) was used. Pearson r was employed to determine the strength and direction of the linear relationship between the variables, and the significance of the

relationship was tested at the 0.05 level of significance. This statistical treatment was appropriate because the study involved quantitative variables measured through numerical scores and sought to determine whether a significant association existed between the learners' error-pattern scores and their mathematical problem-solving performance (Creswell & Creswell, 2018; Zaid, 2015).

To answer Research Question 4 on which of the error patterns in the four fundamental operations significantly predicted the mathematical problem-solving performance of Grade 6 learners, multiple linear regression analysis was used. This statistical procedure was employed to determine the predictive influence of the identified error-pattern indicators on the dependent variable. The regression analysis generated the beta coefficients, coefficient of determination (R^2), adjusted R^2 , F -value, and p -values, which were used to evaluate the strength and significance of the predictive model at the 0.05 level of significance. Multiple regression was appropriate because the study aimed not only to examine relationships but also to test whether the identified predictor variables significantly explained variation in mathematical problem-solving performance (Creswell & Creswell, 2018; Zaid, 2015).

To answer Research Question 5 on the targeted mathematics intervention program that may be proposed based on the findings of the study, no separate inferential statistical treatment was used. Instead, the proposed intervention program was developed from the consolidated results of the descriptive, correlational, and regression analyses, particularly the identified low-performing areas, dominant error patterns, and significant predictive findings. This procedure was appropriate because the intervention output was intended to be data-based and responsive to the actual needs revealed by the statistical results of the study.

RESULTS AND DISCUSSIONS

Problem 1. What is the error pattern performance of the Grade 6 learners in the four fundamental operations in terms of addition, subtraction, multiplication, and division?

Table 1 presents the performance of the Grade 6 learner-respondents in the four fundamental operations. The overall mean score for Error Patterns in the Four Fundamental Operations was 11.71 out of 20 ($SD = 3.06$), equivalent to 58.55%, interpreted as Very Low Accuracy. Among the operations, Multiplication obtained the highest mean percentage (80.65%), interpreted as High Accuracy, while Division obtained the lowest mean percentage (37.42%), interpreted as Very Low Accuracy. These results indicate that the learners were relatively more successful in multiplication than in the other operations but continued to experience serious difficulty in subtraction and especially in division. This pattern is consistent with prior literature showing that division and operations involving rational numbers and place value frequently generate more persistent learner errors than routine multiplication facts or simpler whole-number addition tasks (Alanazi, 2024; Lin et al., 2025; Nelson & Powell, 2018).

Table 1. *Performance of Grade 6 Learners in the Four Fundamental Operations ($n = 31$)*

Operation	Mean Score	SD	Percentage	Interpretation
Addition	3.35	0.61	67.10	Low
Subtraction	2.45	1.31	49.03	Very Low
Multiplication	4.03	0.95	80.65	High
Division	1.87	1.20	37.42	Very Low
Overall Error Patterns in the Four Fundamental Operations	11.71	3.06	58.55	Very Low

Note. Percentages were interpreted using the following scale: 90.00–100.00 = Very High Accuracy, 80.00–89.99 = High Accuracy, 70.00–79.99 = Moderate Accuracy, 60.00–69.99 = Low Accuracy, and 0.00–59.99 = Very Low Accuracy.

At the item level, the strongest performance was recorded in Item 2 and Item 5, both with a 100.00% correct response rate, followed by Item 1, Item 11, and Item 12, each with a 96.77% correct response rate. In contrast, the lowest correct response rates were observed in Item 4 (3.23%), Item 8 (9.68%), Item 17 (12.90%), Item 20 (16.13%), and Item 19 (32.26%). These difficult items largely involved fractions, mixed numbers, decimals, and division, suggesting that the learners' weak performance was concentrated in operations requiring stronger conceptual understanding of rational numbers and more careful procedural execution. Related studies have similarly shown that learners' computation errors tend to cluster around fraction-related procedures, decimal placement, and complex division tasks rather than around simpler whole-number items (Alanazi, 2024; Lin et al., 2025).

Additional error-code tallies further clarified the nature of these weaknesses. The most frequent coded errors were fraction denominator or numerator operation errors (FD = 84), decimal alignment or decimal placement errors (DA = 60), and wrong-method errors (WM = 38). This means that the learners' low performance was not only numerical in magnitude but also diagnostic in character, showing that their mistakes were concentrated in specific conceptual and procedural areas. This result supports the argument that recurring errors in elementary arithmetic are meaningful indicators of incomplete understanding and should be used as bases for targeted remediation (Lin et al., 2025; Nelson & Powell, 2018).

