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Why Do Middle School Students Struggle with Large-Number Word Problems? A Qualitative Study of Conceptual, Procedural, and Place-Value Difficulties in Social Arithmetic

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ABSTRACT:
Background: Persistent difficulties in solving large-number word problems remain a central challenge in middle school mathematics learning, particularly in social arithmetic where students must integrate conceptual understanding, procedural fluency, and accurate place-value reasoning. Previous studies have documented frequent computational errors, yet limited attention has been given to the underlying cognitive and representational mechanisms that shape these difficulties.
Aims: This study aims to examine the nature of students' conceptual, procedural, and place-value difficulties in solving large-number social arithmetic word problems and to identify patterns that hinder effective problem solving.
Method: A qualitative descriptive design was employed involving 65 seventh-grade students from two middle school classes. Data were collected through participant observation and systematic analysis of students' written responses. The data were coded thematically across conceptual understanding, procedural execution, and place-value representation to capture recurring error patterns and learning barriers.
Results: The findings reveal three dominant forms of difficulty: misconceptions in selecting appropriate operations, unstable sequencing of computational procedures, and persistent misplacement of digits in thousands and millions. These difficulties frequently co-occur, resulting in fragmented problem comprehension, inaccurate numerical representation, and ineffective solution strategies.
Conclusion: The results indicate that students' struggles extend beyond procedural weakness and reflect deeper breakdowns in conceptual integration and representational reasoning. Addressing these difficulties requires instructional designs that emphasize conceptual coherence, explicit place-value representation, and sustained engagement with contextual problem structures. By highlighting the interplay between conceptual, procedural, and representational dimensions, this study contributes to a more nuanced understanding of learning barriers in social arithmetic and offers pedagogical directions for strengthening mathematical problem-solving competence in middle school classrooms.

Keywords: Conceptual difficulties, large-number word problems, place-value reasoning, procedural errors, social arithmetic

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INTRODUCTION

Mathematical word problem solving represents a central component of school mathematics because it connects numerical reasoning with real-world situations, as emphasized in the theoretical framework proposed by, (Rio & Protacio, 2025; Wisenöcker et al., 2024). In middle school curricula, social arithmetic constitutes a critical learning domain where students must coordinate linguistic comprehension, numerical magnitude, and symbolic representation to construct meaningful solutions. Empirical findings reported by Colbrook et al., (2022); Kenney & Ntow, (2024) indicate that persistent errors in word problems reflect deeper learning barriers rather than isolated computational weaknesses. The curricular emphasis on contextual learning has further increased the cognitive demands placed on students when interpreting and solving word-based tasks. Experimental evidence from Dresen, İlhan et al., (2025) demonstrates that place-value processing strongly influences students' success in multi-digit arithmetic, particularly in tasks involving thousands and millions. Despite systematic instruction, many learners continue to experience difficulties translating verbal information into appropriate numerical structures, as documented by (Castro et al., 2022; Post & Prediger, 2024). These translation failures often remain hidden in routine classroom assessments that prioritize procedural accuracy over conceptual understanding. Consequently, investigating how students process and misinterpret large-number word problems has become a central concern in contemporary mathematics education research.

International assessments consistently reveal that word problem performance constitutes one of the weakest components of students' mathematical achievement, especially when numerical magnitude and contextual complexity interact. Cognitive analyses conducted by Kappassova et al., (2025) demonstrate that representational ambiguity frequently disrupts students' conceptual coherence during multi-step problem solving. In social arithmetic contexts, learners must simultaneously manage proportional reasoning, arithmetic operations, and semantic interpretation, which places substantial demands on working memory systems. Evidence presented by Canli et al., (2023) shows that individual differences in linguistic proficiency and numerical sensitivity significantly shape students' capacity to coordinate these demands. When large numbers are introduced, the probability of misplacing digits and misaligning place values increases considerably, as reported in the experimental study of (Drummer et al., 2023). Classroom observations suggest that instructional practices often emphasize algorithmic execution while underrepresenting conceptual and representational dimensions of learning. Such instructional imbalances may lead students to rely on mechanical procedures without constructing stable conceptual schemas. These conditions underscore the urgency of examining how conceptual, procedural, and place-value difficulties jointly emerge in large-number social arithmetic problem solving.

