International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Difficulties and Errors of Grade 9 Learners in Solving Quadratic Equation: Input to the Development of Strategic Intervention Material

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Abstract

This study determined the difficulties and errors of Grade 9 learners in solving quadratic equations, it gauged the developmental of strategic intervention material. The researcher used the descriptive-developmental research design and used the 45 Grade 9 learners as respondents. Researcher-made test was used to gather the needed data. Frequency count, percentage, and mean were the statistical tools used. The results of the study showed that Grade 9 learners performed fairly satisfactory in characterizes the roots of quadratic equation using the discriminant, describes the relationship between the coefficients and the roots of a quadratic equation, solves equations transformable to quadratic equations (including rational algebraic equations), solves problems involving quadratic equations and rational algebraic equations, illustrates quadratic inequalities, solves quadratic inequalities, and solves problems involving quadratic inequalities. Additionally, the Grade 9 learners commit more errors in the reading errors and comprehension error. Further, the developed Strategic Intervention Materials on Solving Quadratic Equation for Mathematics 9 is very highly valid. Based from the findings, the following conclusions were drawn: The Grade 9 learners often encounter reading errors when solving quadratic equations, suggesting they have trouble comprehending the problem statements. This issue highlights a fundamental barrier to their mathematical proficiency. Additionally, they face specific challenges in areas such as characterizing the roots of equations, solving equations that can be transformed, and understanding quadratic inequalities, which are critical skills for mastering quadratic equations. To address these difficulties, strategic intervention material has been shown to be highly effective. These materials provide targeted support and practice, significantly improving the learners' abilities to solve quadratic equations and enhancing their overall mathematical competence. It is therefore recommended that teachers use effective instructional strategies, including clear explanations, diverse problem-solving approaches, and real-world examples, to improve learners' understanding and proficiency in quadratic equations. Learners should actively participate in problem-solving activities, seek help when needed, practice regularly, and develop a strong foundation in basic skills. The use of strategic intervention materials for teaching quadratic equations in Grade 9 is advised to enhance learners' problem-solving competencies, and they study's finding should be discussed in school Learning Action Cell (LAC) sessions. Future research should investigate the specific causes of learners' difficulties, explore additional interventions and instructional approaches, and examine the long-term effects on learners' mastery of quadratic equations, as well as the potential benefits of technology integration and gamification in teaching quadratic equations.

Keywords: Difficulties, Errors, Grade 9 learners, Quadratic Equations, Strategic Intervention Material

Introduction

Mathematics is a fundamental subject with applications ranging from simple calculations to complicated problem solving in all fields and industries such as engineering, economics, and science. Mastery of mathematical concepts is necessary not just for academic performance but also for developing critical thinking and logical reasoning skills. In this day of globalization, Mathematics has grown increasingly relevant to all societies as science and technology have advanced, bringing a fresh perspective to people's lives.

Moreover, this importance is visible in the school curriculum and the significance placed on mathematical education. In fact, in this advanced world of education, Mathematics plays an important role where it can be seen through our national education system which makes it a core subject in primary and secondary schools *(Hassan et al., 2016).* Teaching Mathematics is very important for intellectual development. There is no other subject in the curriculum that makes students' brains active like mathematics *(Yadav, 2019).* Therefore, students should master the concepts in this subject in order to be able to apply the concepts in other subjects or daily life.

Meanwhile, Siniguian (2017) posited that one of the interesting concerns about learning Mathematics is that it develops the mind to solve problems needing higher order thinking skills. These problems and puzzles stimulated the curiosity and challenge the ingenuity of learners. Thus, introducing problem solving into the classroom improves students' skills and their ability to think creatively, logically and carefully. Learning mathematics produces both cognitive and affective outcomes. Learning requires both experience and practice. There are many different types of learning, including motor learning, verbal learning, idea learning, discrimination learning, and problem solving. Mathematics learning often falls into three categories: concept, principle, and problem solution. Thus, these higher-order learning processes need cognitive activity and effort from the learner (Abdul & Kurukkan 2015).

Notably, Algebra is a branch of mathematics that involves solving equations and inequalities to find an unknown quantity. It is the most abstract part of mathematics that has correlations with other mathematical topics, such as logarithms, indices, statistics, and calculus (Susac et al., 2014). In its unending pursuit of true academic excellence, the Philippines instituted its educational reform called K to 12 Program upon the enactment of Republic Act (RA) No. 10533 known as Enhanced Basic Education Act 2013. With the intention of uplifting the Philippine educational system, possible indicators of reform's effectiveness would be the country's participation in international educational research studies such as the Trends in International Mathematics and Science Study (TIMSS). This international large-scale assessment is periodically conducted, which could provide feedback on how the Filipino students' performance has improved over time in an international setting from the time its basic education was just 10 years to know that it is K to 12. Yet, there are still many students who face problems with this topic while in high school. Ideally, students are expected to master the concepts in this topic as they do in lower secondary. However, students continuously make errors on this topic, hence failing to have a strong basis for mathematics subjects at tertiary level *(Tendere, 2020).*

Despite the relevance of Mathematics, students are increasingly reluctant to study it. Many of them, although having a strong comprehension of mathematical ideas, struggle with analysis and computation. Errors occur when numbers are misread, carried wrongly, or written clearly in the correct column. They often struggle when fundamental computation and "right answers" are emphasized.

In addition, many errors in Mathematics have different contexts based on the situations in which they occur, which attribute the error to an inability to answer a problem correctly *(Wahab et al., 2014).* Students

find difficulty in learning mathematics for the reason that they do not understand mathematics at a lower level since mathematics is a structured and tiered or hierarchical science. Even with all the efforts, learning mathematics has been difficult all these years for students and it has been a difficult task to deliver for teachers *(Langoban, 2020).* Lack of knowledge plays an important role in misconceptions or misunderstandings. This is supported by Shelly and Kiray (2019) who emphasized that misconceptions have been determined as one of the most important barriers to learning mathematics.

Furthermore, errors made by students in Mathematics refer to a variety of factors. However, many errors made by students are due to not understanding the mathematical concepts contained in a question (Huat, 2015). Accordingly, the result of these errors ultimately leads to the root cause of students 'failure to master this topic. The inability to understand and master the topic of quadratic equations well will influence students' interest and motivation, in turn affecting their use of other components that ultimately affect their performance.

