Teaching Algebra to a Grade 7 Student: Action Research Intervention

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Abstract: Algebra is critical in shaping future mathematics success and is integral to the K-12 curriculum. Despite its inclusion, a common challenge arises as students' progress to higher grades without a solid foundation, resulting in challenging learning experiences. This action research study focuses on the algebraic learning experience of a Grade 7 student. The research explores various teaching and learning approaches, including consideration of cognitive development milestones, real-world applications, interactive learning, differentiated instruction, personalized learning plans, technology integration, and innovative assessment methods. Findings suggest that aligning instructional methods with cognitive development, incorporating real-world applications, facilitating interactive learning, offering differentiated instruction, personalizing learning plans, integrating technology, and utilizing innovative assessment approaches enhance the engagement and comprehension of algebraic concepts.

Keywords: Grade 7 algebra, mathematics, curriculum, foundational, action research, interactive learning.

INTRODUCTION

In the dynamic landscape of modern education, the traditional boundaries of when and how education systems introduce complex mathematical concepts are evolving. The spotlight is now turning to the early years of a child's education, where the seeds of mathematical understanding are sown. Among these foundational concepts, algebra emerges as a critical player. It is traditionally associated with later academic pursuits but is increasingly recognized as a potent catalyst for cognitive development in primary students (Star et al., 2015).

At the heart of this paradigm shift is the acknowledgment that primary students are not just capable of grappling with abstract ideas; they thrive when presented with challenges that stimulate their growing minds. Algebra, emphasizing symbols, relationships, and problem-solving, stands as a bridge between the tangible world of arithmetic and the abstract realm of higher mathematics (Oppenzato & Ginsburg, 2018; Star et al., 2015). Education systems aim to tap into young minds' natural curiosity and flexibility by introducing algebra at this juncture, fostering a solid foundation for future mathematical prowess. Nevertheless, I encounter a challenge concerning the feasibility of achieving this objective concerning my 11-year-old son, referred to as the learner in this paper, who is in Grade 7.

The learner would put in an hour-long self-study on math every day, excluding the time he would spend on math homework. He would manage to complete the homework and additional questions from the math textbook, albeit with my interventions. However, his scores on unit tests would hover around the average score, indicating partial comprehension of the finished topics. As he moves ahead with unit after unit in tandem with the routines of his school, what still needs to be mastered in the completed topics accumulates, and the cumulative effect from such a process result in variegated learning that undermines his ability to cope with new issues. Being a former math teacher in schools, I might have missed this revelation amidst the busy schedules of instructional activities. However, as a parent and faculty member at a teacher education college, I have been helping the learner with his math. As the early introduction of algebra is not merely an adjustment to curriculum sequencing but a deliberate and strategic investment in the intellectual growth of our youngest learners, I will share how I assisted the learner in learning algebra and how the assistance enabled the learner to comprehend algebraic problems.

As I assisted the learner in learning algebra, the central question was, how can I teach algebra to a Grade 7 student?

I sought to address the central question by exploring the theoretical underpinnings of introducing algebra to primary students and the practical strategies and approaches to make this venture feasible and enriching. By examining the cognitive milestones of early development, the relevance of real-world applications, and the integration of interactive and technological tools, we embarked on a journey to learn algebra.

LITERATURE

Cognitive Development and Algebra

The integration of algebra into the primary curriculum is not merely a pedagogical experiment; it aligns with the natural trajectory of cognitive development in young minds. In their formative years, primary students undergo a phase marked by significant cognitive growth and an expanding capacity for abstract thinking.

During the concrete operational period, typically ages 7 to 11, children develop the cognitive ability to think logically about concrete situations (Babakr et al., 2019; Sherrell, 2023; Virtual Lab School, 2023). This foundational phase sets the stage for educators to introduce algebraic concepts strategically, capitalizing on the newfound logical reasoning skills. Through tangible examples and real-world scenarios, educators use manipulatives, visual aids, and relatable problems to guide students through the transition from concrete operations to abstract algebraic thinking (Sa'adah et al., 2023). This intentional approach equips students to understand and apply abstract mathematical concepts in the concrete operational period, establishing a robust foundation for future learning.

Algebra is a natural progression from concrete arithmetic to abstract reasoning (Breiteig & Grevholm, 2006; Driscoll, 1999; Staff, 2019; Star et al., 2015). During this cognitive shift, students move from manipulating tangible objects to manipulating symbols, representing relationships between quantities (Sa'adah et al., 2023). This developmentally appropriate introduction encourages the cultivation of problem-solving skills and logical reasoning, aligning seamlessly with the broader goals of primary education (Breiteig & Grevholm, 2006; Star et al., 2015). Early exposure to algebra establishes a sturdy foundation for future mathematical endeavors, enabling students to comfortably navigate advanced concepts in later grades (Demme, 2018; Gojak, 2013).

