RELEVANCE OF MATHEMATICS VOCABULARY TO STUDENTS' PERFORMANCE IN MATHEMATICS PROBLEM-SOLVING

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Abstract

The recognition of Mathematics as a core subject taught at the nursery, primary, and post-primary school levels highlights its relevance in problem-solving. Mathematics provides students with the necessary tools and skills to analyze and solve complex problems in various fields and follows a systematic approach to provide logical and precise solutions. However, a lack of comprehension of the vocabulary and concepts in Mathematics can hinder problem-solving abilities. Educators need to ensure that students have a solid foundation in mathematical vocabulary and can apply it effectively in real-world situations. This concern motivated this study, which discussed the relevance of Mathematics vocabulary to students' performance in Mathematics problem-solving. The study was based on a review of relevant literature, from which several key findings emerged. The study revealed that the relevance of Mathematics vocabulary in problem-solving includes enhancing logical reasoning skills, promoting critical thinking abilities, facilitating the identification of patterns and relationships, aiding in the organization and structuring of problem-solving steps, and enabling effective communication and collaboration among problem solvers, among others. Based on the outcome of the study, it was concluded that by understanding and using the appropriate mathematical language and terminology, students are better equipped to comprehend and solve complex mathematical problems, which will not just improve their ability to solve problems but also foster a more profound comprehension of mathematical principles, leading to improved overall performance in the subject. It was suggested among others, that by practicing mathematical vocabulary in real-world contexts, students can see the relevance and application of mathematical concepts in their everyday lives.

Keywords: *Relevance, Mathematics, Vocabulary, Student Performance, Problem-Solving*

Introduction

Mathematics holds a crucial position as a fundamental discipline that greatly influences the growth of individuals and societies. The subject is something that can be practically applied to every facet of problem-solving in everyday life, ranging from basic computations to intricate scientific investigations. In the present era, where technological progress is swiftly unfolding, the significance of Mathematics cannot be exaggerated. Mathematics is an essential component in shaping the future of technology, spanning from computer programming to artificial intelligence. Thus, Mathematics serves as a universal tool for understanding and manipulating the world around us. It provides a framework for problem-solving and critical thinking, enabling us to analyze data, make predictions, and develop innovative solutions. In describing Mathematics, George and Charles-Ogan (2019) defined it as a language of quantities, regardless of whether the quantities are numbers, shape dimensions, variables, or a combination of these. Nonetheless, according to Usiskin (2015), the field of

Mathematics encompasses both written and verbal language, making it imperative to possess a thorough grasp of this language to comprehend mathematical concepts.

This specialized language allows mathematicians to communicate complex ideas and concepts precisely and efficiently. For example, terms like "derivative," "integral," and "matrix" have specific meanings in Mathematics that may differ from their everyday usage. Understanding and using these mathematical vocabularies is crucial for effective communication within the field and for accurately conveying mathematical ideas to others. However, what is relevant is being familiar with the nuances and subtleties of these specialized terms and being able to apply them appropriately in mathematical contexts. This requires a deep understanding of the underlying principles and theories behind these concepts, as well as the ability to manipulate and solve problems using them. According to Bulos (2021), there is a noteworthy impact of mathematical vocabulary on students' mathematical development, comprehension, and proficiency.

Mathematics vocabulary has been defined by Bulos (2021) as the specific language and terminology used in mathematical discourse. It encompasses an extensive variety of terms, from basic mathematical operations to advanced concepts and techniques. Flanagan (2009) highlighted that the language of Mathematics can be strange to those who are not familiar with it. Developing a strong Mathematics vocabulary is crucial for students as it allows them to effectively communicate their ideas, thoughts, and solutions in a precise and concise manner. Therefore, developing a strong Mathematics vocabulary not only enhances students' ability to communicate within the subject but also helps bridge the gap between mathematical language and everyday language. This can help students better understand and interpret mathematical problems, enabling them to establish relationships between various mathematical concepts and apply them in various problem-solving scenarios.

Nonyelum et al. (2022) define performance as a person's observable or measurable behaviour in a specific situation. This implies that performance can be assessed and evaluated based on observed or measured actions and outcomes. However, performance, in this context, can be defined as a student's ability to successfully solve mathematical problems and demonstrate an understanding of mathematical concepts. It involves not only achieving high grades in exams but also being able to think critically, reason logically, and effectively communicate mathematical ideas to solve mathematical problems. Assessing and evaluating a student's performance in Mathematics can provide valuable insights into their strengths, weaknesses, and areas for improvement, ultimately guiding instructional strategies and interventions to support their learning journey.