Contemporary theories of mathematical cognition emphasize that effective problem solving requires the coordination of conceptual understanding, procedural fluency, and representational competence, as articulated in the developmental framework proposed by (Gilmore, 2023). However, empirical investigations frequently isolate these components rather than examining their dynamic interaction within authentic classroom tasks. Analyses conducted by Ario et al., (2025) indicate that mathematization errors often originate from fragmented conceptual schemas rather than procedural deficiency alone. In parallel, Herzog & Fritz, (2022) demonstrate that place-value misalignment systematically predicts incorrect solution pathways in multi-digit contexts. Linguistic task characteristics were shown by Wakhata et al., (2024) to mediate the relationship between numerical processing and solution accuracy, highlighting the multidimensional nature of word problem difficulty. Despite these insights, existing studies rarely focus explicitly on large-number operations embedded in social arithmetic contexts where representational demands are particularly pronounced. The limited availability of fine-grained qualitative analyses constrains current understanding of how students coordinate multiple knowledge dimensions during problem solving. Therefore, a focused investigation is warranted to clarify the learning mechanisms that underlie large-number word problem difficulties in middle school mathematics.

Word problem solving has been conceptualized as a multidimensional learning activity requiring the integration of linguistic, numerical, and representational processes, as described in the foundational work of (Jaffe & Bolger, 2023). Experimental studies by Dresen et al., (2020) demonstrate that magnitude processing and place-value structure significantly influence solution accuracy in multi-digit arithmetic tasks. Task-level characteristics such as lexical consistency and numerical configuration were systematically examined by Vessonen et al., (2024), who reported strong associations between linguistic features and problem difficulty. From a mathematization perspective, Jupri & Drijvers, (2016) identified transformation errors as a dominant source of failure when students convert textual information into mathematical representations. Representational ambiguity was further highlighted by Moju et al., (2025), who showed that inconsistent symbolic encoding disrupts conceptual integration during problem solving. Individual learner characteristics, including language proficiency and magnitude sensitivity, were identified by Vessonen et al., (2025) as significant predictors of word problem performance across grade levels. Clinical investigations reported by Ranzato, (2024) indicate that procedural instability frequently co-occurs with conceptual misunderstandings in multi-digit arithmetic. Collectively, these findings establish that word problem difficulty arises from complex interactions among conceptual, procedural, and representational dimensions of mathematical cognition.

Recent research has increasingly emphasized the central role of place-value reasoning in large-number arithmetic, with Dresen et al., (2020) demonstrating that digit misalignment systematically predicts incorrect carry and borrowing operations. Linguistic complexity and structural inconsistency were shown by McMullen et al., (2026) to intensify comparison-type word problem difficulty, particularly when numerical magnitude contrasts are embedded in extended verbal statements. Qualitative analyses by Jupri and Drijvers (2016) revealed that inappropriate operation selection often reflects unstable conceptual schemas rather than lack of procedural knowledge. A comprehensive synthesis by Vessonen et al. (2024) further indicated that representational demands mediate the relationship between language processing and numerical execution in multi-step problems. Classroom-based investigations suggest that instructional practices rarely provide explicit scaffolding for place-value representation in contextualized tasks. Evidence from learners with mathematical difficulties reported by Gilmore, (2023) shows that persistent procedural errors often mask deeper breakdowns in conceptual integration. Despite these advances, few studies have examined how conceptual, procedural, and place-value difficulties co-occur specifically within social arithmetic contexts involving large numbers. This limitation highlights the need for integrative analyses that capture the full complexity of learning barriers in large-number word problem solving.

Although previous studies have documented conceptual errors, procedural instability, and representational difficulties in word problem solving, most investigations have examined these components in isolation rather than as interacting dimensions of learning. Existing research

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emphasizes either place-value processing, mathematization failures, or linguistic complexity without integrating these perspectives within a single analytical framework. Studies rarely focus explicitly on large-number operations embedded in social arithmetic contexts where representational load is substantially amplified. Moreover, empirical evidence concerning how students coordinate conceptual understanding, procedural sequencing, and place-value reasoning within authentic classroom settings remains limited. Prior investigations predominantly rely on quantitative error frequencies rather than qualitative analyses of learning mechanisms. As a result, the convergence of multiple learning barriers during large-number problem solving is insufficiently understood. This theoretical limitation constrains the development of instructional designs that address underlying cognitive processes. Addressing this gap is therefore essential for advancing both theory and pedagogy in mathematics education.

