Using Newman's Error Analysis to Analyse Grade 3 Learners' Errors in Solving Word Problems in a Diverse Classroom

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This study focused on utilising Newman's error analysis model to diagnose the errors made by Grade 3 learners when solving word problems in a diverse classroom setting. The research endeavour seeks to pinpoint the errors manifested by learners when tackling word problems, with the aim of offering practical approaches to bolster the instruction of word problem-solving abilities and foster a more profound comprehension of mathematical principles among Grade 3 learners in varied educational settings. A diagnostic test with seven question items was administered to 54 learners in one primary school of Waterberg district in the Limpopo Province of South Africa. Consecutively, eight scripts of learners who featured the same errors were identified and they were included in semi-structured interviews to establish the cause of the errors. The outcomes unveiled that learners commit reading, comprehension, transformation, process and encoding errors. Based on the results, early identification of errors from learners and making them known is recommended as it will allow teachers to rectify them and promote learning with understanding.

Keywords: Newman's error analysis; mathematics education; word problem; diverse learning needs; reading skills.

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Introduction

Word problem solving can be reasonably thought-provoking for learners facing mathematics challenges as it necessitates proficiency in reading, language interpretation and mathematics (Powell et al., 2019). For the teachers to improve their teaching strategies to support and meet the learning needs of all learners, they must understand how they solve problems and reason. The basis of mathematical education is established in elementary school, underscoring the need to investigate and tackle learning obstacles to ensure learners develop essential skills (Alkramiti, 2020). Mathematics, as highlighted by Mardiyana and Saputro (2019), not only fosters critical thinking, but also aids in analysing real-world problems. Identifying the errors and misconceptions made by learners in early grades can assist in finding the approaches that can be used to develop learners' understanding in mathematics.

Ignorance, choosing the wrong mathematical operation, inability to comprehend the word problem and wrong calculations cause learners to commit different errors (Duong et al., 2017). Error analysis, as outlined by Ancheta (2022), helps identify the types and reasons for learners' errors and determines if there are recurring error patterns. Misconceptions, on the other hand, stem from flawed conceptual comprehension, leading to mistakes in mathematical applications and are a common aspect of mathematics learning (Tobey, n.d). Therefore, it is essential to detect misconceptions and errors early on to support learners in their mathematical learning journey.

In the education system, understanding how learners learn and solve word problems plays a crucial role in active learning and teaching. This study delves into the application of Newman's error analysis (NEA) to scrutinise the errors and misconceptions encountered by Grade 3 learners when solving word problems within a diverse classroom environment. Through investigating errors in early grades, teachers can identify the areas of misunderstanding, gain important perceptions of learners' reasoning skills and identify areas needing additional support. Therefore, it is imperative for teachers to familiarise themselves with common errors, comprehend them, and analyse them in order to enhance their problem-solving skills during instructional sessions (Larrain & Kaiser, 2019). The primary objective of this study is to shed light on the intricate nature of problem-solving among Grade 3 learners, particularly in the realm of solving word problems related to money addition and subtraction within diverse classroom contexts. Through a comprehensive analysis of data collected from diagnostic assessments and one-on-one interviews with learners, this research endeavours to uncover recurring errors, identify trends in learners' problem-solving approaches, and showcase effective teaching strategies that cater to the diverse learning requirements within the classroom. Through the investigation of errors together with learners' abilities of problem-solving, the study aimed at providing teachers with suggestions of improving their teaching strategies that will support the learning needs of all learners and assist them to reach their capabilities. Thus, the specific objectives of the study were:

1. To identify the errors made by Grade 3 learners when solving word problem involving addition and subtraction of money.

2. To explore the underlying factors that cause learners to make those errors when solving word problems.

Theoretical Perspectives

Understanding the types of errors and misconceptions that Grade 3 learners make when solving word problems is crucial for developing effective teaching strategies. Newman's error analysis theory provides a structured approach to diagnosing these errors and categorising them into stages where learners typically falter (Newman, 1977). This study will utilise NEA to analyse the specific challenges faced by Grade 3 learners in a diverse classroom setting. Newman's procedural error analysis categorises errors into reading, comprehension, transformation, process skill and encoding errors (Newman, 1977).

Newman's error analysis (NEA)

The error analysis theory developed by Newman in 1977, is a diagnostic tool used to identify specific stages in the problem-solving process where students make errors. According to Newman, these stages are:

1. **Reading**: The ability to read the problem.
2. **Comprehension**: Understanding what the problem is.
3. **Transformation**: Translating the words into a mathematical operation.
4. **Process skills**: Carrying out the mathematical operation correctly.
5. **Encoding**: Writing the correct answer in an acceptable form.

These errors can stem from factors like haste, confusion, lack of knowledge, and forgetfulness. By applying Newman's theory, educators can identify and address specific areas where learners struggle, such as understanding questions, applying problem-solving steps and writing accurate answers (Afriandani & Nursakiah, 2022; Annizar & Kumala, 2022; Hidayah & Rejeki, 2022; Prasetyaningrum et al., 2022; Jarmita & Hayati, 2023). Applying NEA to Grade 3 learners involves closely examining each of these stages to identify where misunderstandings occur. This can help teachers pinpoint whether errors stem from language comprehension, mathematical reasoning or procedural mistakes. Analysing Grade 3 learners' errors using Newman's error analysis can provide valuable insights for designing targeted interventions to enhance their mathematical problem-solving skills and minimise recurring mistakes.