Then, the comprehension error is an error in understanding the need for the question. The students were not able to interpret the questions and the strategies used to manipulate the question were also less precise, in which they failed to solve the following problem (Abdullah et al., 2015). When students are unable to understand the intent of the question, then it is difficult for the student to determine the work process to be performed at the same time, leading to transformation errors (Mahmud et al., 2020). Students make errors in this section when they use the wrong choice of operation, such as when the question requires the performance of a multiplication operation but the student chooses another operation other than multiplication. Transformation error is when students fail to understand the problem to be transformed into the form of mathematical models, and in addition, students cannot determine the right concept or procedure to solve the problem given (Dj Pomalato et al., 2020). In this case, deep understanding of the concept is very important to ensure an appropriate solution to the question.

Next, process skill errors arise when students choose the wrong process that leads to an arithmetic error, procedural error, or incomplete solutions. Pomalato et al (2020) outlined that process skill errors occur when students use rules to solve problems correctly, but make mistakes in computation and computing. Finally, encoding errors occur when the student is able to solve the problem correctly but fails to write the answer correctly or is not accustomed to writing a conclusion after each work on problem solving. An encoding error occurs when the student finishes solving the problem but misinterprets what it meant (Zamzam & Patricia, 2018).

Interestingly, existing literature suggests that further studies can be carried out to determine the difficulties of the students and their errors in solving quadratic equation (Jashi, 2019). From such studies, instructional materials to address these difficulties will be develop (Prado et al., 2015). These research gap motivated the researcher to propose the study.

Many students do not master the factoring skills necessary for quadratic expressions because they usually use a scientific calculator to get the answers to the questions involving factorization of quadratic equations (Huat, 2015). Students fail to carry out the important working steps in order to solve the given equation due to the lack of prior knowledge of quadratic concepts such as directed numbers while the common error done by the students is procedural error when using factorization (Tendere, 2020). Students considered that quadratic equation topic was challenging conceptually, which was proven by Zakaria (2010) that the highest errors made by students were in this topic compared to other mathematics topics, and it was highlighted as the most difficult topic after linear equation word problems (Didis & Erbas, 2015). Mostly, students get confused when quadratic function concepts are presented in different ways that they are not

used to (Mutambara et al., 2020). Most students had not mastered the concept of quadratic expression well and were unable to factorise quadratic expressions perfectly (Rosli & Rasdi, 2015).

A few students thought that the use of two variables "x" and "y" or the use of x twice in an equation resulted in a second-degree equation, while others' lack of understanding of the variable concept and determining the degree of a polynomial resulted in confusion between the quadratic equation concept and the linear equation concept (Gözde & Kabar, 2018). It is believed that there are many other factors that influence students to make errors in solving quadratic equations. Thus, it is important to identify the type of errors made by students in solving quadratic equations at an early stage to avoid making the same errors in other related topics. Such challenges and the importance of quadratic equations in the mathematics field have prompted the researchers to conduct a study with the aim of identifying the types of errors that students commit and, subsequently, exploring the reasons they make such errors in order to overcome the learning issues.

In recent years, there has been increasing concern about the declining performance of students in Mathematics, particularly in the area of quadratic equations. Grade 9 students often encounter difficulties and errors when solving quadratic equations, which can hinder their overall mathematical proficiency and academic success. Thus, Grade 9 learners at Pascual Rivera Pimentel Memorial Academy (PRPMA) encounter a myriad of difficulties and errors when tackling quadratic equations.

Literature Review

This review of literature that the researcher considered strengthened the importance of the present study. It also presents the synthesis of the art to fully understand the research for better comprehension of the study.

Quadratic Equation

A quadratic equation (QE) is an algebraic equation of the second degree with one variable (Harripersaud, 2021; Kabar, 2018). Tendere and Mutambara (2020) note that a QE is an equation written in standard form as $ax2 + bx + c = 0$ with $a \neq 0$, where a, b and c are constants and x is an unknown variable. Kabar (2018) and Hu et al. (2022) posit that learners can solve QEs by using three identified methods: factorization, completing the square (CS) and using the quadratic formula. In South Africa (SA), quadratic equations are introduced to learners in Grade 10, whereas learners start with quadratic expressions in Grade 9.

Errors in Learning Mathematics

Quadratic equations are a branch of mathematics that cut across all spheres and that need to be taught and learned in secondary schools (Cahyani & Rahaju, 2019). Quadratic equation is a compulsory and important topic to be learned in secondary school mathematics as it bridges the gap between functions, polynomial derivatives, and linear equations (Kim How et al., 2022). Kim How et al. (2022) argue that besides connecting with linear equations, QE is a vital branch of mathematics that is applicable in solving problems in engineering and structural design, physics, as well as in real-life modelling and word problems. According to Yeow et al. (2019), QE seems to be an easy topic to learn which involves basic skills that can be applied in sports and architecture. At school level learners are required to solve QE problems in examinations and standardized tests and here it is found that they have serious challenges because they do not master the topic (Thomas & Mahmud, 2021). Although QE is seen as an easy, important and compulsory topic in mathematics, it seems to be more difficult to learn and master compared

to other mathematical topics (Güner, 2017). The challenges learners face in mastering QE lead them to commit errors and these errors need to be known by both teachers and learners.

Studies have demonstrated that most learners struggle with QE (Kim How et al., 2022; Makgakga, 2016; Tendere & Mutambara, 2020). Tendere and Mutambara (2020) point out that most learners appear to experience difficulties in solving QE by both factoring and using quadratic formula methods. The difficulties in solving QE can be caused by teachercentred strategies' emphasis on memorisation of procedures or steps. Kim How et al. (2022) identify challenges in solving QE as a lack of teaching strategies, teaching aids, learners' acceptance of concepts and procedures, and their thinking capabilities. One of the challenges learners faces in solving QE may be due to the high rate of misconceptions that lead to errors.

Kaufmann et al. (2022) view errors as mistakes, slips or misunderstanding of learners when solving mathematical problems. Slips and errors are distinguished by Gardee and Brodie (2021). It is found that errors mainly occur at a deeper conceptual level than slips (Kaufmann et al., 2022). Gardee and Brodie (2015) add that errors are systematic and caused by misconceptions, due to overgeneralization of prior knowledge. Learner errors in the mathematics classroom can be the most natural and inevitable of all the interactions (Rushton, 2018). They (errors) can either be seen as an opportunity to learn or be a problem that can be avoided in mathematics teaching (Ingram et al., 2015). Gardee and Brodie (2021) postulate that learners can learn better if their errors are discussed during the lessons rather than being corrected or avoided in the mathematics classroom. It is important for teachers not to avoid or ignore learner errors to enable them to understand why they committed those errors (Sari & Jailani, 2019). Gardee and Brodie (2015) add that teachers need to identify and evaluate learner errors, interpreting them from the perspective of those learners. Errors can occur in QE when learners use CS to determine the values of unknown variables. Alhassan and Agyei (2018) describe CS as a technique used to solve QE by changing the form to make the left-hand side take the perfect square form. Completing the square method is regarded as difficult and is taught to high-achieving learners who may sometimes abandon it to apply factorization or the quadratic formula (Foster, 2022). Foster (2022) notes that learners prefer to use factorization and quadratic formula than CS when solving QE. Mostly, learners use CS to solve QE that are difficult to factor (Alhassan & Agyei, 2018).