According to Kaitera and Harmoninen (2022), Mathematics problem-solving is defined as the process of using mathematical knowledge and skills to analyze and solve real-world problems. It involves identifying the problem, devising a strategy, applying relevant mathematical concepts and techniques, and evaluating the solution. Problem-solving in Mathematics requires critical thinking, logical reasoning, and creativity. According to George and Enefu (2019), the significance of problem-solving in school Mathematics remains paramount and has not diminished in its role within the teaching and learning journey. This is because it is the most convenient method of studying Mathematics, particularly when students are engaged in the process of resolving mathematical challenges. According to Margaret (2015), she mentioned that problem-solving abilities in Mathematics enable students to utilize principles in practical situations. As a result, it will be unrealistic to assume that students can engage in Mathematics problem-solving successfully without a solid understanding of the language and symbols used in the discipline, a situation that is likely to have a significant impact on their performance. Based on this background, this study theoretically investigates the relevance of Mathematics vocabulary to students' performance in Mathematics problem-solving.

The Meaning of Mathematics Vocabulary

Without the use of vocabulary, teaching and learning would be very difficult. Aside from being the set of words and phrases that a person knows and understands, it tends to define the scope of one's knowledge and communication abilities in a particular context. As such, vocabulary is essential in both written and spoken language, as it allows individuals to express their thoughts, ideas, and emotions effectively. According to Hornby (2010), vocabulary encompasses all the words present in a specific language. This implies that vocabulary encompasses not only the words themselves, but also their meanings, pronunciation, and usage. In other words, it includes the entire linguistic repertoire that a person possesses in a given language.

Mathematics as a subject has a unique vocabulary that is essential for understanding and solving mathematical problems. This specialized vocabulary includes terms such as "addition," "subtraction," "equation," and

"theorem." Without a strong grasp of these mathematical terms, it can be challenging to comprehend and communicate mathematical concepts effectively. According to Salinas (2016), Mathematics vocabulary is the collection of words, terms, and symbols necessary for understanding Mathematics and navigating Mathematics processes and evaluations. However, Salinas (2016) pointed out that the commonly used mathematical terminology includes expressions like smaller than, a unit of measurement for liquid volume, and belonging to a particular quantity. The inclusion of symbols like ≠, √, and π sets mathematical vocabulary apart from the vocabulary used in other disciplines, making it a unique symbolic category. The amalgamation of these categories of words intensifies the linguistic difficulties for every student. Some Mathematics vocabulary is listed in Tables 1 and 2.

Table 1: Basic Operations of Mathematics Vocabulary

Addition Words	**Subtraction Words**
Add	Change
All together or altogether	Decreased by
And	Difference
Both	Fewer or fewer than
Combined	How many are left (or have left)
How many in all?	How many did not have
How much in all?	How many (or much) more
Increased by	How much longer (shorter, taller, heavier, etc.)
Plus	Less or less than
Sum	Lost
Together	Minus
Total	Reduce
	Remain
	Subtract
	Take away
Multiplication Words	**Division Words**
By (dimension)	As much
Double	Cut up
Each group	Each group has
Every	Equal sharing
Factor of	Half (or other fractions)
Increased by	Split
Multiplied by	Parts
of	Per
Product	Per cent
Times	Quotient of
Triple	Ratio of
Twice	Separated
	Share something equally

Source: Powell et al. (2020).

The basic operations of the Mathematics vocabulary, such as addition, subtraction, multiplication, and division, are fundamental concepts in Mathematics. These operations are used to perform calculations and solve mathematical problems. For instance, addition words such as "sum," "total," and "plus" indicate the combining of two or more quantities to get a larger quantity. Subtraction words like "difference," "minus," and "subtract" represent the process of taking away one quantity from another. Multiplication words such as "product," "times," and "multiply" denote the repeated addition of a quantity to itself or the combining of equal groups. Lastly, division words like "quotient," "divide," and "split" refer to the process of dividing a quantity into equal parts or determining how many times one number can be divided by another. These different mathematical operations provide a framework for solving a wide range of problems and understanding the relationships between numbers. By recognizing and understanding these keywords, individuals can effectively approach and solve various mathematical equations and also apply them to real-world scenarios.