Reading and comprehension

According to Bourke (1979), reading ability and comprehension include reading and being able to explain the meaning of the words and symbols in the question. If a learner is unable to read a single keyword or written mathematical symbol in a mathematical word problem and they cannot go on with the steps to solve the problem, then the error is classified as reading (White, 2005). Mubarokah and Amir (2024) point out that comprehension errors commonly occur when learners experience difficulties in understanding the context of the problem and identifying relevant information to help solve the problem. Young learners often struggle with reading and comprehending word problems, especially in diverse classrooms where language proficiency varies. Research indicates that comprehension errors are prevalent and significantly impact learners' ability to proceed to subsequent stages of problem-solving (Ellerton & Clements, 1996;

Newman, 1977). Ensuring that learners understand the vocabulary and context of word problems is crucial.

Transformation and process skills

Errors at the transformation stage involve incorrectly translating the problem into mathematical terms (Newman, 1977). Zulyanty (2022) emphasises that due to misunderstanding the relationships between numbers, learners show transformation errors by failing to translate the word problem into a mathematical operation. For instance, learners might misunderstand "total cost" as a subtraction problem instead of addition. Process skills errors, on the other hand, occur when learners incorrectly use the mathematical operation or procedure due to misunderstandings or calculation mistakes (Ellerton & Clements, 1996). Legarde (2022) proclaim that process errors occur due to lack of practice or understanding mathematical concept which results in making mistakes in executing mathematical operations. Inability to execute the correct mathematical operation leads the learners in find the incorrect solution to the problem. Focusing on arithmetic operations and procedural knowledge can assist the learners to develop their knowledge in this area.

Encoding

Finally, encoding errors occur when learners fail to write down the answer correctly, even if they have solved the problem accurately (Newman, 1977). This stage is particularly significant in younger learners who may struggle with proper number notation or the syntax of mathematical expressions (Ellerton & Clements, 1996). Similarly, Zulyanty (2022) points out that in encoding errors, learners often miswrite their final answer due to a misunderstanding of the problem's requirements or carelessness. The learners' capability to encode and accurately transcribe the answer highlights the potential disparity between providing an oral response and transcribing it correctly (Bourke, 1979).

Literature Review

Most Grade 3 learners struggle with word problems involving money addition and subtraction due to reading difficulties. The language difference between language of learning and teaching (LoLT) might be creating challenges for learners to read the questions. This might create a challenge for learners in early grades to develop their basic reading skills. This challenge necessitates the application of strategies that can accommodate and support learners in their academic achievement (Duong et al., 2017). Individualised reading programmes that can assist with addressing this challenge and addressing the errors and misconceptions made by learners is important.

Ancheta (2022) posits that learners make errors because of inadequate retention of knowledge, misconceptions, and deficiencies in skills within the subject area. Mohyuddin and Khalil, (2016) pointed out that the persistence of errors hinders learners' assimilation of new knowledge during the learning process, leading to them to developing a strong attachment. It is essential for teachers to assume a crucial role in enhancing the academic performance of learners in mathematics by recognising and rectifying these errors and misconceptions (Mbusi, n.d). Failure to identify and rectify the errors and misconceptions of learners could impede their progress in grasping mathematical concepts. Mardiyana and Saputro (2019) emphasised the

pivotal role of mathematics in fostering the development of analytical thinking to tackle real-life challenges.

Lai (2012) suggests that error analysis serves as a method to pinpoint the underlying reasons behind learners' mistakes, scrutinising the causes of such errors while discerning any recurring patterns of misunderstanding. Error analysis is a systematic procedure that aids teachers in identifying and evaluating learners' errors to determine the presence of consistent error patterns (Brown et al., 2016). The significance of error analysis in the teaching and learning of mathematics lies in enabling educators to discern the learning requirements of their learners and tailor their lessons accordingly to prevent anyone from falling behind.

Brown et al. (2016) summarised the four advantages of error analysis that can help teachers: i) Distinguishing the steps executed properly by learners (instead of simply providing the accurate or inaccurate response) and supporting by differentiating the precise engagements done by the learner ii) Determining the types of errors made by a learner iii) Distinguishing between one-time errors and consistent errors iv) Selecting the instructional approach to rectify learners' misconceptions and impart the correct principles, methods or techniques. Celemin (2023) highlighted that learners who are not given proper numeracy attention during their daily classroom activities display poor counting skills such as narrating number word sequence, weak numerical interactive skills and weak basic arithmetic skills. The teachers' knowledge, expertise and experience in mathematics assist in involving learners in a meaningful way and developing their understanding (Mabena et al., 2021).

Various scholars have noted that a significant number of learners encounter difficulties in basic arithmetic computations involving addition and subtraction. Consequently, teachers frequently encounter difficulties in developing learners' intellectual capacity of both the perceptions and processes (Muthukrishnan et al., 2019). Ubi and Odiong (2018) suggest that misconceptions can be addressed by distinguishing between learners who grasp concepts quickly and those who struggle in the educational setting. This differentiation allows educators to tailor their instructional methods to cater to the diverse learning requirements of all learners.

A study by Obed (2019) in Vanuatu revealed that a considerable number of third and fourth-grade learners struggled with grouping and regrouping numbers based on their respective place values during addition and subtraction. Similarly, Mukunthan (2021) observed that many learners consistently made errors related to place value when performing addition, highlighting the ubiquitous nature of addition in a learner's daily life. Furthermore, Muthukrishnan et al. (2019) stressed that in some cases learners are unable to add the numbers according to their place values. These researchers argue that learners' misconceptions about the fundamental operations stem from a lack of understanding essential concepts and calculation methods, as well as the relationships between different operations.