Makgakga (2016) found that Grade 11 learners committed conceptual and procedural errors when solving QE by CS. A study by Tendere and Mutambara (2020) adds that learners exhibit conceptual, procedural and technical errors when solving QE. The scholars argue that a conceptual error can be a misunderstanding of facts and concepts and result in failure to understand the relationship of concepts involved. Procedural errors can occur when learners follow incorrect procedures to solve mathematical problems. Learners need to have good background knowledge of mathematics to apply rules, methods and procedures to solve problems (Makgakga, 2016). Technical errors can be caused by the misapplication of learned procedures which can be the result of carelessness, a slip or silly mistakes (Tendere & Mutambara, 2020). Thomas and Mahmud (2021) add that errors in QE can be caused by a lack of understanding of basic concepts and learners' learning styles.

Some types of errors identified are cognitive, as revealed in Díaz et al.'s (2020) study with high school learners in Les Lagos in Chile. The study found that errors in solving QE problems could be due to predominating procedural difficulties. Agustyaningrum et al. (2018) note that these types of errors are manifested by both theoretical and conceptual content. To address these errors, teachers need to implement an intervention for learners to learn subsequent concepts (Díaz et al., 2020). In addition, Thomas and

Mahmud (2021) used a diagnostic test with 30 Form 4 learners to diagnose errors they commit when solving QE. Their study revealed that learners showed comprehensive and transformation errors; few of them committed encoding errors and no reader error was found.

Errors in QE committed by learners were also investigated by Abubaker (2017). The study revealed that the majority of learners display multiplicative errors, additive errors, incorrect choices of coefficients and wrong treatment of fractions errors when solving QE. Other errors revealed were choosing the coefficient of the second degree of the variable while the coefficient of the first degree is a fraction. However, a general deficit was found in empirical evidence explaining errors using Newman's EAM when solving QE by CS, especially in SA.

Errors exhibited by learners when solving QE can recur and as a result affect learners' learning of subsequent concepts (Sari & Jailani, 2019). Learner errors need to be identified to avoid their recurrence in subsequent concepts and grades. In the context of this study, errors need to be identified and diagnosed and Grade 11 learners need to be aware of the errors to avoid committing them in the final-year examination and subsequently in higher education algebra and related concepts.

Difficulties in Learning Mathematics

According to Sari & Jailani (2019), the difficulties experienced by learners when solving mathematical problems can be caused by learners' weaknesses of lack of knowledge and understanding of the concept. This conceptual misunderstanding causes learners to commit errors when solving QE (Hu et al., 2022). As such, Thomas and Mahmud (2021) note that it is important for teachers to identify the difficulties and errors in advance to address them as early as possible to prevent learners from committing the same or more errors in other related topics. It is also advantageous for learners to be notified of the errors they commit, in order to understand the root cause of those errors. If errors are made clear to learners, they can identify the misconceptions they possess for teachers to know the strategies that can be used to address those misconceptions. Correcting the misconceptions that learners possess may lead to conceptual understanding of QE. This will then eliminate the errors learners commit.

Quadratic functions area subject that students have difficulty in understanding (Akgün, 2011; López, Robles, & Martínez, 2016; Samo, 2009), and they also do not understand their advantage and application in daily life (Akgün, 2011). Quadratic-function problems have been used in many studies on representation and problem-solving (Bannister, 2014; Samo, 2009; Schoenfeld, 1992).

A study carried out by Corran & Walkerdine (1981), revealed that a child' s difficulty to understand questions such as "what does one and two make?", is due to his or her inability to understand the underlying concepts of a language or a 'formal code' which, whilst containing familiar words, their meanings have no real relevance to that ways children use them in their everyday conversations. The second point Huges makes about the formal code of arithmetic, is that statements within the code are 'context-free'. This, he believes, is a second possible source of much of children' s number difficulties. Such statements, according to Huges, make no reference to any particular objects or entities, rather, they can be used to represent or stand for a whole range of objects. As a result, he states, children need to be taught procedures that can help them 'translate' and create 'links' between those novel, formal language of arithmetic and their existing concepts about number.

All the above views have significant implications, if we consider the difficulties which mathematics can pose for learners with Specific Language Impairment (S.L.I.). Grauberg (1985), describe a variety of problems, which children with this type of difficulty experience, such as: reduced memory capacity,

problems with symbol systems, poor comprehension of relational items, uncertainty over words with multiple meanings, and so forth. However, the possibility that numerical thought is essentially non-verbal, suggested by recent experimental findings, might carry serious educational implications. In particular, the findings generated by the studies carried out by Starkey, Spelke and Gelman (1990), which show that a pre-verbal system allows mental representations of numerical information during early infancy, as well as the Wynn' s (1992, 1994) research findings, which show that prelingual infants are capable of perceiving and processing numerical information, given that this information contains reduced verbal demands, have significant implications for teaching mathematics to SLI children (in: Donlan, 1993). More specifically, as Donlan (1993: 102) suggests: "If current theories are correct, the linguistic deficits should not inhibit the formation of fundamental numerical concepts, despite the vulnerability of later acquired mediated systems". In addition, the data gathered by Mann' s (1994) study on the early development of children' s literacy and numeracy skills, show that the emergent literacy of nursery school-age children, interacts with their emergent numeracy in several important ways, but in a very different manner from the one it does with adults. These findings also have important implications for the teaching methods, through which teachers should make children aware of the adult meanings of both reading and number, without imposing these meanings to them. Finally, Huges and his colleagues; findings presented above, also suggest that educators should encourage children to use all their intuitive methods for dealing with symbolic understanding, including finger counting, imaginary objects, as well as writing down idiosyncratic marks on paper (Gomides et al., 2018). All these methods make 'human sense' to children, as these are the basis for subsequent understanding of formal methods and they can also be a very useful tool for the teaching of language-impaired children, who face difficulties with symbolic understanding (Grauberg, 1995).