Problem 2. What is the level of mathematical problem-solving performance of the Grade 6 learners in terms of fractions and mixed numbers, decimals and money, ratio and proportion, percent, discount, interest, and commission, and multi-step problems?

Table 2 shows the level of mathematical problem-solving performance of the Grade 6 learners across the identified domains. The overall mean score for Mathematical Problem-Solving Performance was 7.68 out of 20 (SD = 2.96), equivalent to 38.39%, interpreted as Low Problem-Solving Performance. Among the domains, Decimals and Money obtained the highest mean percentage (55.91%), interpreted as Moderate Problem-Solving Performance, while Percent, Discount, Interest, and Commission obtained the lowest mean percentage (24.19%), interpreted as Low Problem-Solving Performance. Ratio and Proportion (29.03%), Multi-Step Problems (33.87%), and Fractions and Mixed Numbers (37.90%) also remained in the low-performance range. These results indicate that the learners found applied and multi-stage mathematical situations difficult, particularly in domains requiring proportional reasoning and percentage-based applications (Arenas-Peñaloza et al., 2024; Joutsenlahti & Perkkilä, 2024; Vessonen et al., 2025).

Table 2. *Mathematical Problem-Solving Performance of Grade 6 Learners by Domain (n = 31)*

Domain	Mean Score	SD	Percentage	Interpretation
Fractions and Mixed Numbers	1.52	1.26	37.90	Low
Decimals and Money	3.35	1.82	55.91	Moderate
Ratio and Proportion	1.16	0.78	29.03	Low
Percent, Discount, Interest, and Commission	0.97	0.80	24.19	Low
Multi-Step Problems	0.68	0.70	33.87	Low
Overall Mathematical Problem-Solving Performance	7.68	2.96	38.39	Low

Note. Percentages were interpreted using the following scale: 90.00–100.00 = Very High Problem-Solving Performance, 75.00–89.99 = High Problem-Solving Performance, 50.00–74.99 = Moderate Problem-Solving Performance, and 0.00–49.99 = Low Problem-Solving Performance.

At the item level, the highest correct response rate was recorded in Item 6 (83.87%), followed by Item 12 (70.97%), Item 10 (67.74%), Item 7 (61.29%), and Item 4 (60.00%). In contrast, the most difficult items were Item 11 (10.00%), Item 14 (12.90%), and Items 8, 15, and 16 (all at 19.35%). These low-performing items represented ratio and proportion, percent, and decimal-based problem situations,

confirming that learners struggled most when solving contextual tasks requiring multiplicative reasoning, percent interpretation, and multi-step decision making. This pattern is similar to the findings of previous studies showing that learners often perform better on more familiar decimal and money tasks than on ratio, percentage, and complex problem situations that require deeper conceptual reasoning and strategic planning (Arenas-Peñaloza et al., 2024; Joutsenlahti & Perkkilä, 2024; Kinasoon et al., 2025).

Problem 3. Is there a significant relationship between error patterns in the four fundamental operations and the mathematical problem-solving performance of Grade 6 learners?

Pearson product-moment correlation analysis was conducted to determine the relationship between Error Patterns in the Four Fundamental Operations and Mathematical Problem-Solving Performance. As shown in Table 3, the two variables had a moderate positive and statistically significant relationship ($r = 0.5972$, $p = 0.00039$). This means that learners who obtained higher accuracy scores in the four fundamental operations also tended to obtain higher scores in mathematical problem solving. Conversely, learners who manifested more severe operation-level difficulties tended to perform more poorly in the problem-solving test. The result indicates that mastery of basic operations remained closely associated with the ability to solve contextualized mathematical problems (Lariviere et al., 2025; Nob & Pañares, 2025).

Table 3. *Relationship Between Error Patterns in the Four Fundamental Operations and Mathematical Problem-Solving Performance (n = 31)*

Variable Pair	r	Strength	p	Decision at .05
Error Patterns in the Four Fundamental Operations and Mathematical Problem-Solving Performance	0.5972	Moderate Positive	0.00039	Reject H_{01}

Note. Pearson product-moment correlation coefficient was used. Correlations were tested at the 0.05 level of significance.