In their examination of learners' errors in higher-order thinking tasks, Abdullah et al. (2015) found that 20.92% of errors were linked to fluency issues like reading and comprehension, while 79.08% were attributed to mathematical process factors such as transformation, process skills and encoding. They highlighted learners' struggle in comprehending mathematical problems, which led to errors in selecting appropriate operations and articulating solutions. The learners'

incorrect use of the mathematical operations reveal that they did not have a strong foundation in understanding basic mathematical operations or symbols (Nofrianto et al. 2022). As a result, the capability to read mathematical problems with comprehension is vital for learners to pinpoint the required mathematical sign for problem-solving.

Alhassora et al. (2017) discovered that although many learners could read and encode information, they faced challenges in interpreting, describing, validating, and narrating provided data due to lacking foundational knowledge. Similarly, Kusmayadi et al. (2022) emphasised the significance of reading comprehension skills in successfully tackling word problems, as some students struggle to recognise keywords, symbols, operational signs and sentence interpretations. Learners need to connect prior knowledge with new information to effectively address problems. Failure to comprehend or interpret texts makes it challenging for learners to determine the appropriate operations for problem-solving. Engaging in problem-solving activities enables learners to enhance their mathematical thinking abilities, generate innovative ideas, and explore new methodologies or products (Zamzam & Patricia, 2018).

Mukunthan (2021) asserts that errors arise from inattention, misinterpretation of symbols or text, and inadequate information pertaining to the mathematical topic, learning objective or concept. Mukunthan (2021) further argues that errors stem from a lack of comprehension or verification of the proposed solution to a problem or a misunderstanding. According to Bayaga et al. (2021), deficiencies in reading skills, poorly constructed questions, or insufficient reading comprehension may lead to learners' mathematical errors, resulting in incorrect responses. This suggests that teachers must ensure that questions are accurately formulated to prevent learners from becoming perplexed or misinterpreting the task. Wahyudi et al. (2019) suggest that identifying learners' errors can aid educators in tailoring the delivery of subject matter to meet their learning requirements.

Scholars have noted that learners struggle with formulating number sentences for word problems due to challenges in selecting the appropriate mathematical operation (Cheva & Luneta, n.d). Ramsingh (2020), however, suggests that utilising diagrams or concrete objects as aids can assist educators in bridging learners' mathematical understanding with their existing knowledge. On the other hand, Cumhur and Terez (2020) state that learners' comprehension is influenced by the strategies they develop to tackle mathematical difficulties and apply problem-solving skills. They underscore the significance of influencing preceding knowledge to enthusiastically build new knowledge, participating in insightful thinking, and learning from errors.

Zourmpakis et al (2023) found that incorporating adaptive gamification aroused the learners' interest, motivated them and their confidence was associated with fun aspects of learning. Hence, learners engaged more, felt less nervous during learning and teaching, and increased attentiveness. Through the identification of errors and misconceptions, the teacher can incorporate them during teaching to help learners avoid them when solving word problems. Van de Walle et al (2018) proclaim that common errors in word problem-solving can be mitigated by integrating visual illustrations, scaffolding and related problem-solving instructions. Moreover, differentiated instructional techniques, such as peer-assisted learning and language

support, can benefit learners in diverse classrooms (Tomlinson, 2017). Khalid and Abdullah (2021) have shown that reading with understanding contributes to the learners' challenges of solving word problems, necessitating integrating literacy and numeracy teaching. Early identification of errors in the Foundation Phase can assist the teachers in identifying strategies to help learners overcome them when solving problems. Likewise, Chowdhury and Choudhury (2020) emphasised the importance of scaffolding strategies in supporting learners to progress through the problem-solving stages.

Methodology

This descriptive-interpretive qualitative methodology was employed in the study to explore the errors displayed by learners in solving word problems in addition and subtraction, and the reasons why they display those errors using Newman's error analysis theory. The main concepts are reading errors, comprehension errors, transformation errors, process errors and encoding errors. This qualitative descriptive/interpretive approach study utilised open-ended questions to explore errors committed by learners when solving addition and subtraction of word problems dealing with money. Qualitative descriptive/interpretive approach is a research approach that follows a flexible inquiry of gathering data from the participants while providing them the opportunity to communicate their experiences (Creswell & Plano Clark, 2018). According to Elliot and Timulak (2021), descriptive/interpretive approach uses open-ended, exploratory research questions to gain understanding of the participants' experiences in the phenomenon being studied. NEA was employed in this research study to gain understanding of gathered data.

A diagnostic test was administered to 54 Grade 3 learners (25 boys and 29 girls) in one of the semi-rural primary schools in the Waterberg district of Limpopo Province in South Africa (SA). The school is comprised of diverse learners who speak different languages and their age ranges from 8 to 10 years. The test encompassed three primary questions along with associated sub-questions that were adapted from the past Grade 3 question sets. The assessment was presented in Sepedi (Table 1), as the subject of mathematics is instructed in this language. The questions for the diagnostic test were selected from previous question papers provided by the Limpopo Department of Education and questions used during mathematics competitions in the district. The questions were given to the teacher for validation and verification if the content was covered before administering the test. The learners independently perused the questions during the examination and were allotted one hour, a period deemed sufficient for them to write the test. Two teachers who have been teaching Grade 3 for 15 years and the departmental head, were requested to moderate the test instrument and validate it.

Table 1.