Strategic Intervention Material

Strategic Intervention Material, according to (Bunagan, 2012) tries to increase and deepen skills, knowledge and understanding from concrete to what is more abstract. It gave students the chance to explore their understanding and add up of those new ideas. Furthermore, an intervention material meant to recall the concepts and skills to assist and help the learners master a competency-based skill which they were not able to develop during classroom discussion. Dy (2011) also defined Strategic Intervention Material (SIM) as a teaching aid introduced into the teaching methods to stimulate the activity of the students and thereby increase their level of understanding.

The Department of Education prescribed the use of Strategic Intervention Material (SIM) to boost students' achievements and reduce least mastered skills in Mathematics subjects. Different studies have shown that the utilization of SIM successfully decreased the least mastered skills in Mathematics subject; thus, poor performance is addressed. Furthermore, SIM is an instructional material prescribed by the Department of Education (DepEd) to boost students' performance in Mathematics subjects. To promote successful learning within the field of Science and Technology subjects in both elementary and secondary among public schools, DepEd provided the teachers with training and workshop on how to prepare this intervention material (DepEd Memorandum No. 117 s. 2005).

To promote and encourage teachers to use and develop intervention materials, SIM making for Math teachers was included by the Department of Education in the annual Mathematics Fair as one of the contests in the school, division, region, and national level competitions. DepEd Memo No. 225, s. 2009 enclosure No. 2 There are criteria and areas to be considered in making Strategic Intervention Materials in Mathematics. The parts of the SIM are title card, guide card, activity card, enrichment card, assessment

card, and reference card. In a Strategic Intervention Material (SIM), alignment of activities with the tasks/objectives is ensured and guaranteed. Activities are kept short and simple for the learners to easily work independently; variety of activities are provided as well to cater to the diverse learners of different intelligences and leaning styles; and a number of activities are also provided so that the learner can have enough practice and time in developing the skill and focus on the least mastered skills. Each intervention material has five parts such as the guide card, activity card, assessment card, enrichment card and reference card. The overview of the lesson, learning competency and subtasks about the entire SIM are found in the guide card; activities to concretize learning competencies and to develop the mastery of the least-mastered skill are provided in the activity card; the assessment card provides exercises that will assess and check the level of mastery of the skill upon the completion of the activities and tasks given; the enrichment card provides activities that reinforce the content of the lesson to make learning meaningful; and the reference card lists resources found in the whole material or card that the learner may refer for further reading and learning.

There are numerous studies conducted on the effectiveness of strategic intervention materials in mastering the competencies set by the Department of Education. Alboruto (2017) in her study on Beating the Numbers through Strategic Intervention Materials (SIMs): Innovative Science Teaching for Large Classes, found out that the use of SIMs significantly contributed to the mastery of science concepts and also to the development of science process skills. She used experimental research design where students were grouped into two – the control and experimental group. Similar to the method being used in this research, the experimental group was given the Strategic Intervention Materials as an aid for learning. She also concluded that the project [strategic intervention material] is effective in improving student performance. Villonez (2018) also concluded that the employment of

SIM was better and effective than the use of traditional method in teaching some topic in science. SIM can also be very acceptable, applicable, and useful to the potential users. Regarding the use of SIM in Mathematics IV for the fourth-year students, Herrera & Soriano (2016) revealed that the students easily mastered the least learned topics. Furthermore, Blalock (2010) described SIM as a competency-based academic support approach which will help students in upper elementary, middle high school, and higher education become independent and successful learner.

In conclusion, the exploration of difficulties and errors encountered by Grade 9 learners in solving quadratic equations provides valuable insights that can inform the development of strategic intervention materials. By identifying common misconceptions, procedural errors, and conceptual challenges, educators can tailor interventions to address specific needs and enhance student understanding. Through targeted instructional approaches, such as differentiated instruction, scaffolding, and problem-based learning, educators can effectively support learners in mastering quadratic equation solving. Additionally, integrating visual representations, interactive activities, and real-world applications into intervention materials can engage students and facilitate deeper comprehension. Moreover, ongoing assessment and feedback mechanisms are essential for monitoring progress and refining intervention strategies. By leveraging these findings to inform the creation of strategic intervention materials, educators can empower Grade 9 learners to overcome obstacles and achieve proficiency in quadratic equation solving, ultimately fostering mathematical success and confidence.

Methods

This study used a descriptive–developmental research design focused on developing a Strategic

Intervention Material in Mathematics 9 to address the difficulties and errors of Grade 9 learners. This approach also referred to the output of the study.

Descriptive research was the method used for this study to collect and analyze data. According to Bayat (2007), descriptive research is collecting data that will explain the situation more completely and will give objectivity to current issues or problems. This method ensures that collecting information for the study's variables are objective. It can give a compound and clearer picture of a group.

Developmental research, those studies that involve the production of knowledge with the ultimate aim of improving the processes of instructional design, development, and evaluation. Such research is based on either situation-specific problem solving or generalized inquiry procedures. Developmental research, as opposed to simple instructional development, has been defined as "the systematic study of designing, developing and evaluating instructional programs, processes and products that must meet the criteria of internal consistency and effectiveness" (Seels & Richey, 1994, p. 127).

The quantitative approach allows for the collection of numerical data that can be analyzed using statistical techniques to identify patterns, trends, and relationships.

This study used a quantitative research approach and focused on Grade 9 students from Pascual Rivera Pimentel Memorial Academy. Factors such as accessibility, school administration participation, and resource availability may impact the choice of this specific school as the location of the study.

By conducting the study within a specific locale, such as PRPMA, the researcher can closely examine the difficulties and errors encountered by Grade 9 students in solving quadratic equations within that specific educational setting. This localized approach can provide valuable insights that are relevant to the specific context and inform targeted interventions or instructional strategies tailored to the needs of the students in that particular school or academy.

The research instrument for data collection will be a teacher-made test. The test will be designed to assess the difficulties and errors encountered by Grade 9 learners in solving quadratic equations. It will consist of a set of carefully constructed quadratic equations that cover various aspects of quadratic equation solving, such as factoring, completing the square, and using the quadratic formula. The test will be reviewed by subject matter experts to ensure its validity and reliability.

RESULTS AND DISCUSSIONS

The following are the findings of this study:

This chapter presents the discussion of findings based on the sequence of research problem in Chapter 1, including the conclusions and recommendations of the researcher based on the findings of the study.

Errors do learners commit in solving quadratic equations.