Supplementary operation-level correlations showed that Addition was not significantly related to mathematical problem-solving performance ($r = 0.2694$, $p = 0.1427$), while Subtraction ($r = 0.5193$, $p = 0.00276$), Multiplication ($r = 0.4434$, $p = 0.01249$), and Division ($r = 0.4650$, $p = 0.00839$) were all significantly related. These results suggest that performance in subtraction, multiplication, and division was more closely associated with problem-solving performance than performance in addition. This pattern is consistent with prior findings that computation and arithmetic-related skills support word-problem solving, especially when the tasks demand flexible operation selection, accurate execution, and interpretation of intermediate quantities (Nob & Pañares, 2025; Pongsakdi et al., 2020; Stevens et al., 2024).

Problem 4. Which of the error patterns in the four fundamental operations significantly predict the mathematical problem-solving performance of Grade 6 learners?

Multiple linear regression analysis was conducted to determine whether the operation-based error-pattern indicators significantly predicted Mathematical Problem-Solving Performance. As shown in Table 4, the overall regression model was statistically significant, $F(4, 26) = 3.790$, $p = 0.0148$, with $R^2 = 0.368$ and adjusted $R^2 = 0.271$. This means that the four predictors, taken together, explained 36.8% of the variance in mathematical problem-solving performance. However, when examined individually, none of the four operations emerged as a statistically significant unique predictor: Addition ($p = 0.999$), Subtraction ($p = 0.121$), Multiplication ($p = 0.290$), and Division ($p = 0.173$). Therefore, the null hypothesis on the overall predictive model was rejected, but no single operation-based predictor made a unique significant contribution when all four were entered simultaneously.

Table 4. *Multiple Regression Analysis Predicting Mathematical Problem-Solving Performance (n = 31)*

Predictor	B	SE B	β	t	p
Constant	2.1830	2.7230	—	0.802	0.430
Addition	-0.0014	0.8840	-0.0003	-0.002	0.999
Subtraction	0.6877	0.4285	0.3050	1.605	0.121
Multiplication	0.6607	0.6111	0.2116	1.081	0.290
Division	0.6142	0.4387	0.2498	1.400	0.173

Note. The regression model was significant, with $R^2 = 0.368$, adjusted $R^2 = 0.271$, $F(4, 26) = 3.790$, and $p = 0.0148$.

This pattern suggests that the operation-based predictors overlapped in their contribution to mathematical problem solving. In other words, the shared influence of the four operations on the dependent variable was meaningful, but no single operation retained a statistically unique effect after the other operations were controlled. A plausible explanation is that mathematical problem solving in Grade 6 does not rely on one operation in isolation; rather, it depends on the coordinated use of several basic operations together with comprehension, reasoning, and monitoring of solution steps. Similar predictive studies have shown that arithmetic contributes substantially to problem solving, but that the size and uniqueness of individual predictors may vary depending on the complexity of tasks and the overlap among related foundational skills (Pongsakdi et al., 2020; Sury & Pilchin, 2025; Tolar et al., 2012).

Problem 5. Based on the findings of the study, what targeted mathematics intervention program may be proposed?

Based on the identified low-performing areas, the significant relationship between the variables, and the regression model showing the combined predictive value of the four operations, a targeted mathematics intervention program was proposed for the Grade 6 learners of Portlamon Elementary School. The proposed program focused on the specific areas of weakness revealed by the study, particularly division, subtraction, fraction- and decimal-related computation, proportional reasoning, percentage applications, and multi-step problem solving. The proposed intervention program is presented in Table 5.

Table 5. *Proposed Targeted Mathematics Intervention Program*

Program Element	Description
Program Title	Project MATIBAY 6: A Targeted Mathematics Intervention Program for Grade 6 Learners
Target Learners	Grade 6 learners of Portlamon Elementary School, especially those who obtained low scores in the four fundamental operations and mathematical problem-solving test.
General Objective	To improve learners' accuracy in the four fundamental operations and strengthen their mathematical problem-solving performance through focused, diagnostic, and skill-based remediation.
Priority Skill Areas	Division and subtraction; fraction and mixed-number operations; decimal alignment and decimal computation; ratio and proportion; percent applications involving discount, interest, and commission; and multi-step problems.
Key Diagnostic Bases	Very Low overall accuracy in the four fundamental operations (58.55%), Low overall mathematical problem-solving performance (38.39%), weakest performance in division (37.42%), and lowest problem-solving domain in percent, discount, interest, and commission (24.19%). Additional error-code tallies showed frequent fraction-related, decimal-alignment, and wrong-method errors.
Core Strategies	Diagnostic grouping of learners; explicit reteaching of weak operations; use of manipulatives and visual models for fractions and decimals; step-by-step guided practice; Read–Plan–Solve–Check