The structure of the test instrument

Items (Sepedi translated to English)	Motivation
1. Apola e tee ke disente tše 90. Neo o na le 50c tše nne le 20c tše 2. (*One apple is 90c. Neo has four 50c and two 20c*).	
1.1 Na tshelete ya Neo ke bokae? (*How much is Neo's money*?) (2)	To understand how learners add to get the answer in rand and cents or cents only.
1.2 Na diapola tše pedi ke bokae? (*How much will two apples cost*?) (2)	
1.3 Na Neo o setše ka bokae? (*How much money does Neo have left*?) (2)	To understand how learners will subtract to get the answer in rand and cents or cents only.
2. Šoma dikarabo tsa tše di latelago: (*Workout the following amounts*):	
2.1 Bana ba filwe R2 tše pedi le R5 tše pedi (tshelete e filwe ka di swantsho). Ge o reka ka tšhelete e gomme wa lefela ka R20, na tšhentšhi ya gago ke bokae? (*Learners were provided with two R2 coins and two R5 coins that they should pay with (pictures of the coins were displayed so that learners can add the amount). When you buy with this money, how much change will you get when you pay with R20?)* (3)	The learners were assessed to identify that they must first add the R2 coins together and then add the R5 coins, and thereafter add the total of the two sums. Thereafter, the learners must subtract to get the answer.
2.2 Bana ba filwe diswantšho tše nne tša R2. Na tšhentšhi ya gago ke bokae? (*Learners were given four pictures of R2 coins. How much change will you get when you pay with R20?)* (3)	
3.1 Tshepo o rekile borotho ka R18.95 le dilitara tše 2 tša tšusi ka R22.99. Na o tla gwetša tšhentšhi ya bokae ge a lefila ka R50? (*Tshepo bought a loaf of bread at R18.95 and 2 litre of juice at R22, 99. How much change will he get when he pays with R50*?) (3)	To understand how learners will add and then subtract to get the answer in one question.
3.2 Lebo o rekile senwamaphodi ka R23.95 le rolo ka R8.95. Na o patetše bo kae? Ge a patella ka R50, o tla gwetša tšhentšhi ya bokae? *(Lebo bought a cool drink at R23.95 and a roll at R8.95. How much did she pay? If she pays with R50.00, how much change will she get?*) (3)	

The researcher collected all the scripts immediately after writing and marked them the same day. The semi-structured interviews of five minutes with each of the four sampled learners (2 girls and 2 boys) purposefully selected according to the types of committed errors, were conducted the following day. During data collection, learners had learnt addition and subtraction of money word problems according to the term's annual teaching plan (ATP). To

determine the errors made by learners when solving addition and subtraction of money word problems, the researcher used the NEA during the interviews. The gathered data were analysed and interpreted based on Newman's (1977) error analysis, reading error, comprehension error, transformation error, process error and encoding error.

Permission to conduct the research study was sought from the school, the teacher and learners who participated. Prior conducting the research, the role and participation of the teacher and learners were explained. Parents signed the consent forms for their children while learners signed the assent form to take part in the study. Learners' privacy and confidentiality were protected.

Methodological approach

This part designates how Newman's error analysis is used to analyse the collected data for the study. Reading error, comprehension error, transformation error, process error and encoding error are the main concepts of the framework that are used to analyse data. Table 2 provides the definitions of the following main concepts of the framework and describes the performance indicators.

Table 2.

Methodological approach

Concept	Definition	Performance indicator
Reading error	Determines the ability or inability of the learners to read word problems	Learners need to be able to identify or read keywords or mathematical symbol in a word problem to be able to go on with the steps to solve the word problem.
Comprehension error	Determines the ability or inability of the learners to understand word problems	Learners should be able to understand mathematics vocabulary or keywords and the mathematical context of the word problems.
Transformation error	The learners' ability or inability to correctly of incorrectly choose the mathematical operation or procedure to solve word problems	Learners can transform the word problem into number sentence. They apply the process by first adding the total amount (50c + 50c + 50c + 50c + 20c + 20c = R2, 40) and cost of two apples (90c + 90c = R1,80) then subtract the money used from the total they had in the beginning (R2,40 – R1,80 = 60c).
Process error	Learners correctly or incorrectly execute the mathematical procedure to solve word problems.	Learners should be able to solve the problem by using the correct mathematical operations and be able to carry when they add and be able to borrow when they subtract. At the end, they should be able to write the amounts in rands and cents.
Encoding error	Learners can solve the problem correctly but fail to write the answer correctly.	The learners can add the amount in rands and cents but are unable to put the answer in writing.

Findings

The analysis of the findings is presented using Newman's error analysis (1977) which includes reading error, comprehension error, transformation, process error and encoding error. Seven question items were used to identify the errors demonstrated by learners when solving addition and subtraction word problems of money. The findings revealed errors in all the NEA from the learners when solving the word problem questions. Table 3 shows the number of errors committed by learners in each question item analysed using NEA. Absolute numbers and percentages were used to analyse the types of errors identified in the learners' scripts. The samples of the work of the learners were coded LG1 (learner girl 1), LB2 (learner boy 2), LG3 (learner girl 3), LB4 (learner boy 4), LG5 (learner girl) and LB6 (learner boy). Table 3 analysis used the actual number of learners who made errors and percentages of NEA error type. Many learners with more than 50% made reading errors in items 1.3, 3.1. and 3.2, comprehension errors, transformation errors and process errors in items 1.3, 2.1, 2.2, 3.1 and 3.2 and encoding errors in items 1.3, 3.1 and 3.2.

Table 3 illustrates reading errors, comprehension errors, transformation errors, process errors and encoding errors in all the seven items of the questions from the word problems. Few reading errors, comprehension errors, transformation errors, process and encoding errors with less than 40% were found in items 1.1.

Table 3.