Table 2: Basic Mathematics Vocabulary and Meaning

Vocabulary	Meaning
Integers	The collection of elements includes zero, the positive integers (1, 2, 3, ...), and the negations of the positive integers (-1, -2, -3, …)
Factor	An expression that is multiplied with one or more additional expressions to obtain a product.
Expression	A mathematical expression is a combination of numbers, operators (such as addition, subtraction, multiplication, and division), and at least one variable (such as x or y) that is used to represent various operations.
Equation	A mathematical assertion that asserts the equivalence of two expressions; any numerical sentence featuring an equals sign (=).
Exponent	A numerical value that signifies the process of iteratively multiplying.
Coefficient	The numerical factor multiplies a variable in an algebraic expression.
Perimeter	The total length of all the sides of a polygon
Area	The measurement of the area of a flat region or surface in square units.
Volume	A quantification of space, or capacity
Angle	The combination of two rays that share a common endpoint, known as the vertex
Radius	The measurement from the midpoint to a location on a circular shape; the line segment connecting the midpoint to a position on a circular shape.
Diameter	The line segment that passes through the center of a circle and connects two points on its circumference is known as the diameter. The line segment encompasses the midpoint and has its endpoints situated on the outer edge of the circular shape.
Circumference	The distance around a circle.
Parallel	Two lines are considered parallel if they exist within the same plane and do not intersect with each other.
Perpendicular	Two lines are considered perpendicular when the angle formed between them measures exactly 90 degrees.
Intercept	The location of a point where a line, curve, or surface intersects a coordinate axis.

Source: Princehorn and Deleeuw (2005).

Consequent to the foregoing, Mathematics poses a significant challenge for students who are not familiar with its specialized vocabulary. The use of symbols and unique terminology can create barriers to understanding and hinder comprehension, especially for those who have not been exposed to mathematical concepts before. With the uniqueness of the Mathematics vocabulary, it may be erroneous to assume that students would grasp the meaning of mathematical terms in the same way they understand everyday language. This can lead to confusion and frustration among students, as they struggle to make connections between mathematical concepts and their real-world applications. Therefore, ample opportunities should be provided for students to engage with and practice mathematical language to foster a deeper understanding of the subject.

Mathematics Problem-solving

In Mathematics parlance, a problem is a situation or scenario that requires the application of mathematical concepts, principles, and techniques to find a solution or answer. While Wohuruche and Wonu (2021) defined solving a problem as getting a clue and finding a way out of the difficulty, a way around the obstacle, and achieving one's aim for the given problem, Thus, with regards to Mathematics, Otikor and Iheanacho (2021) defined it as a mathematical mental activity with obstacles and impediments that poses challenges in arriving at the desired solution, thereby improving students' critical thinking and mental development. Thus, one can deduce that mathematical problem-solving involves the application of logical reasoning, problem-solving strategies, and mathematical concepts to analyze and solve complex mathematical problems. This process requires students to think critically, evaluate different approaches, and make connections between various mathematical concepts to arrive at the correct solution.

Consequently, since problem-solving in Mathematics involves applying logical reasoning and critical thinking skills to analyze and solve mathematical problems, it is a valuable skill that can be applied to real-world situations outside of the classroom. By developing problem-solving skills in Mathematics, students are better equipped to tackle challenges in other areas of their lives, especially in their everyday problem-solving tasks. This is because the logical and critical thinking skills developed in Mathematics can be transferred to various situations. It is important to note that since the process of problem-solving takes a step-by-step approach, it motivates students to dissect intricate problems into smaller, more feasible assignments. This aids individuals in

cultivating a methodical and structured method for resolving issues, which can prove advantageous in any scenario necessitating the use of critical thinking and problem-solving abilities. Additionally, the process of problem-solving in Mathematics often involves trial and error, teaching students the importance of perseverance and resilience when faced with difficult challenges.

For example, to solve a Mathematics problem like $2x^2 + 3x - 2 = 0$, students must use logical reasoning and critical thinking to determine the values of x that satisfy the equation. This problem-solving process trains their minds to think analytically and approach problems systematically, which can be applied to various real-world scenarios.

Thus, the solution to the problem $2x^2 + 3x - 2 = 0$ can be derived using the following steps:

First: Identify the coefficients of the equation equivalent to ax^2 bx + c = 0, which in this case are 2, 3, and -2.

Second: Use the quadratic formula $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$ to find the values of x that satisfy the equation.

Third: Substitute the values of a, b, and c into the quadratic formula.