	routine for problem-solving; focused drills on subtraction and division; contextualized exercises on ratio, proportion, and percent; and periodic formative assessment.
Time Frame	Eight weeks, with three remediation sessions per week lasting 30 to 45 minutes per session.
Persons Involved	School head, Grade 6 mathematics teacher, learner-respondents, and parents or guardians for home-based follow-up practice.
Success Indicators	Improved post-remediation scores in the weakest operations and domains, reduction in dominant fraction- and decimal-related errors, and movement of more learners from low performance categories toward moderate or higher performance levels.

Note. The proposed program was derived from the descriptive, correlational, and regression findings of the study and was intended as a school-based intervention framework for Grade 6 mathematics improvement.

The proposed program was grounded on the diagnostic pattern of the findings. The lowest operation performance was found in division, while the most frequent error codes were fraction denominator or numerator operation errors, decimal alignment or placement errors, and wrong-method errors. In mathematical problem solving, the lowest-performing domain was percent, discount, interest, and commission, followed by ratio and proportion and multi-step problems. These findings suggest that remediation should not be generic; instead, it should address the exact conceptual and procedural weaknesses manifested by the learners. This is consistent with intervention literature emphasizing that effective mathematics support should be diagnostic, explicit, skill-focused, and responsive to identified learner needs (Bognar et al., 2025; Fuchs et al., 2021; Vessonen et al., 2025).

Overall, the Grade 6 learners demonstrated very low accuracy in the four fundamental operations and low mathematical problem-solving performance. Multiplication was the strongest operation, whereas division was the weakest. Decimals and money was the highest problem-solving domain, whereas percent, discount, interest, and commission was the lowest. The inferential results further showed that error patterns in the four fundamental operations were significantly related to mathematical problem-solving performance and that the four operation-based indicators, taken together, significantly predicted mathematical problem-solving performance. These findings support the educational importance of strengthening foundational computation as a basis for improving mathematical problem solving among Grade 6 learners.

Summary of Findings

The study examined the performance of Grade 6 learners in the four fundamental operations and their mathematical problem-solving performance using a quantitative predictive-correlational research design. Specifically, it determined the performance of the learners in addition, subtraction, multiplication, and division; the level of mathematical problem-solving performance in terms of fractions and mixed numbers, decimals and money, ratio and proportion, percent, discount, interest, and commission, and multi-step problems; the significant relationship between error patterns in the four fundamental operations and mathematical problem-solving performance; and the predictive influence of the operation-based indicators on mathematical problem-solving performance. It also generated a targeted mathematics intervention program based on the diagnostic, correlational, and predictive findings of the study. The respondents were 31 Grade 6 learners with complete and valid responses. Statistical tools used included weighted mean, standard deviation, rank ordering, Pearson product-moment correlation coefficient, and multiple linear regression.

Findings

1. Performance of Grade 6 Learners in the Four Fundamental Operations

- 1.1 The overall performance of the Grade 6 learners in the four fundamental operations was very low, with a mean score of 11.71 out of 20 ($SD = 3.06$), equivalent to 58.55% accuracy.

- 1.2 Among the four operations, Multiplication obtained the highest mean percentage of 80.65%, interpreted as High Accuracy.
- 1.3 The lowest mean percentage was obtained by Division at 37.42%, interpreted as Very Low Accuracy. Addition obtained 67.10%, interpreted as Low Accuracy, while Subtraction obtained 49.03%, interpreted as Very Low Accuracy.
- 1.4 The most frequent error codes were fraction denominator or numerator operation errors (FD = 84), decimal alignment or decimal placement errors (DA = 60), and wrong-method errors (WM = 38). These results suggest that the learners' most persistent difficulties were concentrated in rational-number procedures, decimal alignment, and incorrect solution methods, a pattern consistent with prior studies showing that division, fractions, and decimals tend to generate more enduring computational errors than simpler whole-number operations (Alanazi, 2024; Lin et al., 2025; Nelson & Powell, 2018).