This study aims to examine the conceptual, procedural, and place-value difficulties experienced by middle school students when solving large-number social arithmetic word problems. The investigation seeks to identify dominant error patterns that emerge from the interaction between operation selection, procedural sequencing, and numerical representation. By employing qualitative analysis of students' written work and classroom observations, the study explores how learning barriers develop within authentic instructional contexts. The research further aims to clarify how representational reasoning mediates the relationship between conceptual understanding and procedural execution. In addition, the study intends to reveal how linguistic interpretation shapes students' construction of numerical meaning in large-number contexts. Through this integrative perspective, the research contributes to a more nuanced understanding of mathematical learning difficulties beyond surface computational errors. The findings are expected to inform the design of instructional strategies that emphasize conceptual coherence and representational accuracy. Ultimately, this study seeks to strengthen theoretical and pedagogical approaches to improving students' problem-solving competence in social arithmetic.

METHOD

Research Design

This study employed a qualitative descriptive research design to examine students' conceptual, procedural, and place-value difficulties in solving large-number social arithmetic word problems. Qualitative inquiry is particularly suitable for investigating learning processes and cognitive mechanisms that cannot be adequately captured through quantitative indicators, as emphasized by Maxwell & Levitt, (2023) in interpretive research traditions. The design was grounded in an error pattern analysis framework commonly applied in mathematics education to reveal underlying reasoning structures, as illustrated by Rohati et al (2023) in their studies of mathematization difficulties. A classroom-based approach was adopted to preserve the naturalistic character of students' problem-solving behavior and instructional interactions. Consistent with recommendations by Fahmie et al., (2023), the study prioritized ecological validity by embedding data collection within routine instructional activities. The descriptive orientation enabled systematic documentation of students' solution strategies, representational choices, and procedural sequencing across authentic tasks. Observational and artifact-based data sources were integrated to capture both external performance and internalized reasoning processes. Through this design, the study sought to generate a fine-grained account of learning barriers that extend beyond surface computational errors.

Participants

The participants consisted of 65 seventh-grade students drawn from two intact middle school classes in a public junior high school, representing a heterogeneous group in terms of prior achievement and language proficiency. Middle school learners were selected because this developmental stage marks a critical transition in the acquisition of multi-digit arithmetic and contextual problem solving, as described by Träff et al., (2025) in their developmental model of numerical cognition. The use of intact classes ensured minimal disruption to instructional routines and preserved the authenticity of classroom interactions. All participants had previously received formal instruction in basic arithmetic operations and introductory social arithmetic topics in accordance with the national curriculum. Demographic information including age range and instructional exposure was recorded to contextualize observed learning behaviors. Ethical procedures followed the guidelines articulated by the American Educational Research Association regarding voluntary participation and informed consent. Anonymity and confidentiality were maintained throughout data collection, coding, and reporting stages. This participant configuration provided an appropriate foundation for examining large-number word problem difficulties within typical middle school learning environments.

Instrument

The primary instruments consisted of a researcher-designed set of large-number social arithmetic word problems and a structured observation protocol for documenting students' solution processes. Task construction followed authentic problem design principles proposed by Magana et al., (2024) to elicit conceptual interpretation, procedural execution, and representational accuracy. Each problem required students to select appropriate operations, sequence multi-step procedures, and represent thousands and millions correctly within contextual scenarios. The observation protocol captured students' verbal explanations, written representations, and strategy shifts during problem solving, consistent with classroom methodologies described by (Xiong et al., 2025). Content validity was established through expert review by two experienced mathematics educators to ensure alignment with curricular objectives and cognitive demands. Pilot testing with a comparable student group was conducted to refine item clarity and calibrate difficulty levels. Written student responses served as the principal data source for error pattern identification. Together, these instruments enabled systematic examination of conceptual, procedural, and place-value difficulties in authentic learning contexts.