The total number of errors according to the test item and Newman's error analysis

Item	Reading		Comprehension		Transformation		Processing		Coding		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
1.1	14	25.9	18	33.3	18	33.3	18	33.3	22	40.7	82	30.4
1.2	23	42.6	26	48.1	26	48.1	26	48.1	22	40.7	123	45.6
1.3	33	61.1	35	64.8	37	68.5	37	68.5	30	55.6	172	63.7
2.1	25	46.3	28	51.9	29	51.9	29	51.9	25	46.3	126	46.7
2.2	24	44.4	29	53.7	32	59.3	32	59.3	23	42.6	140	51.9
3.1	31	57.4	31	57.4	33	61.1	33	61.1	33	61.1	161	59.6
3.2	32	59.3	32	59.3	34	63.0	34	63.0	33	61.1	165	61.1

How learners identify the keywords or mathematical operation from word problems

Test item 1.1 revealed few learners (25.9%) with reading errors and 33.3% with comprehension errors as the questions did not require much reading and comprehension from the word problem. The question used pictures of money as resources to assist learners in understanding the problem. As suggested by Ramsingh (2020), application of resources helps the learners in bridging the gap between mathematical understanding and new knowledge. However, most learners did not take advantage of the use of pictures to assist them in understanding the word

problems. Higher reading errors and comprehension errors were from items 1.2, 1.3, 2.1, 2.2, 3.1 and 3.2 which range from 42.6% to 59.3% reading errors and 48.1% to 64.8% comprehension errors. Learners were unable to identify the keywords or to understand mathematics vocabulary in a word problem to be able to go on with the steps to solve the word problem. This led to learners writing incorrect answers without even showing how they solved the problem. This is in line with the findings of Abdullah et al. (2015) that learners' errors linked to fluency issues like reading and comprehension, led to errors in selecting appropriate operations and articulating solutions. Some of the learners did not write the mathematical operation they used to work out the answer.

LG1 **LB2**

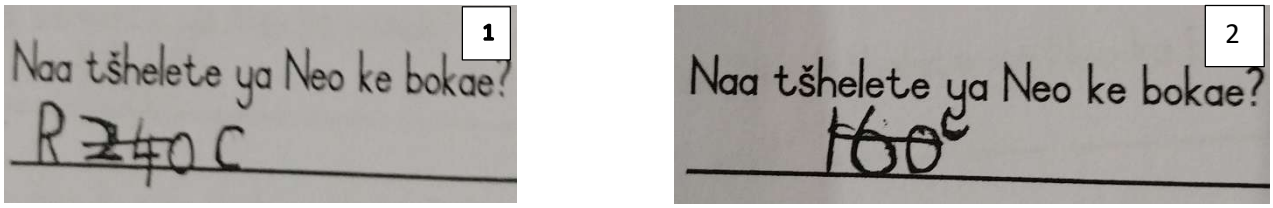

Figure 1.

Learners' samples in identifying keywords or a mathematical operation from a word problem

Figure 1 shows the answers they provided without the mathematical operation or showing how they worked out the solution to the problem. This shows learners' lack of conceptual understanding, which created difficulties in identifying the mathematical operation and solving the problem correctly. Bayaga et al (2022) pointed out that deficiencies in reading skills or insufficient reading comprehension may lead to learners' mathematical errors, resulting in incorrect responses. LG1 wrote the answer as R240c without the comma to separate the rands and cents, while LB2's answer was completely incorrect. Both learners did not show how they worked out their answers. This instance underscores the inadequacy in the addition skills required to sum amounts that encompass both rand and cents, a deficiency observed among many learners. Mukunthan (2021) declares that errors arise from inattention, misinterpretation of symbols or text, and inadequate information pertaining to the mathematical topic. It can be inferred that the learners lack proficiency in expressing monetary values in rand and cents. Furthermore, the learners may have difficulty in grasping the appropriate mathematical operation to utilise when formulating a numerical statement. Consequently, they encountered challenges in articulating the numerical sentences for word problems due to the struggle in selecting the suitable mathematical operation (Cheva & Luneta, n.d).

The other type of error that was found is encoding errors where learners were expected to write the amount after solving the problem. Encoding errors occur when learners fail to write the answer correctly even if they have solved the problem accurately (Newman, 1977). Firstly, both learners did not show the process they used to arrive to the answers they provided. Then, the encoding error was found from LG1 where the learner wrote R240c as the answer instead of

writing R2.40c or 240c without an “R”. The learners' incapability to encode and accurately transcribe the answer highlights the lack of potential disparity between providing an oral response and transcribing it correctly (Bourke, 1979). The learner's omission of a comma after inscribing two indicated a misconception regarding the representation of money in rand and cents concurrently. As Mukunthan (2021) elucidates, learners frequently commit systematic errors related to place value when performing addition, emphasising the interconnection between addition and various aspects of the learner's daily life.

How learners transform the word problem into number sentence

Transformation errors were discovered from the learners’ scripts as they appeared not to transform the word problem to the number sentence and not knowing the correct method or procedure in solving the word problem (Newman, 1977). This discloses that learners were unable to interpret the word problem so as to write it in number sentence. Table 3 illustrates a higher percentage of transformation errors in 1.2 (48.1%), 1.3 (68.5%), 2.1 (51.9%), 2.2 (59.3), 3.1 (61.1%) and 3.2 (63.0%). Figure 2 displays the examples of transformation errors.