Beyond its cognitive benefits, integrating algebra into the primary curriculum promises to enhance motivation and engagement (Centres for Excellence in Maths, 2020). Naturally curious and eager to explore, young learners discover a captivating outlet in algebra's puzzle-like nature and real-world applications. This intentional integration taps into their innate curiosity, transforming mathematical exploration into a dynamic and enjoyable experience. Consequently, this approach not only aligns with the cognitive development of primary students but also sets the stage for a lifelong appreciation and mastery of mathematical concepts.

Real-World Applications

One of the most compelling reasons to introduce algebra to primary students is its immediate and tangible relevance to their world. Far from an abstract set of rules and symbols, algebra finds its roots in real-world scenarios, making the learning experience meaningful and applicable to children's daily challenges.

Recognizing that algebra has immediate and tangible relevance to the world inhabited by young learners, exploring diverse real-world applications that bring algebra to life in the primary classroom can enhance the learners' curiosity. From routine trips to the grocery store (Trethewy, 2022) to the intricate patterns found in nature (Lassiter, 2023), the design of dream bedrooms (Hello Learning, n.d.), the captivating arena of sports statistics (West, 2022), and even the playful experimentation in a sandbox (Driscoll, 1999), each facet contributes to the overarching goal of making algebra not only meaningful but also an integral tool for understanding and navigating the environment of primary students.

Incorporating real-world applications into teaching algebra to primary students transforms abstract concepts into practical tools for understanding and navigating their environment. By embedding algebra in everyday experiences, educators can bridge the gap between theoretical knowledge and practical application, fostering a deep and lasting appreciation for algebra's relevance in the lives of young learners.

Interactive Learning Strategies for Algebra

Interactive learning, centered on collaboration and group activities, turns algebra into a shared adventure (Jackson et al., 1998). Games, from board games to apps, make algebra fun and competitive (Sun-Lin & Chiou, 2019; Timotheou et al., 2023). Tactile tools, like manipulatives, make abstract algebra tangible and memorable (Hodge-Zickerman et al., 2020). Through apps and online platforms, technology offers a dynamic virtual playground for personalized learning (Attard et al., 2015).

Interactive learning includes real-time feedback and reflection, refining understanding, and promoting metacognitive skills. Technology is crucial in teaching algebra to primary students, offering dynamic and interactive platforms. Apps and software gamify learning, making algebra accessible and enjoyable. Virtual manipulatives bring abstract concepts to life in a digital space (Freina & Ott, 2015). Online platforms foster collaborative learning beyond the classroom, breaking down geographical barriers.

Technology enables adaptive learning systems tailoring instruction to individual needs. Multimedia presentations and interactive lessons replace traditional lectures, enhancing comprehension. Augmented and virtual reality provide immersive experiences, opening new frontiers for teaching algebra.

Teaching Strategies for Algebra

In primary education, algebra teaching introduces challenges characterized by variations in cognitive development and diverse learning paces (Arcavi et al., 2016). This examination delves into the strategies to address these challenges while nurturing an inclusive and supportive learning environment for primary students.

Recognition of the unique characteristics inherent in each learner within the primary classroom prompts educators to adopt differentiated instruction (Tomlinson, 2017). Through tailoring teaching methods, materials, and assessments to accommodate individual learning styles and paces, this approach aims to ensure that algebraic concepts resonate with each student, averting feelings of overwhelm and fostering a culture of inclusivity. As the exploration extends into the intricacies of primary algebra education, the concept of personalized learning plans emerges as a pivotal tool designed to cater to the diverse needs of primary students (Shemshack & Spector, 2020). By identifying individual strengths, weaknesses, and preferences, educators create targeted frameworks for interventions or extensions, ensuring that algebra instruction is accessible and appropriately challenging (Zheng et al., 2022). Proactive measures, encompassing the early identification and rectification of potential misconceptions, contribute to a classroom culture that values questions, encourages critical thinking, and utilizes formative assessments. This personalized and proactive approach extends to scaffolded learning (Grotherus et al., 2019), the prioritization of conceptual understanding (Joffrion, 2007), fostering a growth mindset (Breckenridge, 2014), encouraging peer collaboration (Alegre et al., 2019), and involving parents in the learning process (Muir, 2012).

These strategies establish a supportive and empowering space for primary students to thrive in their algebraic learning journey.