Table 1. Errors learners commit in solving quadratic equations

Types of Errors	Frequency	Percentage
Reading Error	17	42.5%
Comprehension Error	8	20%
Transformation Error	7	17.5%
Process Skill	6	15%
Encoding Error	2	5%
Total	40	100%

Table 1 presents the errors of Grade 9 learners in solving quadratic equations using the Newman Error Analysis. Reading errors with 17 learners garnered a percentage of 42.5%, comprehension errors with 8

learners garnered a percentage of 20%, transformation errors with 7 learners garnered a percentage of 17.5%, process skill errors with 6 learners garnered a percentage of 15%, and encoding errors with 2 learners garnered a percentage of 5%. The data suggests that reading errors is the most frequent, followed by comprehension errors and transformation errors. Process skill errors and encoding errors are less common but still present in the data set. These findings could inform strategies for improving reading comprehension and critical thinking skills, as well as techniques for minimizing errors during information processing and memory encoding.

This is in consonance with the findings of Prakitipong & Nakamura (2006) and Gordo-Imson (n.d.) to determine learners' causes of errors in attempting mathematical tasks. It is deemed appropriate to find out whether the roots of learners' difficulties in this study stem from language or content-knowledge causes. According to Suyitmo & Suyitmo (2015), students often make mistakes in understanding the problem, and they do not know what is known about the problem or what was asked in the problem.

Difficulties do learners commit in solving quadratic equations.

Table 2. Difficulties learners commit in solving quadratic equations

Learning Competency	No. of Items	Mean	DER
Illustrates quadratic equation. *(M9AL-la-1)*	10	6.04	VS
Solves quadratic equations by: (a) extracting square roots; (b) factoring; (c) completing the square; and (d) using the quadratic formula. *(M9AL-lb1)*			
Characterizes the roots of quadratic equation using the discriminant. *(M9AL-lc-1)*	12	2.62	FS
Describes the relationship between the coefficients and the roots of a quadratic equation. *(M9AL-lc-2)*			
Solves equations transformable to quadratic equations (including rational algebraic equations). *(M9AL-ld-1)*	18	3.64	FS
Solves problems involving quadratic equations and rational algebraic equations. *(M9AL-le-1)*			
Illustrates quadratic inequalities. *(M9AL-lf-1)*	10	2.58	FS
Solves quadratic inequalities. *(M9AL-lg-1)*			
Solves problems involving quadratic inequalities. *(M9AL-lg-2)*			
Total	50		

Legend: DER-Descriptive Equivalent Rating VS-Very Satisfactory FS-Fairly Satisfactory

Table 2 presents the difficulties learners commit in solving quadratic equations along with their learning competencies. Illustrates quadratic equation (M9AL-la-1) and solves quadratic equations by: (a) extracting square roots; (b) factoring; (c) completing the square; and (d) using the quadratic formula (M9AL-lb1) with 10 total items have mean score of 6.04 which indicates very satisfactory; Characterizes the roots of quadratic equation using the discriminant (M9AL-lc-1) and describes the relationship between the coefficients and the roots of a quadratic equation (M9AL-lc-2) with 12 total items have mean score of 2.62 which indicates fairly satisfactory; Solves equations transformable to quadratic equations (including rational algebraic equations) (M9AL-ld-1) and solves problems involving quadratic equations and rational algebraic equations (M9AL-le-1) with 18 total items have mean score of 3.64 which indicates a fairly

satisfactory, while Illustrates quadratic inequalities (M9AL-lf-1); Solves quadratic inequalities (M9AL-lg-1), and Solves problems involving quadratic inequalities (M9AL-lg-2) with 10 total items have mean score of 2.58 which indicates a fairly satisfactory. The data indicates that the difficulties the learners commit in solving quadratic equations have a descriptive equivalent rating of fairly satisfactory.

The result corroborates the study of Limjap (2014), which revealed that learners have difficulties in translating worded problems into mathematical symbols classified into six categories: misinterpretation of the problem, lack of comprehension of the problem posed, incorrect use of operation, carelessness, interchanging values, and unfamiliar words. Likewise, it jibes with the findings of Jucutan (2015) and Aliena (2016) that learners lack mastery in the fundamental operations or basic skills in problem-solving.

Level of Validity of the SIM on Solving Quadratic Equations.

Table 3. Level of Validity of the SIM on Solving Quadratic Equations.

Category	Mean	DER
A. Content		
1. The content is complete and up-to-date.	5.00	VHV
2. The content is accurate.	5.00	VHV
3. The content is appropriate for Grade 9 learners.	4.80	VHV
4. The content includes adequate development of concepts and is appropriate to Grade 9 learners.	5.00	VHV
5. The content is relevant to Grade 9 learners.	4.60	VHV
Sub-mean	4.88	VHV
B. Organization		
1. The organization and selection of topics follow the difficulties encountered by the Grade 9 learners.	4.80	VHV
2. Organization is flexible permitting variation in sequence.	4.60	VHV
3. Material within the topic is well-organized.	4.60	VHV
4. Approach is suitable to the wide range of learners.	4.60	VHV
5. The organization is represented at a variety of cognitive levels.	4.80	VHV
Sub-mean	4.68	VHV
C. Mechanics		
1. Topics, titles and subheadings are concrete, meaningful and interesting.	4.8	VHV
2. Writing style of the text is appealing to the learners.	5.00	VHV
3. Questions are well-constructed and useful for review.	4.60	VHV
4. Activities are suited to the learners' interest.	4.80	VHV
5. Suggested activities are thought-provoking and challenging.	4.80	VHV
6. Text provides positive and motivating models for both sexes as well as for the other racial, ethnic and socio-economic groups.	4.80	VHV
Sub-mean	4.80	VHV
D. Appropriateness		

1. Reading level of the text is fitting to the grade level of the learners.	5.00	VHV
2. The text vocabulary is suitable.	4.80	VHV
3. New concepts explicitly linked to the learner's prior knowledge and experience.	5.00	VHV
4. Text introduces abstract concepts by accompanying them with numerous concrete examples.	5.00	VHV
5. Text avoids irrelevant details.	5.00	VHV
Sub-mean	4.96	VHV
OVERALL MEAN	4.83	VHV

*Legend: **DER**-Descriptive Equivalent Rating VHV-Very Highly Valid*

Table 3 presents the level of validity of the Strategic Intervention Material based on the assessment of five Mathematics experts. Based on the result, the Strategic Intervention Material for Grade 9 learners is very highly valid by the overall mean of 4.83.