LG3 **LB4**

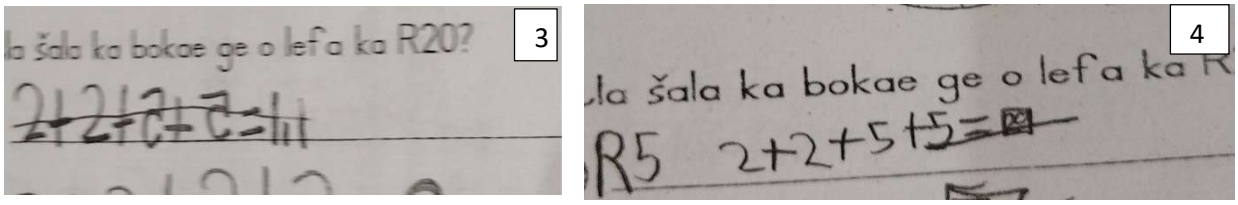

Figure 2.

Learners’ sample in transforming word problems into number sentence

Transformation errors as they could not interpret the word problem correctly to write it in number sentence and they wrote the numbers instead of showing that they were working with money. The persistence of misconceptions hinders learners' assimilation of new knowledge during the learning process, leading them to develop a strong attachment to these misconceptions (Mohyuddin & Khalil, 2016). The learners showed that they lack the knowledge of transforming the word problem into the number sentence. Also, LG3 showed that she still experiences challenges with number reversal by writing 5 facing to the right-hand side. Learners need to pay more attention on how to transform the word problem into the number sentence. As per Alhassora et al. (2017), most learners struggle to interpret, explain, validate, and recount the provided data due to a lack of fundamental knowledge.

Executing mathematical procedure in solving word problems

Process errors were also found in this study from learners when solving word problems. Process errors involve the wrong use of mathematical operations or procedure to solve the problem (Newman, 1977; Ellerton & Clements, 1996). Most question items recorded the higher percentage of process errors with 1.2 (48.1%), 1.3 (68.5%), 2.1 (51.9%), 2.2 (59.3%), 3.1

(61.1%) and 3.2 (63.0%). Some learners used the incorrect mathematical operation to solve the problem. Figure 3 below illustrates how the two learners encountered the process error by using the incorrect mathematical operation to solve the problem. The samples exposed the lack of comprehension of the word problem which led to them committing transformation errors, hence, they used the division instead of subtracting the total amount spent from R20. They followed the wrong procedure of working out the solution to the problem; LG5 divided R20 by 3 while LB6 divided it by 5. Muthukrishnan et al. (2019) posit that learners' misconceptions about the fundamental operations stem from the lack of understanding essential concepts and calculation methods, as well as the relationships between different operations. Nofrianto et al. (2022) proclaim that the incorrect use of mathematical operations indicates that learners lack strong foundation in understanding the basic mathematical operations, hence they used division instead of subtraction. Alternatively, they might be experiencing challenges in differentiating between subtraction and division since they used division as the operation to find the solution to the problem. Celemin (2023) highlighted that for learners who are not given proper numeracy attention during their daily classroom activities, poor counting skills such as narrating number word sequence, weak numerical interactive skills and weak basic arithmetic skills can be observed. Figure 3 below presents LG5 and LB6 samples.

LG5 **LB6**

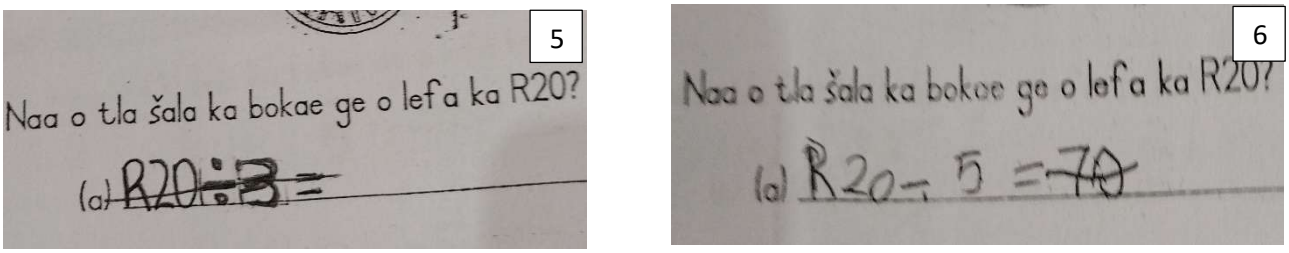

Figure 3.

Learners' samples in executing mathematical procedure in solving word problems

The learners selected for the interview revealed challenges when solving addition and subtraction of word problems about money. The interview was employed to understand how learners solved the word problems. They seem to have a challenge of solving word problems as they could not write the number sentence and have difficulties in writing money in rands and cents.

Table 4.

Extract of LG7 for item 1.3

Speaker	Dialogue
Interviewer	[Wants to see if they understand or can interpret the word problem] "O kwisisa eng ka potsiso ye?" (What do you understand about this question?)
LG7	"Ke kwisisa gore diapola tse pedi ke di 90c tse pedi." (*I understand that two apples are two 90c).*
Interviewer	Bjale ge ile di 90c tse pedi, o swanetse o e ngwale bjang go bontsha gore diapola tse pedi ke bokae? (If it is two 90c, how should you write it to show the amount of two apples?)
LG7	"Ke ngwala 90c tse pedi." (I write two 90c.)
Interviewer	Mpotshe gore o e ngwala bjang. [Show me how you write it] (give her a pencil to write on the paper).
LG7	The learner wrote like this 90c 90c
Interviewer	Ga o ngwale gore ke bokae ka moka le gore o diren eng go gwetsa karabo? (You do not write the total amount and how you got the answer?)
LG7	Ah! Nna ga ke tsebe gore ke e ngwale bjang. (Ah! I do not know how to write it)
Interviewer	O swanetse o ngwale 90c + 90c gomme wa ngwala karabo gore ge o dihlakantsha ke bokae. (You should write 90c + 90c and write the answer that you get when you add)
LG7	"Ee! Ne ke sa tsebe gore ke e ngwale bjang. Bjale ke bona gore ke swanetse ke ngwale bjang" (Ee! I did not know how to write it. Now I see how I must write it.)
Interviewer	Naa go na le se sengwe seo o nyakago go sebolela? (Is there anything that you what to say?)
LG7	"Aowa." (No.)