Assessment Strategies for Algebra

Assessing primary students in algebra requires a nuanced approach considering developmental stages, diverse learning styles, and the dynamic nature of understanding (Oguguo et al., 2024). Formative assessments, like quizzes and interactive activities, offer real-time insights for tailored instruction. Performance-based assessments evaluate application skills through real-world scenarios (Oguguo et al., 2024; Tejeda & Gallardo, 2017). Portfolios showcase progression over time, capturing diverse skills and encouraging reflection (Torres et al., 2016). Observational (Schoenfeld et al., 2018) and interview assessments (Ardiansari et al., 2023) during activities and discussions provide qualitative data on problem-solving and collaboration. Self-assessment promotes metacognition, involving students in the evaluation process (Babic et al., 2019). Technology facilitates adaptive assessments, providing immediate feedback and personalized experiences (Wu et al., 2023). Clear rubrics standardize evaluation, offering criteria and constructive feedback (Poh et al., 2015).

METHOD

I employed participatory action research because of its attributes of pragmatism, baseline data, use of intervention, post-intervention data, evaluation of interventions, and reflexivity (Kemmis et al., 2014; McNiff, 2013; MicNiff & Whitehead, 2006; Mills, 2014; Stringer, 2021).

I had only one student participant, my son studying in Grade 7. In the study, the participant was referred to as a learner. The teaching and learning sessions occurred at home after school hours and on weekends, and they were one to two hours daily.

Baseline Data Collection

My baseline data was sourced from the Grade 7 math textbook, the learner's notebook, and conversations with the learner. Grade 7 math textbook has units, and the units have chapters, and the chapters have topics, examples, and exercise questions (refer to Table 1).

Chapter	Topic
Chapter 1	Patterns and Relationships; Using variables to describe pattern rules; Creating and evaluating expressions; and Simplifying expressions

Chapter 2	Solving Equations; Solving equations using models; Solving equations using guess and test; Solving equations using inverse operations; and Solving equations using reasoning
Chapter 3	Graphical Representations; Graphing a relationship; Examining a straight-line graph; Describing change on a graph; and Relationship graphs straight lines

Table 1: Grade 7 algebra unit

A series of instructional activities were organized to collect baseline data. First, I would teach the topics to the learner using the chalk and blackboard approach, a typical variant of the traditional teaching approach (Bamne & Bamne, 2016). Second, I would give the learner tasks on the topics taught. The learner would complete the tasks during the teaching sessions, while I would observe the process the learner would follow to complete the tasks. The process followed by the learner when doing the tasks would be recorded with anecdotal records (Obano & Enowoghommwenma, 2021). Third, I would assign the learner homework; homework in this study was independent tasks the learner would do after the teaching sessions. I would assess the homework and give symbolic feedback through ticks or cross marks (Chappuis, 2012; Hattie & Timperley, 2007). I would use analytic rubrics to evaluate the homework (Brookhart, 2013). This would continue for the whole unit on algebra. I would instruct the learner to redo the incorrect work, but the learner would complete the job with the same errors, and I would reteach the relevant topics again in the same way. This cycle would continue until my focus would shift to the next topic simply because there would be more topics to teach—a phenomenon that compelled D Carlo (2009) to sloganeer, "Too much content, not enough thinking, and too little FUN." The number of anecdotal records and analytic rubrics would increase over time without much attention from me as I moved ahead with topic after topic, assuming that the learner would have acquired the intended knowledge and skills from the taught topics until the unit tests were conducted. The unit test results would indicate what the learner knows and what he can do with what he knows. A set of sample questions from the algebra unit test is depicted below:

Q1 Simplify $(3n+2) + (5n+6)$.
Q2 List the variables, coefficients, and the constants in $-2m-4$.
Q3 Evaluate the expression $3h-4+7h+8$, when $h=4$.
Q4 Kinley earns Nu. 7000 each month. He also receives an allowance of Nu. 500 each month.
(a) Write an algebraic expression that represents how much Kinley receives in m months.
(b) Evaluate the expression to determine his annual income.