2. Mathematical Problem-Solving Performance

- 2.1 The overall mathematical problem-solving performance of the Grade 6 learners was low, with a mean score of 7.68 out of 20 (SD = 2.96), equivalent to 38.39%.
- 2.2 Among the domains, Decimals and Money obtained the highest mean percentage of 55.91%, interpreted as Moderate Problem-Solving Performance.
- 2.3 The domain with the lowest mean percentage was Percent, Discount, Interest, and Commission at 24.19%, interpreted as Low Problem-Solving Performance.
- 2.4 The other domains also remained in the low-performance range: Fractions and Mixed Numbers at 37.90%, Multi-Step Problems at 33.87%, and Ratio and Proportion at 29.03%. These findings indicate that the learners found applied and multi-stage mathematical situations difficult, especially those requiring percentage reasoning, proportional thinking, and strategic coordination of several steps (Arenas-Peñaloza et al., 2024; Joutsenlahti & Perkkilä, 2024; Vessonen et al., 2025).

3. Relationship Between Error Patterns in the Four Fundamental Operations and Mathematical Problem-Solving Performance

- 3.1 The relationship between the overall error-pattern score and mathematical problem-solving performance was positive, moderate, and statistically significant ($r = .5972$, $p = .00039$).
- 3.2 At the operation level, Addition was not significantly related to mathematical problem-solving performance ($r = .2694$, $p = .1427$).
- 3.3 Subtraction had a significant positive relationship with mathematical problem-solving performance ($r = .5193$, $p = .00276$).
- 3.4 Multiplication also had a significant positive relationship with mathematical problem-solving performance ($r = .4434$, $p = .01249$).
- 3.5 Division likewise had a significant positive relationship with mathematical problem-solving performance ($r = .4650$, $p = .00839$).
- 3.6 These findings indicate that better performance in the four fundamental operations, particularly in subtraction, multiplication, and division, was associated with stronger mathematical problem-solving performance. This pattern supports previous evidence that foundational arithmetic skills remain closely linked with success in contextualized mathematical tasks (Nob & Pañares, 2025; Pongsakdi et al., 2020; Stevens et al., 2024).

4. Predictive Influence of Error Patterns in the Four Fundamental Operations on Mathematical Problem-Solving Performance

- 4.1 Multiple linear regression analysis showed that the four operation-based indicators, taken together, significantly predicted mathematical problem-solving performance, $F(4, 26) = 3.790$, $p = .0148$.
- 4.2 The regression model explained 36.8% of the variance in mathematical problem-solving performance ($R^2 = .368$, adjusted $R^2 = .271$).
- 4.3 None of the four operation-based predictors emerged as a statistically significant unique predictor when entered simultaneously in the model: Addition ($B = -0.0014$, $p = .999$), Subtraction ($B = 0.6877$, $p = .121$), Multiplication ($B = 0.6607$, $p = .290$), and Division ($B = 0.6142$, $p = .173$).
- 4.4 These results indicate that the four basic operations had meaningful shared predictive influence on mathematical problem solving, but no single operation retained a unique significant effect after the other operations were controlled. This suggests overlap in the contribution of the four operations to problem solving, which is consistent with studies showing that mathematical problem solving depends on the coordinated use of multiple foundational skills rather than one operation in isolation (Pongsakdi et al., 2020; Sury & Pilchin, 2025; Tolar et al., 2012).

5. Proposed Targeted Mathematics Intervention Program

- 5.1 Based on the findings of the study, a targeted mathematics intervention program was proposed for the Grade 6 learners of Portlamon Elementary School.
- 5.2 The proposed intervention program focused on the low-performing areas and dominant error patterns revealed by the study, particularly division, subtraction, fraction denominator or numerator operation errors, decimal alignment or decimal placement errors, wrong-method errors, ratio and proportion, percent-based applications, and multi-step problem solving.
- 5.3 The proposed program was intended to provide diagnostic, skill-focused, and school-based support to address the identified weaknesses in both foundational computation and mathematical problem solving, consistent with intervention literature emphasizing explicit, targeted, and data-based mathematics support for struggling learners (Bognar et al., 2025; Fuchs et al., 2021; Vessonen et al., 2025).

CONCLUSIONS

1. Overall Patterns

- 1.1 The Grade 6 learners of Portlamon Elementary School manifested very low accuracy in the four fundamental operations, indicating that their mastery of foundational computation remained insufficient.
- 1.2 The learners likewise manifested low mathematical problem-solving performance, showing that they experienced substantial difficulty in applying mathematics to contextualized and multi-step tasks.
- 1.3 Among the operations, multiplication was the strongest area, whereas division was the weakest. Among the problem-solving domains, decimals and money was the strongest area, whereas percent, discount, interest, and commission was the weakest.