Along content, it garnered the sub mean of 4.88 described as very highly valid. The items with a mean value of 5.00 are the content is complete and up to date, the content is accurate, and the content includes adequate development of concepts and is appropriate to Grade 9 learners while the content is appropriate for grade 9 learners with a mean value of 4.80 and the content is relevant to grade 9 learners with a mean of 4.60 described as highly valid.

Along organization with a sub mean of 4.68 described as very highly valid, the item that garnered the highest mean of 4.80 is the "the organization and selection of topics follow the difficulties encountered by the Grade 9 learners and the organization is represented at a variety of cognitive levels", while "organization is flexible permitting variation in sequence", "material within the topic is well-organized", and "approach is suitable to the wide range of learners" have mean of 4.60.

Meanwhile, the category mechanics garnered a sub mean of 4.80 described as very highly valid. The item in this category garnered a mean value of 5.00 is "writing style of the text is appealing to the learners", while the items that garnered a mean value of 4.80 are "activities are suited to the learners' interest", suggested activities are thought-provoking and challenging", and "text provides positive and motivating models for sexes as well as for the other racial, ethnic and socio-economic groups" and the item garnered a mean value of 4.60 is "questions are well-constructed and useful for review".

Lastly, the category appropriateness garnered a mean value of 4.96 described as very highly valid. The items in this category garnered a mean value of 5.00 are "reading level of the text is fitting to the grade level of the learners", "new concepts explicitly linked to the learner's prior knowledge and experiences", "text introduces abstract concepts by accompanying them with numerous concrete examples", and "text avoids irrelevant details" while the item that garnered a mean value of 4.80 is "the text vocabulary is suitable".

The average mean of 4.83 described as very highly valid implies that the Strategic Intervention Material is appropriate for Grade 9 learners to use as learning material to enhance the errors and difficulties in solving quadratic equations.

This corroborates with the claim of Salviejo, Aranes and Espinosa (2014) that uses of strategic intervention material as another instructional material meant to re-teach the least mastered competencies in the classroom has positive impact in the teaching-learning process. It also jibes with the findings of Bautista

(2016) and Quiton (2015) that use of Strategic Intervention Material has positive effect in learner's mathematics performance.

Conclusions

The following conclusions were drawn from the findings presented:

1. The errors of Grade 9 learners in solving quadratic equations using the Newman Error Analysis, reveals that reading errors emerged as the most prevalent issue, indicating difficulties in comprehending problem statements.
2. Grade 9 learners face difficulties in solving quadratic equations, particularly in areas such as characterizing roots, solving transformable equations, and understanding quadratic inequalities, indicating the need for targeted interventions to improve their proficiency.
3. Strategic Intervention Material (SIM) is very useful in enhancing the quadratic equation competencies of the Grade 9 learners.
4. The Strategic Intervention Material in solving quadratic equation for Mathematics 9 is effective for use among Grade 9 learners.

Recommendations

The following recommendations are hereby offered by the researchers based from the findings and conclusions.

1. Teachers should employ effective instructional strategies, such as providing clear explanations, offering diverse problem-solving approaches, and incorporating real-world examples to enhance learner's understanding and proficiency.
2. Learners should actively engage in problem-solving activities and seek clarification or additional support from their teachers when facing difficulties. Learners should also practice regularly, utilize different problem-solving techniques, and develop a strong foundation in fundamental operations and basic skills.
3. The Strategic Intervention Material on Solving Quadratic Equation for Mathematics 9 should be utilized by teachers to enhance the problem competencies of learners. It is further recommended that the result and output of the study be presented and discussed during LAC sessions to be conducted in the school.
4. Future researchers may conduct deeper into the specific causes of the identified difficulties, explore additional interventions or instructional approaches to address them, and analyze long-term effects on learners' mastery of quadratic equations. Additionally, investigating the impact of technology integration or gamification in quadratic equation learning could provide insights for innovative teaching methods.

Acknowledgments

I extend my heartfelt gratitude and appreciation to the following individuals and entities who have significantly contributed to the completion of this research study:

Dr. Ederlina M. Sumail, for your guidance and support throughout this endeavor. Your wisdom has been invaluable, and I thank you for your encouragement and belief in the importance of this research.

Dr. Agnes D. Torres, your mentorship and insightful advice have shaped the direction of this study profoundly.

The esteemed panel members and critics whose expertise and constructive feedback enriched the quality of this work. The gracious respondents whose involvement made this study possible—your contributions are genuinely appreciated.

I also express my deep appreciation to Dr. Ernest D. Padiwan for his invaluable assistance and mentorship, which played a crucial role in leading me to publish in the International Journal of Frontiers in Medical Research (IJFMR).

The ISPSC-Tagudin Campus is responsible for providing resources and an environment conducive to research.

Lastly, I extend my gratitude to the Heavenly Father for the strength and inspiration granted throughout this journey.

REFERENCES

1. Abdullah, A. H., Abidin, N. L. Z., & Ali, M. (2015). Analysis of Students' errors in Solving Higher Order Thinking Skills (HOTS) Problems for the Topic of Fraction. Asian Social Science, 11(21), 133–142. https://doi.org/10.5539/ass.v11n21p133Aksoy, N. (2008). Multigrade schooling in Turkey: An Overview. *International*
2. Abubaker, I. (2017). Error analysis in solving simultaneous and quadratic equations in some selected senior secondary schools in Sabon Gari Zaria in Kaduna State. Journal of Science, Technology & Education, 5(1), 198–209.
3. Agustyaningrum, N., Abadi, A., & Mahmudi, A. (2018). An analysis of students' errors in solving abstract algebra tasks. Journal of Physics: Conference Series. 1097. 012118. https://doi.org/10.1088/1742-6596/1097/1/012118
4. Ah Huat, T. (2015). Kaedah Penfaktoran Ajaib Ungkapan Kuadratik (P.A.U.K). Jurnal Penyelidikan Kent, 14.
5. Akgün, L. (2011). Experiences of undergraduate students with literal symbols. Scientific Research and Essays, 6(7), 1489-1497. https://doi.org/10.5897/SRE10.075.
6. Alboruto, V. (2017). Beating the numbers through strategic intervention materials (SIMs): Innovative science teaching for large classes [Conference proceedings]. AIP Conference Proceedings. https://doi.org/10.1063/1.4983982
7. Alhassan, M.N., & Agyei, D.D. (2018). Colleges of Education mathematics tutors' problems and challenges associated with the teaching of quadratics using completing a square approach. International Journal of Science and Research, 9(2), 1842–1853. Retrieved from https://www.ijsr.net/archive/v9i2/SR20212181653.pdf
8. Alhassan, M.N., & Agyei, D.D. (2020). Examining colleges of education mathematics tutors' conceptions in teaching completing the square in Ghana. International Journal of Scientific and Research Publications, 10(3), 253–261. https://doi.org/10.29322/ijsrp.10.03.2020.p9927
9. Arief Aulia Rahman. (2018). "Analysis of Student's Answer Error in Learning Mathematics Using Newman Analysis." IOSR Journal of Research & Method in Education (IOSR-JRME) , vol. 8, no. 6, 2018, pp. 77-82.
10. Blalock, G. C. (2010). Strategic intervention material model 6. Transition project: Education Transition Consulting UC. https://www.ku.crl.org.pdf
11. Biggs, J. B. (2003). *Teaching for Quality Learning at University*, 2nd ed. Buckingham: Society for Research into Higher Education and Open University Press.