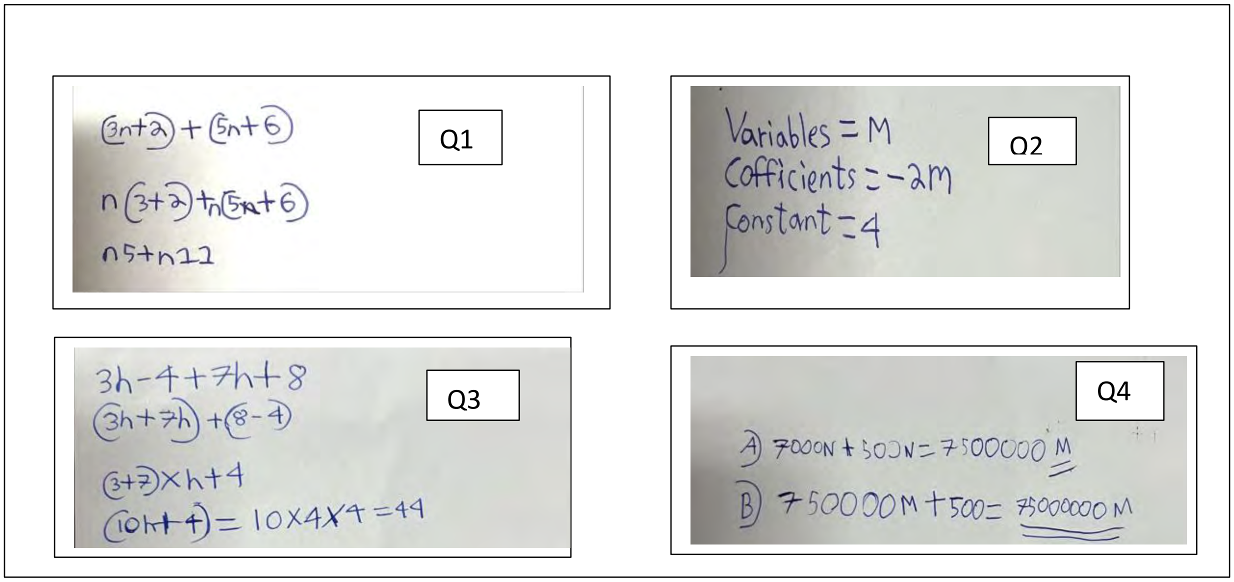

Figure 1: The learner's responses

Figure 1 shows a sample test result of the learner on the algebra unit. The learner's total score on a 100-mark test was 40 marks.

Analysis of the Learner's Responses to the Algebra Unit Test

In scrutinizing the learner's responses, I adopted a systematic approach outlined in Tables 2 and 3, extending the analysis to the teaching sessions and homework materials. The comprehensive assessment of during-the-session tasks and homework unveiled challenges encompassing generalization, function, structures, variables, constants, the concept of division in algebra, the principles of addition, subtraction, multiplication, and simplifying algebraic fractions.

No.	Learner's Answer	My Interpretation
1	$n(3 + 2) + n(5 + 6)$ $n5 + n11$	The mistake here is a failure to distribute the terms within the parentheses correctly. Specifically, the student didn't combine the 'n' terms separately from the constant terms. It's a common error known as not applying the distributive property properly when simplifying expressions.
2	Coefficient=2 Variable=m Constant=4	The mistake could be a misunderstanding or oversight regarding the inclusion of the negative sign in both the coefficient and the constant. This is a common error when learning about terms with negative coefficients and constants. It's an opportunity for the student to refine their understanding of signed numbers in algebraic expressions. Also, the student might be confusing the coefficient with the absolute value of the coefficient.

No.	Learner's Answer	My Interpretation
3	(3*h*+7*h*) + (8-4) (3+7) x *h* +4 10x4x4=44	So, the student's error is in the calculation, not in the substitution of the value. The correct calculation yields 44, but the student wrote 1044=44, which is an incorrect statement and a calculation error. The error could be attributed to a miscalculation or misunderstanding of the steps involved in evaluating the expression.
4	(a) 7000 x *m* (b) 9000	The key knowledge and skills that seem to be missing relate to the translation of verbal descriptions into algebraic expressions and equations. In part (a), it involves understanding that m × (7000+500) represents the total income for m months. In part (b), it involves recognizing the need to multiply by the number of months in a year (12) to find the annual income. Improving in this area would involve practicing translating verbal statements into algebraic expressions and equations, understanding the structure of mathematical expressions, and recognizing the operations needed to represent real-world scenarios algebraically.

Table 2: Analysis of the responses

I analyzed the results of the during-the-session tasks, homework, and algebra unit tests in Table 3. Table 3 delineates the frequency and distribution of errors across these domains, shedding light on notable patterns. The elevated percentage of mistakes in variables and constants is noteworthy, underscoring a concentrated struggle in this realm. Generalization and division concepts in algebra persist as formidable challenges, as evidenced by consistently high mistake counts. This detailed breakdown affords a holistic understanding of the learner's hurdles, guiding targeted interventions to fortify comprehension in specific algebraic facets.

Area of Difficulty	Mistake Count (% of Total)	Tasks			
		Classwork	Homework	Test	Total
Generalization	10 (47.6%)	10	5	6	21
Function	3 (15.8%)	10	4	5	19
Variables and constants	7 (58.3%)	8	3	1	12
Concepts of division in algebra	10 (35.7%)	15	5	3	28
Principle of addition, subtraction, and multiplication	6 (30.0%)	10	6	4	20
Simplifying algebraic fractions	8 (38.1%)	12	5	4	21

Table 3: Areas of difficulty and mistake counts

Interventions

The intervention strategies employed in this study were meticulously designed to address specific areas of difficulty identified in the learner's comprehension of algebraic concepts. Table 4 provides a comprehensive overview of these difficulties and the interventions implemented during the study.