Table 5.

Extract of LB8 for item 1.3

Speaker	Dialogue
Interviewer	[Wants to see if they understand or can interpret the word problem] "O kwisisa eng ka potsiso ye?" (What do you understand about this question?)
LB8	"Ba re diapola tse pedi ke bokae." (They say how much are two apples*).*
Interviewer	Bjale o ka mpotsa gore ke bokae? (Now, can you tell how much they are?)
LB8	"Ee, ke one rand eighty eighty cents." (Yes, it is one rand eighty cents)
Interviewer	Naa o ka nngwalela yona? [Can you write it (while giving him a pencil to write on a paper)?]
LB8	"Ee" (He wrote R180c)
Interviewer	Naa e ngwadiwa ka mogwa woo? [Is this how it is written? (pointing at R180c)]
LB8	"Ee, ke one rand eighty cents." (Yes, it is one rand eighty cent)
Interviewer	O swanetse go ngwala fegelwana ka morago ga one rand go fapantsha diranta le disente. (You must write a comma after one rand to separate rand and cents, like this R1,80c).
LB8	"Oho! Maths le wona o bothata, Mam." (Oho! Maths is difficult, Mam.)
Interviewer	Naa go na le se sengwe seo o nyakago go sebolela? (Is there anything that you what to say?)
LB8	"Aowa. Ke bone gore diranta le disente di ngwalwa bjang. Nka se sa lebala." (No. I saw how to write the rands and cents. I no longer forget.)

The two extracts (Tables 5 and 6) portray that learner experience challenges in transforming the word problems to number sentences and writing amount in rands and cents. This led to LG7 committing encoding errors and LB8 not knowing which mathematical operation to use to work out the solution to the problem. Transformation errors affect the ability to interpret and transcribe the word problems which leads to using incorrect process in solving the problem.

LG7 **LB8**

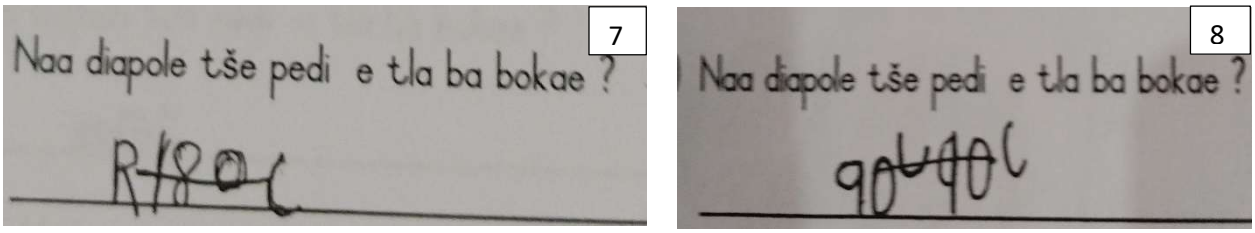

Figure 4.

Learners' samples during interviews

Tables 5 and 6 looked for the reasons why learners wrote the answers to the question the way they did. The extract uncovered that the learners lacked conceptual understanding that would enable them to comprehend the information to write the word problems in number sentence. According to scripts in Figure 4, LG7 and LB8 presented a lack of comprehension of word problems which led them to be unable to transform the problem into a number sentence. Like LG1, LG7 wrote the answer as R180c without separating the rand and the cents while LB wrote two 90c without writing the mathematical operation in between. They struggled to write the word problem to number sentence 90c + 90c and add the amounts to get the total of R1,80c or 180c (writing in rands and cents or in cents only). LG7 in Table 5 revealed an encoding error that showed that she could orally say the answer but was unable to write it correctly. The learners' capability to encode and accurately transcribe the answer highlights the potential disparity between providing an oral response and transcribing it correctly (Bourke, 1979). The learner's omission of a comma after inscribing two indicated a misconception regarding the representation of money in rand and cents concurrently. As Mukunthan (2021) elucidates, learners frequently commit systematic errors related to place value when performing addition, emphasising the interconnection between addition and various aspects of the learner's daily life. This further revealed that the learner's misconception might have not been identified and rectified when learning about converting cents to rands and cents, and vice versa. Hence, she developed a strong attachment to the misconception (Mohyuddin & Khalil, 2016) of writing money in rands and cents (R180c) without separating them with a comma. Moreover, the persistence of misconceptions hinders learners' assimilation of new knowledge during the learning process (Mohyuddin & Khalil, 2016). This requires teachers to recognise and rectify this error and misconception to enhance the academic performance of learners in mathematics.

LB8 experienced the challenge of transformation error as he struggled to identify the mathematical operation to use, hence, he wrote two 90c without the operation in between and

did not write the total amount. The learner also gave the reason that he did not know what to write. Similar findings were found by Abdullah et al. (2015) where learners struggle with comprehending mathematical problems, which led to errors in selecting appropriate operations and articulating solutions. Most learners struggle with transforming the word problems to number sentence because they are unable to identify the correct mathematical operation, hence they write numbers without the mathematical operation, or they write the answer without showing the process used to work out the answer. Cumhur and Terez (2020) concur that learners' comprehension is influenced by the strategies they develop to tackle mathematical difficulties and apply problem-solving skills. However, identifying learners' errors can assist teachers in adapting the delivery of the subject matter to meet the learning requirements of learners (Wahyudi et al. 2019).