Table 1. Analytical Framework of Students' Difficulties in Large-Number Word Problems

Dimension of Difficulty	Analytical Indicator	Description of Observed Error Patterns	Theoretical Basis
Conceptual difficulties	Operation selection	Inappropriate identification of arithmetic operations based on problem context	Jupri & Drijvers (2016)
Conceptual difficulties	Problem representation	Misinterpretation of verbal information leading to incorrect mathematical modeling	Rio & Protacio, (2025)
Procedural difficulties	Sequencing of operations	Incorrect ordering of multi-step computational procedures	Gilmore, (2023)

Procedural difficulties	Algorithm execution	Unstable application of standard algorithms in multi-digit calculations	Dresen et al. (2020)
Place-value difficulties	Digit alignment	Misplacement of digits in thousands and millions positions	Dresen et al. (2020)
Place-value difficulties	Magnitude representation	Inaccurate interpretation of numerical magnitude in contextual settings	Vessonen et al. (2024)

Table 1 presents the analytical framework employed to classify students' difficulties into conceptual, procedural, and place-value dimensions. Each dimension was operationalized through specific analytical indicators derived from established theoretical models in mathematics education. The framework integrated perspectives on mathematization, representational reasoning, and numerical cognition to ensure theoretical coherence in the coding process. Analytical indicators guided the identification of recurrent error patterns across students' written and observed solution strategies. The inclusion of theoretical bases for each category strengthened construct validity and interpretive consistency. This framework enabled systematic differentiation between conceptual misunderstanding, procedural instability, and representational misalignment. By organizing error types within a structured taxonomy, the table facilitated transparent and replicable analysis procedures. The framework served as the central reference for subsequent thematic coding and interpretation stages.

Data Analysis Plan

Data analysis followed a multi-stage thematic error analysis procedure integrating conceptual, procedural, and representational coding schemes. Initial open coding was conducted to identify recurrent solution patterns and error types, drawing on the classification principles articulated by González Canché, (2023) in mathematization research. Axial coding was subsequently applied to cluster errors into conceptual misunderstandings, procedural sequencing failures, and place-value misalignments, consistent with analytical strategies employed by Themane, (2022) in multi-digit arithmetic studies. Triangulation was achieved by comparing observational records with students' written work to enhance analytic credibility, as recommended by (Schlunegger et al., 2024). Inter-coder reliability was established through independent coding by two researchers followed by consensus discussions. Emergent categories were interpreted in relation to representational reasoning and cognitive integration processes described by (Koufidis et al., 2022). Analytic memos documented theoretical reflections and category refinement throughout the analysis. This procedure enabled identification of dominant difficulty profiles and their underlying learning mechanisms.

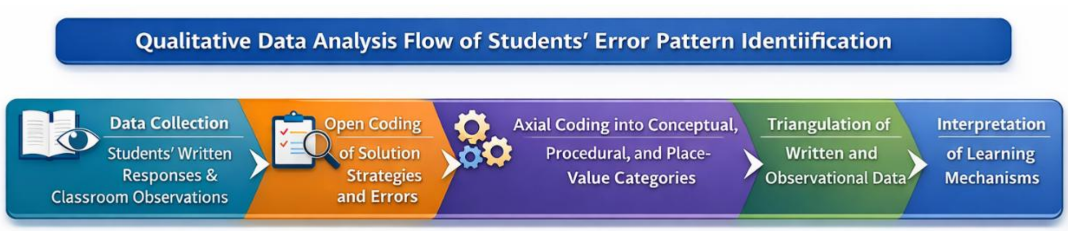

Figure 1. Qualitative Data Analysis Flow of Students' Error Pattern Identification

Figure 1 illustrates the stages of qualitative data analysis applied in this study to identify students' dominant error patterns. The process begins with integrated data collection from written responses and classroom observations to capture both performance and reasoning. Open coding was used to generate initial categories reflecting solution strategies and error manifestations. Axial coding organized these categories into conceptual, procedural, and place-value dimensions in accordance with the analytical framework. Triangulation strengthened trustworthiness by cross-validating observational and artifact-based evidence. Subsequent identification of dominant profiles revealed recurrent difficulty configurations across participants. The final interpretive stage linked observed patterns to theoretical models of numerical cognition and representational reasoning. This analytic flow ensured systematic, transparent, and theoretically grounded interpretation of students' learning difficulties.

RESULTS AND DISCUSSION

Results

The analysis revealed three dominant categories of difficulties in students' solutions of large-number social arithmetic word problems, namely conceptual, procedural, and place-value difficulties. Conceptual difficulties were most frequently observed during the initial interpretation of problem context and selection of appropriate operations. Procedural difficulties primarily occurred during multi-step sequencing and algorithm execution in division and proportional reasoning tasks. Place-value difficulties emerged when students manipulated thousands and millions, leading to persistent digit misalignment and magnitude misinterpretation. Observational data indicated that many students initiated solution strategies without constructing complete problem representations. Written responses demonstrated systematic breakdowns in coordinating symbolic notation and quantitative meaning. Error patterns appeared stable across tasks and learning situations. These findings suggest that learning barriers arise from integrated cognitive and representational processes rather than isolated computational weaknesses.