Area of Difficulty	Conceptual Underpinnings of Intervention	Instructional Activities
Generalization	Emphasize that the distributive property works for both addition and subtraction. Provided examples of distributing a number across a subtraction operation to illustrate the general applicability of the rule. Reinforce the idea that the same principle applies to different scenarios involving parentheses and operations. Generalization in mathematics refers to the process of identifying and describing patterns, trends, or relationships that hold true across a range of situations or numbers. In algebraic terms, generalization often involves finding a formula or expression that represents a pattern or relationship for a broader set of values. It's about creating a rule that can be applied to a variety of specific cases.	Differentiated Instruction: Offered various examples that cater to different learning styles. Some students may benefit from visual representations, while others may prefer symbolic or verbal explanations. Personalized Learning Plans: Identified individual students' preferred learning styles and tailor examples accordingly. Provided additional practice problems with varying contexts to reinforce the generalization concept.
Function	Emphasize the need to distribute 3 to both terms inside the parentheses. Provide step-by-step guidance on simplifying the expression correctly. A function is a mathematical relationship between two sets of elements, where each element in the first set (domain) is related to exactly one element in the second set (codomain).	Differentiated Instruction: Used multiple representations such as graphs, tables, and verbal descriptions to cater to diverse learning preferences. Offered different levels of complexity for functions to challenge advanced learners.

Area of Difficulty	Conceptual Underpinnings of Intervention	Instructional Activities
	In algebra, a function is usually represented by an equation or expression that relates an input variable (usually denoted as 'x') to an output variable (usually denoted as 'y'). Each input value corresponds to exactly one output value. For example, y=2x+3 represents a linear function where for every x, there's a unique y.	Personalized Learning Plans: Assessed each student's proficiency in understanding functions and provide additional resources or challenges based on their current level of mastery.
Variables and constants	Review the definition of variables and constants in a typical equation like: y=mx+b. Reinforce that *m* and *b* are constants with known values, while x is the variable.	Differentiated Instruction: Used real-world examples and analogies to explain the difference between variables and constants (provided concrete instances where constants remain fixed while variables changed). Provide concrete instances where constants remain fixed while variables change. Personalized Learning Plans: Assessed each student's grasp of variables and constants and tailor additional examples or activities to reinforce the understanding of these foundational concepts.
Concepts of Division in Algebra	Clarify that a/b means *a* divided by *b*, not the other way around. Provide examples to illustrate the correct interpretation.	Differentiated Instruction: Offer multiple approaches to explaining division in algebra, including visual models and real-world scenarios. Use concrete examples to illustrate the concept. Personalized Learning Plans: Identify individual misconceptions about algebraic division and provide targeted interventions. Offer additional practice problems that focus on

Area of Difficulty	Conceptual Underpinnings of Intervention	Instructional Activities
		the specific challenges each student faces.
Principle of Addition, Subtraction, and Multiplication	Emphasize that addition and subtraction are not commutative. Use specific examples to illustrate the inverse relationship between these operations.	Differentiated Instruction: Utilize manipulatives, visuals, and real-world examples to illustrate the principles of addition, subtraction, and multiplication. Offer a variety of problems with different levels of complexity.
		Personalized Learning Plans: Assess each student's understanding of these principles and provide targeted reinforcement based on their specific needs. Adjust the difficulty of problems to match individual proficiency levels.
Simplifying Algebraic Fractions	Guide the learner through the correct process of simplifying algebraic fractions by canceling out common factors. Emphasize simplifying both the coefficient and the variable term.	Differentiated Instruction: Break down the steps of simplifying algebraic fractions using visual aids and interactive examples. Offer alternative methods for students who may struggle with the traditional approach.
		Personalized Learning Plans: Identify specific errors or misconceptions related to simplifying algebraic fractions. Provide individualized practice problems and additional resources to address these challenges.

Table 4: Areas of difficulties and interventions

Furthermore, I incorporated scaffolded learning and nurtured a growth mindset. I also facilitated peer collaboration by asking the learner to take some tasks to the school and solve them with his peers. The instructional approach involved a gradual elevation in problem complexity, offering support and guidance in tandem with students' progression. Commencing with more straightforward examples, I systematically introduced increasingly challenging problems. I underscored the significance of a growth mindset, highlighting that mistakes are invaluable learning opportunities. The emphasis was on fostering a positive attitude towards challenges, cultivating resilience, and instilling a belief in the inherent capacity for improvement. Collaborative activities were implemented to promote an interactive and supportive learning atmosphere, encouraging the learner to work with his school peers to solve problems. This peer collaboration not only provided varied perspectives but also contributed to the creation of a nurturing and conducive learning environment. In addition to these focused interventions, I incorporated real-world problem-solving scenarios in the tasks to provide a practical context for algebraic concepts. Activities such as grocery shopping, studying patterns in plant leaves, measuring vegetable growth, solving car-related problems, using scoreboards, and plotting electricity bills were presented to the learner. Integrating interactive websites, including ChatGPT (Open AI, 2023), further enriched the intervention process. ChatGPT has many helpful features.