12. Blömeke, S., Houang, R., Hsieh, F. J., & Wang, T. Y. (2017). *Effects of job motives, teacher knowledge and school context on beginning teachers' commitment to stay in the profession: A longitudinal study in Germany, Taiwan and the United States*. In G. K. LeTendre& M. Akiba (Eds.), International handbook of teacher quality and policy (pp. 374–387). London: Routledge.
13. Braithwaite, P., Moore, S. Saba, D., Dieringer, L., De Bruycker, M., Smith, P. Mysak, J. & Harding, L. (2017). Teachers of Tomorrow: Why Become a Teacher? Retrieved on September 2,2021 from https://www.teachersoftomorrow.org/blog/insights/should-i-be-a-teacher
14. Bunagan, F. (2012). Science intervention material. Retrieved from http://www.slideshare.net/felixbunagan/strategic-intervention-aterial
15. Burke, J. (2021). *15 Ways to Vary Instruction*. Retrieved on September 2, 2021fromhttps://www.scholastic.com/teachers/articles/teaching-content/fifteenways-vary-instruction/
16. Cahyani, L., & Rahaju, E.B. (2019). Students' reflective abstraction of middle school in reconstructing quadratic equation concepts based on high mathematical ability. Journal of Physics: Conference Series, 1417(1), 012044. https://doi.org/10.1088/1742-6596/1417/1/012044
17. Chusnul, C., Mardiyana, & Retno, D.S. (2017). Errors analysis of problem solving using the Newman stage after applying cooperative learning of TTW type. In AIP conference proceedings, 1913, Malang, 2–3 August. https://doi.org/10.1063/1.5016662
18. Clarkson, P.C. (1991). Language comprehension errors: A further investigation. Mathematics Education Research Journal, 3(2), 25–33. https://doi.org/10.1007/BF03217225
19. Cohen, D., Crabtee, B. (2016). *Qualitative Research Guidelines Project*. Retrieved from http://www.qualres.org/HomeCrit-3814.html
20. Corran & Walkerdine (1981). International Journal of Education and Research. Vol. 8 No. 2 February 2020, https://www.ijern.com/journal/2020/February-2020/11.pdf
21. Curriculum and Assessment Policy Statement (CAPS). (2011). CAPS for further education and training phase. Department of Education.
22. Daniels, H. and Anghilieri, J. (1995). Secondary mathematics and special educational needs. Cassell.
23. DepEd Memorandum No. 117 s. 2005 https://nlpdl.nlp.gov.ph/DE02/ memoranda/DE00M2005/DE02M020050117.pdf
24. DepEd Memo No. 225, s. 2009 enclosure No. 2
25. Díaz, V., Aravena, M., & Flores, G. (2020). Solving problem types contextualized to the quadratic function and error analysis: A case study. EURASIA Journal of Mathematics, Science and Technology Education, 16(11), 1–16. Retrieved from https://files.eric.ed.gov/fulltext/EJ1285007.pdf
26. Donlan, C. (1993). Basic numeracy in children with specific language impairment, Child Language Teaching and Therapy, Vol.9, No.1., pp. 95-105.
27. Dowker, A. (2017). Interventions for primary school children with difficulties in mathematics. In Advances in child development and behavior (Vol. 53, pp. 255-287). JAI.
28. Dy, L. (2011). Teaching mathematics through Strategic Intervention Materials (SIM). http://www.mathlanding.org/collections/pd_collection/strategies teaching-students-struggling-mathematics
29. Finzer, W., & Bennett, D. (1995). Technology tips: From drawing to construction with The Geometer's Sketchpad. Mathematics Teacher, 88(5), 428–431. https://doi.org/10.5951/MT.88.5.0428
30. Fitriani, H.N., Turmudi, T., & Prabawanto, S. (2018). Analysis of students' error in mathematical

problem solving based on Newman's Error Analysis. In International conference on mathematics and science education of Universitas Pendidikan Indonesia (Vol. 3, pp. 791–796). Retrieved from https://www.semanticscholar.org/paper/Analysis-of-students-error-in mathematical-problem-Fitriani-Turmudi /60fe875b2fd606db83043b33e846a778ce2381a8

31. Foster, C. (2022). Starting with completing the square. Mathematics in Schools. Retrieved from www.m-a.org.uk
32. Gardee, A., & Brodie, K. (2015). A teacher's engagement with learner errors in her Grade 9 mathematics classroom. Pythagoras, 36(2), 293. https://doi.org/10.4102/pythagoras.v36i2.293
33. Gardee, A., & Brodie, K. (2021). Relationships between teachers' interactions with learner errors and learners' mathematical identities. International Journal of Science and Mathematics Education, 20(1), 193–214. https://doi.org/10.1007/s10763-020-10142-1
34. Gomides, M. R. D. A., Martins, G. A., Alves, I. S., Júlio-Costa, A., Jaeger, A., & Haase, V. G. (2018). Heterogeneity of math difficulties and its implications for interventions in multiplication skills. Dementia & neuropsychologia, 12(3), 256-263.
35. Grauberg, E. (1995). Language and early mathematics – ten years on, Child Language Teaching and Therapy, Vol.11, No.1., pp.34-39.
36. Güner, P. (2017). High school students' achievement of solving equations. Bartin University Journal of Faculty of Education, 6(2), 447–467. https://doi.org/10.14686/buefad.277494
37. Harripersaud, A. (2021). The quadratic equations concept. American Journal of Mathematics and Statistics, 11(3), 67–71.
38. Herrera, F. T., & Soriano, A. T. (2016). The efficacy of strategic intervention materials with physics and mathematics remediation to the achievement of selected fourth year students of Las Nieves, Agusan del Norte. Annals of studies in science and humanities, 2(2), 22-33.
39. Hu, Q., Son, J.W., & Hodge, L. (2022). Algebra teachers' interpretation and responses to student errors in solving quadratic equations. International Journal of Science and Mathematics Education, 20, 637–657. https://doi.org/10.1007/s10763-021-10166-1
40. Huges, M. (1991). Chapter 11: What is difficult about learning arithmetic?, in: Light, P., Sheldon, S. and Woodhead, M. (Eds). Child Development in Social Context (2): Learning to think (1991), Open University.
41. Ingram, J., Pitt, A., & Baldry, F. (2015). Handling errors as they arise in whole-class interactions. Research in Mathematics Education, 17(3),183-197. https://doi.org/10.1080/14794802.2015.1098562
42. Institute of Education-UCC. (2018). Chief examiners report for Algebra and Geometry. Institute of Education.
43. Kabar, M.G.D. (2018). Secondary school students' conception of quadratic equations with one unknown. International Journal for Mathematics Teaching and Learning, 1, 112–129. https://doi.org/10.4256/ijmtl.v19i1.94
44. Kaufmann, O.T., Larsson, M., & Ryve, A. (2022). Teachers' error-handling practices within and across lesson phases in the mathematics classroom. International Journal of Science and Mathematics Education, 21, 1–26. https://doi.org/10.1007/ s10763-022-10294-2
45. Kenys, F.Z., & Firda, F.A. (2018). Error analysis of Newman to solve Geometry problem in terms of Cognitive Style. Advances in Social Science, Education and Humanities Research, 160, 24–27. https://doi.org/10.2991/incomed-17.2018.5