2. Relationship Between the Variables

- 2.1 Error patterns in the four fundamental operations had a significant positive relationship with mathematical problem-solving performance.
- 2.2 At the operation level, subtraction, multiplication, and division were significantly related to mathematical problem-solving performance, whereas addition was not.

- 2.3 These findings imply that stronger foundational computation, especially in the more demanding operations, tended to accompany better performance in mathematical problem solving.

3. Predictive Influence

- 3.1 Error patterns in the four fundamental operations, taken together, significantly predicted mathematical problem-solving performance.
- 3.2 However, no single operation emerged as a significant unique predictor when the four operations were entered simultaneously in the regression model.
- 3.3 This implies that mathematical problem solving among the respondents depended on the combined contribution of the four operations rather than on one isolated computational skill.

4. Null Hypotheses

- 4.1 The null hypothesis stating that there is no significant relationship between error patterns in the four fundamental operations and the mathematical problem-solving performance of Grade 6 learners in Portlamon Elementary School, Division of Surigao del Sur was rejected.
- 4.2 The null hypothesis stating that error patterns in the four fundamental operations do not significantly predict the mathematical problem-solving performance of Grade 6 learners in Portlamon Elementary School, Division of Surigao del Sur was rejected because the overall regression model was statistically significant, although none of the individual operation-based predictors made a unique significant contribution.

5. General Inference

- 5.1 The findings imply that weaknesses in basic operations remained an important barrier to mathematical problem solving among the Grade 6 learners.
- 5.2 The results further suggest that improvement in mathematical problem-solving performance requires not only better exposure to contextual tasks but also stronger mastery of the foundational operations that support those tasks.
- 5.3 Therefore, a targeted mathematics intervention program grounded on diagnosed operation-level errors and low-performing problem-solving domains was appropriate for the learners in this context.

Recommendations

1. Strengthening Performance in the Four Fundamental Operations

- 1.1 School heads and mathematics teachers may prioritize targeted remediation in division and subtraction, since these were the weakest operations among the Grade 6 learners.
- 1.2 Mathematics instruction may also provide focused support on fraction denominator or numerator operations, decimal alignment or decimal placement, and correct use of methods, because these were the most dominant error patterns found in the study.
- 1.3 Explicit instruction, guided practice, visual representations, and frequent error-analysis activities may be used to help learners overcome persistent computation difficulties (Bognar et al., 2025; Fuchs et al., 2021).

2. Improving Mathematical Problem-Solving Performance

- 2.1 Mathematics teachers may strengthen instruction in percent, discount, interest, and commission, ratio and proportion, and multi-step problems, since these domains obtained the lowest performance levels.
- 2.2 Learners may be provided with more structured problem-solving exercises that gradually build competence in interpreting problem situations, selecting appropriate operations, and checking the reasonableness of answers.

- 2.3 Classroom activities may integrate contextual tasks, step-by-step modeling, and strategy discussions so that learners can connect foundational computation with real problem-solving demands (Joutsenlahti & Perkkilä, 2024; Vessonen et al., 2025).

3. Using Diagnostic and Data-Based Intervention

- 3.1 The proposed targeted mathematics intervention program may be implemented as a school-based support mechanism for Grade 6 learners.
- 3.2 Learners may be grouped according to common error patterns or low-performing domains so that intervention sessions can be more focused and responsive to actual learning needs.
- 3.3 Regular progress monitoring may be conducted to determine whether learners are improving in the targeted operations and problem-solving areas and to guide further refinement of the intervention program (Bognar et al., 2025; Fuchs et al., 2021).

4. Support for School and Division Mathematics Programs

- 4.1 School administrators and mathematics coordinators may use the results of the study as basis for strengthening school-level numeracy programs, diagnostic assessment practices, and remediation efforts in elementary mathematics.
- 4.2 The findings may also serve as reference for division-level support initiatives intended to improve foundational computation and problem-solving performance among learners in comparable public elementary school contexts.

5. Future Research

- 5.1 Future researchers may include larger samples and multiple schools so that the results can be compared across different contexts.
- 5.2 Future studies may test other possible predictors of mathematical problem-solving performance, such as reading comprehension, mathematics anxiety, motivation, home support, and teacher-related variables.
- 5.3 Future researchers may also evaluate the effectiveness of the targeted mathematics intervention program proposed in this study in order to determine whether it leads to measurable improvement in computation and problem-solving performance.

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