ChatGPT offers tailored examples and explanations for individual learning styles. The learner can interact with ChatGPT to seek clarifications or explore alternative approaches to generalization. It generates graphs, tables, or verbal descriptions based on students' preferences, fostering dynamic interaction to deepen understanding. ChatGPT reinforces the distinction between variables and constants by engaging the learner in conversations about real-world examples, providing personalized analogies, and answering specific queries. Through interactive discussions, ChatGPT provides visual models and real-world scenarios, ensuring a comprehensive understanding of algebraic division. It assists in creating manipulative scenarios and real-world examples, offering personalized reinforcement, and addressing specific challenges related to addition, subtraction, and multiplication principles. ChatGPT breaks down the steps of simplifying algebraic fractions using visual aids and interactive examples, providing alternative methods, and engaging in conversations to address the learner's specific challenges. The conversations enabled me to understand the learner's deep-seated challenges, which were not normally accessible through word problems or written tasks (Yildirim-Elbasali et al., 2023). Therefore, the conversations were pointers for the zone of proximal development, a gap between what is known and what is not known (Vygotsky, 1978). For instance, the conversations about constants and variables helped identify misconceptions arising from proactive interferences of arithmetic rules when solving algebraic problems. The conversations also helped me understand how the learner construed the words' meanings when teaching, facilitating clarifications later.

These interventions were administered over three weeks, creating a structured and immersive learning experience for the learner. The study aimed to enhance the learner's holistic grasp of algebraic principles by combining targeted academic interventions with real-world applications and interactive technologies.

Post-Intervention Data Collection

The post-intervention phase involved carefully evaluating the learner's proficiency through a 100-mark test strategically designed with randomly selected questions from the algebra unit of the math textbook. This assessment aimed to gauge the learner's grasp on diverse algebraic concepts, covering tasks such as identifying variables, coefficients, and constants in expressions, devising pattern rules for geometric figures, evaluating complex algebraic expressions, constructing word problems based on given expressions, simplifying algebraic expressions, and solving equations. The learner's commendable total score of 70 marks on the test serves as an initial indicator of the efficacy of the interventions implemented to address the identified difficulties. Some sample questions from the test are provided below:

(1) List the variable, the coefficient, and the constant in -3*h*+2*f*-5.

(2) (a) Complete the table below.

(b) Write a pattern rule that could be used to find the number of squares if you know the figure number.

Figure number	**Figure**	**Number of squares**
1	□ □ □ □ □	6
2	□ □ □ □ □ □ □ □ □ □ □	11
3	□ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □	16
4		
5		

(3) Evaluate $\frac{(3n+2)(n-4)}{2n}, when\ n = 5.$

(4) Write a word problem that could be solved by using the expression 2*x*+60.

(5) Simplify $(4x - 3) + (2x + 6) - (-3x - 4)$.

(6) Solve $10 + 5m = 55$.

Analysis of the Post-Intervention Data

Figure 2 visually represents the learner's sample responses, offering a qualitative glimpse into the learner's approach and understanding of the varied algebraic tasks presented in the test. As shown in Figure 2, the learner responded correctly to all sample questions, but there were mistakes in other questions of the 100-mark test.