Table 2. Distribution of Students' Difficulty Types in Large-Number Word Problems

Type of Difficulty	Number of Students	Percentage (%)
Conceptual difficulties	24	36.9
Procedural difficulties	21	32.3
Place-value difficulties	20	30.8
Total	65	100

Table 2 presents the distribution of students across the three dominant difficulty categories identified in the analysis. Conceptual difficulties constituted the largest proportion, indicating frequent misinterpretation of problem meaning and inappropriate operation selection. Procedural difficulties represented a substantial proportion, reflecting instability in sequencing and executing multi-step computations. Place-value difficulties accounted for nearly one-third of the sample, highlighting persistent representational challenges in handling large numbers. The relatively balanced distribution suggests that learning barriers are multidimensional rather than dominated by a single error type. These patterns confirm the integrated nature of difficulties in large-number problem solving. The table provides quantitative support for the qualitative profiles derived from coding procedures. This distribution served as the basis for subsequent subtype analysis. The results demonstrate the need for instructional interventions addressing multiple dimensions simultaneously.

Further analysis identified distinct subtypes of error patterns within each difficulty dimension. Conceptual errors were primarily associated with incorrect operation selection and misinterpretation of problem context. Procedural errors were dominated by incorrect sequencing of operations and unstable application of standard algorithms. Place-value errors involved digit misalignment and inaccurate magnitude representation in multi-digit numbers. Several students exhibited more than one subtype within a single solution attempt. Overlapping error patterns suggested interaction between conceptual and procedural processing stages. The frequency of place-value errors increased markedly in problems involving millions. Observational records confirmed that representational instability often preceded procedural breakdowns. These patterns indicate that difficulty dimensions are internally structured and cognitively interconnected.

Table 3. Subtypes of Error Patterns Across Difficulty Dimensions

Dimension	Subtype of Error	Frequency	Percentage (%)
Conceptual	Incorrect operation selection	14	21.5
Conceptual	Misinterpretation of problem context	10	15.4
Procedural	Incorrect sequencing of operations	11	16.9
Procedural	Algorithm misapplication	10	15.4
Place-value	Digit misalignment	12	18.5
Place-value	Magnitude misinterpretation	8	12.3

Table 3 summarizes the internal structure of error patterns across conceptual, procedural, and place-value dimensions. Incorrect operation selection emerged as the most frequent conceptual error subtype. Procedural instability was primarily reflected in sequencing failures and algorithm misapplication. Place-value errors were dominated by digit misalignment, indicating fragile representational mapping in large-number contexts. The distribution reveals that no single subtype overwhelmingly dominates the error profile. Multiple subtypes frequently co-occurred within individual solutions. This internal structure highlights the complexity of students' learning barriers. The table provides a refined diagnostic perspective beyond global difficulty categories. These results support the multidimensional nature of large-number word problem difficulty.

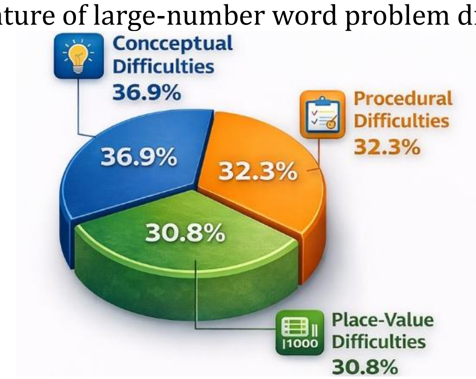

Figure 2. Difficulty Profile Distribution Across Error Dimensions

Figure 2 illustrates the proportional distribution of difficulty profiles across conceptual, procedural, and place-value dimensions. The visualization highlights the predominance of conceptual difficulties while showing comparable proportions across all three categories. This balanced pattern indicates that learning barriers are distributed across multiple cognitive components. The figure facilitates rapid interpretation of dominant error tendencies. The graphical summary complements the quantitative information in Table 2. The distribution underscores the integrated character of large-number problem difficulty. The figure supports the need for multidimensional instructional approaches. These patterns guided the subsequent interpretive analysis.