46. Kim How, R.P.T., Zulnaidi, H., & Abdul Rahim, S.S. (2022). HOTS in quadratic equations: Teaching style preferences and challenges faced by Malaysian teachers. European Journal of Science and Mathematics Education, 10(1), 15–13. https://doi. org/10.30935/scimath/11382
47. Laridon, P., Barnes, H., Kitto, A., Myburg, M., Rhodes-Houghton, R., Sasman, M., Scheiber, J., & Sigabi, M. (2010). Classroom mathematics. Grade 11 Learner's book. Heinemann Publishers (Pty) Ltd.
48. López, J., Robles, I., & Martínez, P.R. (2016). Students' understanding of quadratic equations. International Journal of Mathematical Education in Science and Technology, 47(4), 552–572. https://doi.org/10.1080/0020739X.2015.1119895.
49. Mahmud, M.S., Zainal, M.S., Rosli, R., & Maat, S.M. (2020). Dyscalculia: What we must know about students' learning disability in mathematics? Universal Journal of Educational Research, 8(12B), 8214–8222. https://doi.org/10.13189/UJER.2020.082625
50. Makgakga, S. (2016). Errors and misconceptions in solving quadratic equations by completing a square. Association for Mathematics Education of South Africa.
51. Mann S (1994) Mediated reality. TR 260, M.I.T. Media Lab Perceptual Computing Section, Cambridge, Ma, 1994
52. Piaget, J. & Inhelder, B. (1996). The psychology of the child. Routledge and Kegan Paul, London.
53. Pretorius, J., Pretorius, J., Potgieter, R., & Ladewig, W. (2006). Oxford mathematics plus. Grade 11 learner's book. Oxford University Press Southern Africa.
54. Retrieved from https://acesse.dev/9dp5D Newman, M.A. (1977). An analysis of 6th grade pupils' errors on written mathematical tasks. In M.A. Dlm. Clements & J. Foyster (Eds.), Research in mathematical education in Australia (pp. 239–258). Hutchinson, Inc.
55. Rushton, S.J. (2018). Teaching and learning mathematics through error analysis. Fields Mathematics Education Journal, 3(1), 1–12 https://doi.org/10.1186/s40928-018-0009-y
56. Samo, M.A. (2009). Students' perceptions about the symbols, letters and signs in Algebra and how do these affect their learning of Algebra: A case research in a government girls secondary school Karachi. International Journal for Mathematics Teaching and Learning, 35.
57. Santoso, D.A., Farid, A., & Ulum, B. (2017). Error analysis of students working about word problem of linear program with NEA procedure, Journal of Physics: Conference Series, 855(1). https://doi.org/10.1088/1742-6596/855/1/012043
58. Sari, I.F.D.P., & Jailani, J. (2019). Error analysis for grade IX students in completing the materials of quadratic equations. Annals of Mathematics Models, 1(2), 64–80.
59. Singh, P., Rahman, A.A., & Hoon, T.S. (2010). The newman procedure for analyzing primary four pupils errors on written mathematical tasks: A Malaysian perspective. University Technology MARA.
60. Starkey, P., Spelke & Gelman, R. (1990). The development of addition and subtraction abilities prior to formal schooling in arithmetic. In T.P. Carpenter, J.M. Moser, & T.A. Romberg (Eds.), Addition and subtraction: A cognitive perspective. Hi&dale, NJ: Eribaum.
61. Sumule, U., Amin, S.M., & Fuad, Y. (2018). Analysis of junior high school students' errors in solving HOTS geometry problems based on Newman's error analysis. Journal of Physics: Conference Series, 11(12), 947012053. https://doi.org/10.1088/1742-6596/1321/3/032131
62. Swaraj, A. (2019). Exploratory research: Purpose and process. Parisheelan, XV(2),666–670.
63. Tendere, J., & Mutambara, L.H.N. (2020). An analysis of errors and misconceptions in the study of quadratic equations. European Journal of Mathematics and Science Education, 1(2), 81–90.

https://doi.org/10.12973/ejmse.1.2.81
64. Thomas, D.S., & Mahmud, M.S. (2021). Analysis of students' error in solving quadratic equations using Newman's procedure. International Journal of Academic Research in Business and Social Sciences, 11(12), 222–237. https://doi.org/10.6007/IJARBSS/V11-I12/11760
65. Wynn, K. (1992). Addition and subtraction by human infants. Nature, 358,749-750.
66. Villonez, G. (2018). Use of SIM (Strategic Intervention Material) as strategy and the academic achievement of grade 7 students on selected topic in earth science. Pupil: International Journal of Teaching, Education and Learning, 2, 78-88. https://doi.org/10.20319/pijtel.2018.23.7888
67. Yeow, P.C., Thavamani, R., Kamalah, R., Wong, J.W., & Santhanasamy, V.D. (2019). Buku Teks Matematik Tingkatan Empat. Penerbit Pustaka Yakin.
68. Yin, R. (1994). Case study research: Design and methods (2nd ed.). Sage.