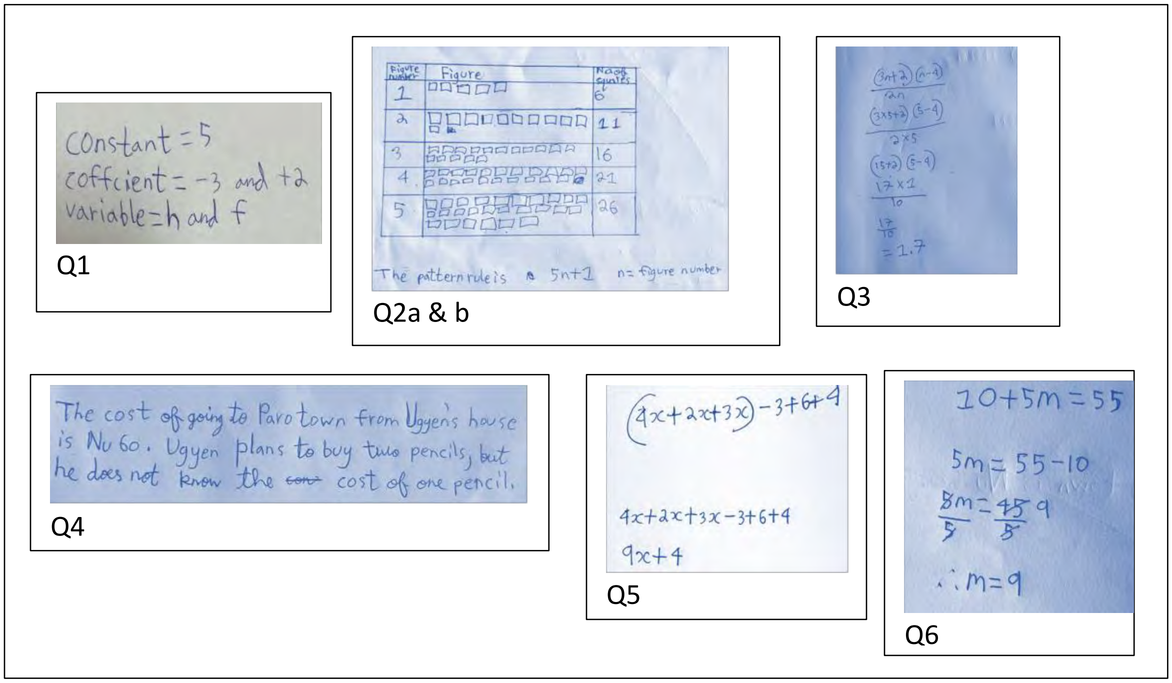

Figure 2: The learner's responses to the sample questions

The detailed examination of individual responses allows for a nuanced understanding of the learner's application of mathematical principles and identifies specific areas where further improvement or intervention may be warranted. The subsequent analysis, as illustrated in Table 5, delves into the learner's performance across distinct areas of difficulty, providing a comprehensive breakdown of mistake counts in classwork, homework, and the test.

Area of Difficulty	Tasks				
	Mistake Count (% of Total)	**Classwork**	**Homework**	**Test**	**Total**
Generalization	3 (20%)	6	3	6	15
Function	2 (12.5%)	7	4	5	16
Variables and constants	0	3	2	1	6
Concepts of division in algebra	2 (11.1%)	12	3	3	18
Principle of addition, subtraction, and multiplication	0	8	4	4	16
Simplifying algebraic fractions	2 (11.1%)	9	5	4	18

Table 5: Area of difficulty and mistake counts

Notably, there are observable reductions in mistake percentages across various algebraic concepts, signifying positive progress from the targeted interventions. These findings affirm the effectiveness of the intervention strategies in addressing the learner's challenges and enhancing their comprehension and proficiency in specific algebraic domains.

RESULTS

Comparing Baseline and Post-Intervention Data

I conducted a comparative analysis between the baseline data and the post-intervention results, scrutiny encapsulated in Table 6. This table is a comprehensive snapshot, capturing the landscape of mistake percentages before and after implementing targeted interventions across various algebraic domains. The comparison unravels a compelling narrative of improvement, signaling a positive trajectory in the learner's grasp of algebraic concepts.

One notable transformation emerges in generalization, where the learner initially grappled with a 47.6% mistake rate. This percentage significantly plummeted to a commendable 20% through the strategic interventions, showcasing a substantial leap in understanding this intricate algebraic facet. Similarly, the domain of variables and constants witnessed a remarkable turnaround. Initially burdened with a daunting 58.3% mistake count, interventions wrought a complete elimination of errors, portraying a resounding success in addressing challenges in this area.

Areas of Difficulty	Mistake Counts before Interventions	Mistake Counts after Interventions
Generalization	47.6%	20%
Function	15.8%	12.5%
Variables and constants	58.3%	0
Concepts of division in algebra	35.7%	11.1%
Principle of addition, subtraction, and multiplication	30.0%	0
Simplifying algebraic fractions	38.1%	11.1%

Table 6: Comparing the percentages of mistake counts before and after interventions

The overarching theme resonating from Table 6 is one of progress and improvement. The reduction in mistake percentages across the spectrum—in functions, concepts of division in algebra, or simplifying algebraic fractions—paints a picture of successful intervention strategies. This nuanced analysis not only underscores the positive impact of interventions but also provides a roadmap for refining future strategies to fortify the learner's grasp of algebraic principles.

Overall, Table 6 suggests that interventions had a positive impact, reducing mistake percentages across various algebraic concepts, with some areas showing significant improvement.

DISCUSSION

The choice of action research as the methodology for this study aligns with the pragmatic nature of addressing real-world challenges in the classroom setting. Action research, as described by McNiff (2013), McNiff and Whitehead (2006), Stringer (2021), Mills (2014), and Kemmis et al. (2014), provided a systematic approach to understanding and improving the teaching and learning process.