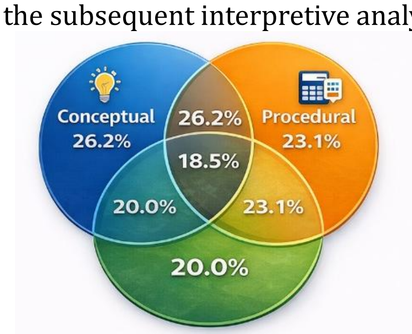

Figure 3. Co-occurrence of Difficulty Dimensions in Students' Solutions

Figure 3 depicts the co-occurrence of difficulty dimensions within individual student solutions. Many students exhibited simultaneous conceptual and procedural difficulties within the same problem. Overlap between procedural and place-value difficulties was frequently observed in multi-digit division tasks. A smaller group displayed combined difficulties across all three dimensions. This co-occurrence pattern indicates that learning barriers are rarely isolated. Interactions between dimensions suggest cascading cognitive breakdowns. The figure highlights the dynamic nature of error generation. These overlaps reinforce the need for integrative diagnostic frameworks. The visualization strengthens interpretation of multidimensional learning barriers.

Discussion

The predominance of conceptual difficulties observed in this study aligns with the multidimensional model of word problem solving proposed by Rio & Protacio, (2025). Similar transformation failures were reported by Jupri and Drijvers (2016), who demonstrated that misinterpretation of problem context frequently disrupts operation selection. The present findings extend these models by revealing persistent conceptual instability in large-number social arithmetic contexts. Linguistic complexity identified by Vessonen et al. (2024) further explains frequent breakdowns in contextual interpretation. The fragility of conceptual integration observed here supports the numerical cognition framework advanced by Gilmore, (2023). These converging perspectives indicate that conceptual understanding remains the central bottleneck in contextual arithmetic learning. The present study confirms that conceptual coherence is a prerequisite for procedural fluency and representational stability. Strengthening conceptual scaffolding therefore represents a primary instructional priority.

Procedural difficulties identified in this study resonate with computational instability patterns documented by Dresen et al. (2020) in multi-digit arithmetic performance. Similar sequencing failures were reported by Schulz, (2024) in analyses linking procedural fluency and word problem competence. The current findings suggest that procedural breakdowns often emerge after incomplete conceptual interpretation rather than from isolated algorithmic weakness. This pattern supports integrative processing models proposed by Al-Afifi et al., (2025) in classroom-based studies. The interaction between sequencing errors and representational instability indicates that procedural execution depends on coherent symbolic mapping. Procedural fluency therefore cannot develop independently of conceptual understanding. These results challenge instructional approaches that emphasize repetitive algorithm practice without contextual integration. Integrative instructional designs are required to stabilize procedural performance in large-number contexts.

Place-value difficulties observed in this study corroborate representational fragility reported by Dresen et al. (2020) in experimental investigations of digit alignment. Linguistic embedding effects described by Alabi & Jelili, (2023) further explain magnitude misinterpretation in extended verbal statements. The current findings extend representational mediation models advanced by Vessonen et al. (2024) by situating place-value instability within authentic social arithmetic scenarios. The frequent misalignment of thousands and millions suggests incomplete internalization of base-ten structure. Similar representational breakdowns were originally described by Li & Armstrong, (2024) in early word problem research. The present study demonstrates that place-value reasoning constitutes a foundational competence in contextual mathematics. Representational instruction must therefore be explicitly integrated within large-number problem solving. This emphasis represents a critical pedagogical implication.

The co-occurrence of difficulty dimensions identified in this study supports integrative cognitive models proposed by Gilmore, (2023), which conceptualize mathematical learning as coordinated processing across multiple subsystems. Rather than isolated deficits, students exhibited cascading breakdowns across conceptual, procedural, and representational stages. This pattern aligns with multidimensional task frameworks described by Jupri and Drijvers (2016). Evidence from Schulz, (2024) further suggests that such interactions amplify learning barriers in contextual tasks. The present findings demonstrate that difficulty profiles emerge from cumulative cognitive load rather than single-point failure. These interactions challenge reductionist diagnostic approaches that target isolated skills. Coordinated instructional scaffolding is therefore required to address integrated learning barriers. This integrative perspective constitutes a significant theoretical contribution to word problem research.