Discussion

This study envisioned to investigate the errors exhibited by learners during addition and subtraction of money word problems. The study uncovered higher rate of percentages in reading, comprehension, transformation, process and encoding errors in items 1.2, 1.3, 2.1, 2.2, 3.1, 1 and 3.2 with more than 40%. Low reading, comprehension, transformation, process and errors were found in item 1.1 with less than 40%. The outcomes demonstrated a deficiency among learners in expressing monetary values in South African money units, particularly when dealing with amounts in rand and cents. It has been disclosed that some of the learners exhibit deficiencies in reading with comprehension. They exhibit an inability to identify keywords or select the appropriate mathematical operation to resolve the word problems. It was uncovered that comprehension errors are prevalent and significantly impact learners' ability to proceed to subsequent stages of problem-solving (Ellerton & Clements, 1996; Newman, 1977). The cause of comprehension errors could be that some learners are unable to read a single keyword or written mathematical symbol in a mathematical word problem, which causes them not to continue with the steps to solve the problems (White, 2005). According to Van de Walle, Karp, & Bay-Williams (2018), incorporating visual illustrations, scaffolding and related problem-solving instructions can these common errors.

Moreover, lack of comprehension leads to the failure of many learners recognising the mathematical operations (Kusmayadi et al., 2022), which causes learners to be unable to transform the word problem to number sentence. The persistence of misconceptions hinders learners' assimilation of new knowledge during the learning process, leading them to develop a strong attachment to these misconceptions (Mohyuddin & Khalil, 2016). According to Alhassora et al. (2017), most learners struggle in interpreting, explaining, validating, and recounting the provided data due to a lack of fundamental knowledge. Tomlinson (2017) proclaims that differentiated instructional techniques, such as peer-assisted learning and language support, can benefit learners in diverse classrooms. The strategy can assist in enhancing the reading skills for struggling learners with comprehension.

It was also revealed that some learners committed processing errors because they could identify the operation to be used but executed it incorrectly due to procedural misunderstandings or calculation mistakes (Ellerton & Clements, 1996). This underscores the importance of

identifying and addressing the specific types of errors made by learners, whether they are erratic or consistent (Brown et al., 2016), to intervene promptly. Moreover, it is plausible that some learners can provide a verbal response but encounter difficulties in transcribing it accurately (Bourne, 1979). Chowdhury and Choudhury (2020) emphasised the importance of scaffolding strategies in supporting learners to progress through the problem-solving stages.

The data extracted from the sample provided revealed that some learners exhibit difficulties in retaining knowledge, harbour misconceptions, and display deficits in problem-solving skills (Ancheta, 2022). This could be that the learners' misconception was not identified, and proper measures were not applied to correct them. Errors often emanate from oversight, misinterpretation of symbols or text, and insufficient relevant information pertaining to mathematical concepts (Mukunthan, 2021). Consequently, there is a growing concern regarding numerical errors arising from learners' inadequate grasp of concepts and ineffective teaching methodologies employed by educators (Bayaga, 2021). Hence, leveraging error analysis to pinpoint the underlying causes of learners' misconceptions, errors, scrutinising the reasons behind these errors, and discerning any recurring patterns of misunderstanding (Lai, 2012) are imperative. This will allow teachers to tailor their instructional approaches to mitigate numerical errors and cater to the diverse learning needs of the learners.

Conclusion

The research concludes by highlighting that the types of errors made by learners when learning word problems in relation to money differ in classification. As such, teachers need to identify the root cause of errors and misconceptions when teaching word problems. Further than the shared conclusion, the precise conclusion and suggestion thereof is that (1) Some learners experience challenges of comprehending the word problem and transforming it into a number sentence (2) they struggle with reading and comprehending mathematical problems, leading to challenges in selecting the appropriate operations and articulating the solution (3) there is oversight, misinterpretation of symbols or text, and insufficient relevant information pertaining to mathematical concepts (4) some learners exhibit difficulties in retaining knowledge, harbour misconceptions, and display deficits in problem-solving skills. The prevalence of comprehension errors implies that many learners fail to realise keywords and choose inappropriate mathematical operations, which relentlessly hold back their problem-solving expertise. Furthermore, misconceptions and procedural misunderstandings further impact the problems learners face, demonstrating an urgent need for effective instructional methods.

Recommendation

Misconceptions and errors made by learners should be identified as early as possible so that they are dealt with, and comprehension learning can be developed. Teachers are encouraged to integrate differentiated teaching strategies such as language support and peer-assisted learning to accommodate the diverse learning needs of learners. Furthermore, visual representations and scaffolding strategies can support understanding word problems more successfully. The teachers should conduct regular error analysis to identify the specific types of errors learners

commit. Understanding the original cause of the errors made by learners can assist teachers in tailoring their teaching strategies to address these matters and strengthen foundational knowledge. Moreover, intervention reading programmes that focus on reading with understanding and mathematical operations can help learners to practice identifying keywords and to execute mathematical procedures accurately. Ongoing workshops and professional development should be presented to develop teachers' understanding of applicable teaching strategies and equip them to support learners in overcoming their problem-solving errors. By implementing these recommendations, teachers can provide a supportive learning classroom that addresses the specific needs of learners, ultimately improving their proficiency in solving money word problems.

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Competing interests

The authors declare that no competing interests or personal relationships influenced the writing of this article.

Ethical Consideration

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