The baseline data collection comprehensively examined the Grade 7 math curriculum, utilizing textbooks and learners' notebooks. This approach allowed for a detailed breakdown of the topics covered in the algebra unit. The instructional activities employed for baseline data collection provided insights into the learner's understanding of algebraic concepts. Using classwork, homework, assessments, and detailed feedback mechanisms ensured a holistic view of the learner's progress.

Drawing upon the baseline data, the analysis of the learner's responses to algebraic problems revealed specific areas of difficulty, such as generalization, function, variables and constants, concepts of division in algebra, and principles of addition, subtraction, and multiplication. This detailed breakdown illuminated the nuances of the learner's struggles, guiding the subsequent interventions (Shemshack & Spector, 2020; Zheng et al., 2022).

My interventions targeted each identified difficulty, demonstrating a tailored approach to addressing the learner's challenges. From emphasizing the distributive property to providing real-world applications of algebraic concepts, the interventions aimed to enhance the learner's understanding and application of mathematical principles (Lassiter, 2023; West, 2022). Also, the incorporation of real-world problems and interactive tools like ChatGPT in the intervention process showcased a creative and practical dimension to teaching algebra. These approaches sought to bridge the gap between theoretical knowledge and its real-world applicability, fostering a more engaging and immersive learning experience. The conversations with the learner about his tasks effectively brought forth the deep-seated challenges in the learner, which were not accessible with written responses. Mostly, the written responses showed what the learner knew and did not know. However, understanding the gap between the two is crucial for the learner to further his learning, and it is where the learner's deep-seated challenges are concentrated (Vygotsky, 1978). Conversations helped me recognize the challenges ((Yildirim-Elbasali et al., 2023)

The post-intervention data collection involved thoroughly examining the learner's performance on a follow-up test. Randomly selecting questions from the algebra unit ensured a comprehensive assessment of the learner's progress. Comparing baseline and post-intervention data revealed a positive impact, significantly reducing mistake percentages across various algebraic concepts.

This study opens new paths in math education, suggesting a long-term perspective by tracking learners for insights into sustained intervention impact. Future research may explore adaptive tech, like AI tutoring and optimizing algebra learning. Tailoring interventions to diverse learning profiles is crucial. Collaborative interventions across disciplines, drawing on cognitive science and psychology, offer novel methods for mathematical comprehension. Exploring culturally responsive pedagogy in algebraic instruction is promising. Future directions may involve targeted teacher professional development for a responsive educational environment. Extending interventions to diverse settings informs broader educational practices. Investigating metacognitive dimensions in algebraic learning is a future research frontier, exploring how teaching metacognitive strategies enhances autonomy in problem-solving. Furthermore, future research may use interactive, conversation-based assessments with students as additional data sources to gain greater insight into their challenges.

CONCLUSIONS

In reflection, this study has not only shed light on the intricacies of teaching algebra but has also catalyzed profound changes in my approach to mathematics education. Through the lens of action research, I delved deep into the challenges faced by learners and crafted interventions that went beyond mere numerical improvements, aiming to foster a conceptual understanding of algebraic principles.

One of the most transformative aspects of this study was the realization that traditional teaching methods must be transcended and embrace a more dynamic and engaging approach. By using personalized learning plans, differentiated instructions, scaffolding, and incorporating real-world applications and interactive tools, I made my teaching immersive and relatable for the learner. Rather than focusing solely on numerical results, I prioritized conceptual understanding, encouraging the learner to explore algebra's practical implications in everyday life, which motivated him to study mathematics. ChatGPT made the learner self-regulating as he interacted with it for procedural doubts and validation of his solutions. Furthermore, conversations with the learner about the lessons and assessment tasks were essential to understanding his deep-seated, recurring challenges. The study showed that verbal tasks highlighted what the learner knew and did not know, not the deep-seated difficulties between the two—a space commonly known as the zone of proximal development, a gold mine for teachers. Teaching algebra requires a holistic approach.

Moreover, the collaborative nature of this study, drawing insights from diverse disciplines such as cognitive science and psychology, underscored the importance of interdisciplinary approaches in mathematics education. I integrated principles from these fields into my teaching practice, recognizing the value of holistic and multidisciplinary perspectives in enhancing mathematical comprehension. I was able to comprehend the learners' challenges from different perspectives.

Furthermore, this study highlighted the significance of cultural responsiveness in algebra instruction. Acknowledging and embracing my learner's experiences, I created a supportive learning environment for him. Through culturally relevant pedagogy, I sought to empower my learner to see himself reflected in the mathematics he learned, fostering a more profound sense of belonging and engagement.

In essence, this study provided valuable insights into the teaching and learning of algebra and ignited a passion for transformative pedagogy within me. Based on this insight, I am committed to embracing innovation, collaboration, and cultural responsiveness in my teaching practice to empower the learners to become critical thinkers and lifelong learners in mathematics and beyond.

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