The present study contributes a structured multidimensional profiling framework that simultaneously captures conceptual, procedural, and place-value difficulties in large-number social arithmetic. Unlike previous studies that focused on single error categories, this framework reveals internal subtypes and co-occurrence patterns within authentic classroom contexts. This contribution extends representational mediation models proposed by Vessonen et al. (2024) by incorporating procedural sequencing as an interacting dimension. The identification of cascading difficulty profiles offers a novel diagnostic lens for instructional intervention. The framework advances theoretical understanding of how cognitive subsystems interact during contextual arithmetic processing. This integrative model provides a foundation for future intervention design and learning analytics. The novelty lies in combining subtype analysis with co-occurrence profiling in large-number contexts. These contributions position the study as a substantive theoretical and methodological advance in mathematics education research.

Implications

The findings imply that instruction in social arithmetic must prioritize conceptual coherence, procedural integration, and explicit place-value representation. Teachers should design tasks that foreground meaning construction before algorithm execution. Diagnostic profiling may guide targeted instructional scaffolding. Visual representations can stabilize magnitude interpretation in large-number contexts. Curriculum development should integrate representational reasoning explicitly. Professional development may emphasize error-based diagnostic assessment. Integrative instructional models may reduce cascading learning barriers. These implications directly inform mathematics pedagogy and curriculum design.

Limitations

This study was limited by its focus on a single school context, restricting generalizability. The sample size constrained broader statistical inference. Data sources excluded interviews that might capture deeper reasoning processes. The cross-sectional design limited developmental analysis. Task content was confined to social arithmetic. Coding remained interpretive despite triangulation. Instructional variation was not controlled. Future studies should address these constraints.

Suggestions

Future research should examine longitudinal development of difficulty profiles across grade levels. Mixed-method designs may integrate quantitative modeling. Cross-cultural comparisons may reveal representational variation. Intervention studies should test multidimensional scaffolding strategies. Digital diagnostics may enhance error detection. Teacher training should incorporate profiling frameworks. Curriculum innovation should emphasize representational coherence. These directions will advance theoretical and pedagogical development.

CONCLUSION

This study provides a comprehensive account of students' difficulties in solving large-number social arithmetic word problems through an integrative analysis of conceptual, procedural, and place-value dimensions. The findings demonstrate that learning barriers rarely occur in isolation but emerge from interconnected breakdowns in interpretation, execution, and representation processes. Conceptual difficulties were identified as the primary source of error, frequently triggering subsequent procedural and representational failures. Procedural instability was shown to depend strongly on the quality of initial conceptual integration, while place-value errors reflected fragile internalization of base-ten structure in large-number contexts. The multidimensional profiling framework developed in this study reveals internal subtypes and co-occurrence patterns that extend beyond traditional single-category error classifications. This framework contributes a novel diagnostic lens for understanding how cognitive subsystems interact during contextual arithmetic processing. By integrating subtype analysis with co-occurrence profiling, the study advances theoretical models of mathematical cognition and representational mediation. These contributions position the study as a substantive theoretical and methodological extension of contemporary word problem research.

From an educational perspective, the results highlight the necessity of instructional approaches that simultaneously address conceptual coherence, procedural sequencing, and representational stability. Instruction that prioritizes meaning construction before algorithm execution may reduce cascading cognitive breakdowns in large-number contexts. The profiling framework offers practical guidance for diagnostic assessment and targeted scaffolding in middle school mathematics instruction. Beyond immediate pedagogical implications, the study establishes a foundation for future intervention design and learning analytics focusing on integrated difficulty dimensions. The findings underscore the importance of multidimensional instructional models in supporting contextual arithmetic learning. By clarifying the structure and interaction of learning barriers, this study contributes directly to the refinement of mathematics education theory and practice. The integrative perspective presented here enhances understanding of how students process complex numerical information in authentic learning situations. Overall, the study affirms that addressing conceptual, procedural, and representational dimensions in a coordinated manner is essential for improving large-number word problem competence.

AUTHOR CONTRIBUTION STATEMENT

Novalia Sudiatik Ewol conceptualized the study, designed the research framework, and coordinated the overall implementation of the investigation. She led the development of the analytical framework, supervised data collection procedures, and contributed substantially to the interpretation of results and theoretical integration. Maria Dafrosa Finu conducted data collection, performed initial coding of students' solution strategies, and participated in the thematic error analysis and category refinement. She also contributed to drafting the results and supporting the preparation of tables and figures. Wilibaldus Bhoke assisted in instrument development, validation of analytical indicators, and verification of coding consistency through inter-coder reliability procedures. He contributed to the discussion of findings, refinement of theoretical implications, and critical revision of the manuscript for intellectual content. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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