Fourth: Simplify the equation and solve for x to find the solutions to the problem.

$$x = \frac{-(3) \pm \sqrt{3^2 - 4(2)(-2)}}{2(2)}$$

$$x = \frac{-3 \pm \sqrt{9 + 16}}{4}$$

$$x = \frac{-3 \pm \sqrt{25}}{4}$$

$$x = \frac{-3 \pm 5}{4}$$

$$x = \frac{-3+5}{4} \text{ or } x = \frac{-3-5}{4}$$

$$x = \frac{2}{4} \text{ or } x = \frac{-8}{4}$$

$$x = \frac{1}{2} \text{ or } x = -2$$

To Check

For $x = \frac{1}{2}$

$2x^2 + 3x - 2 = 0$

We have:

$$2\left(\frac{1}{2}\right)^2 + 3\left(\frac{1}{2}\right) - 2 = 0$$

For $x = -2$

$2x^2 + 3x - 2 = 0$

We have:

$$2(-2)^2 + 3(-2) - 2 = 0$$

Relevance of Mathematics Vocabulary in Problem-Solving

The use of precise mathematical language allows for clear communication and understanding between problem solvers. Additionally, a strong grasp of mathematical vocabulary enables individuals to accurately identify and define key concepts, making it easier to devise effective problem-solving strategies.

According to Powell et al. (2020), the relevance of Mathematics vocabulary in problem-solving includes: (1) enhancing logical reasoning skills, (2) promoting critical thinking abilities; (3) facilitating the identification of patterns and relationships; (4) aiding in the organization and structuring of problem-solving steps; (5) enabling effective communication and collaboration among problem solvers, (6) supporting the development of problem-solving heuristics; (7) fostering a deeper understanding of mathematical concepts and principles; and (8) promoting precision and accuracy in problem-solving processes.

i. **Enhancing logical reasoning skills**: Mathematical vocabulary helps individuals develop their logical reasoning skills by providing a framework for organizing and analyzing information. By understanding and using mathematical terms, problem solvers can identify patterns, make connections, and draw logical conclusions to solve complex problems. This ability to think critically and logically is essential in problem-solving across various disciplines and real-life situations. Furthermore, mathematical vocabulary promotes precision and accuracy in problem-solving as it allows individuals to express their ideas and solutions with clarity and specificity.
ii. **Promoting critical thinking abilities**: Mathematical vocabulary helps students develop their critical thinking abilities. By using precise mathematical language, students can analyze problems more effectively and make logical connections between different concepts. This promotes a deeper understanding of the problem-solving process and encourages students to think critically about possible solutions. Furthermore, mathematical vocabulary allows students to communicate their thoughts and reasoning clearly, facilitating collaborative problem-solving discussions and enhancing overall problem-solving skills.
iii. **Facilitating the identification of patterns and relationships:** By using mathematical vocabulary, students can identify patterns and relationships within mathematical problems. This skill is crucial in problem-solving as it allows for the recognition of recurring patterns or similarities in different scenarios, leading to more efficient problem-solving strategies. Additionally, the ability to identify relationships between different mathematical concepts enables individuals to apply their knowledge across various problem-solving situations, enhancing their overall problem-solving abilities.
iv. **Aiding in the organization and structuring of problem-solving steps**: Students who are proficient in Mathematics vocabulary are better able to organize and structure their problem-solving steps. This skill helps them break down complex problems into manageable parts, allowing for a more systematic approach to finding solutions. Furthermore, a solid understanding of mathematical vocabulary allows students to effectively communicate their problem-solving process and reasoning to others, fostering collaboration and the exchange of ideas.
v. **Enabling effective communication and collaboration among problem solvers**: Students who can use mathematical language effectively can more easily communicate their ideas and collaborate with others in problem-solving scenarios. This allows for a more efficient and productive problem-solving process, as different perspectives and approaches can be shared and combined. Furthermore, the use of mathematical vocabulary helps to eliminate ambiguity and misunderstandings, ensuring that everyone is on the same page when working towards a solution.
vi. **Supporting the development of problem-solving heuristics**: The mathematical vocabulary provides problem solvers with a common language to discuss and analyze different strategies and approaches. This shared understanding allows for collaboration and the exchange of ideas, ultimately leading to more efficient problem-solving processes. Furthermore, the use of precise mathematical language helps problem solvers articulate their thoughts and reasoning, making it easier to identify any errors or misconceptions that may arise during the problem-solving process.
vii. **Fostering a deeper understanding of mathematical concepts and principles**: Developing a more profound comprehension of mathematical concepts and principles is essential for effective problem-solving. It allows individuals to recognize patterns, make connections, and apply mathematical reasoning to solve complex problems. This deeper understanding also helps problem solvers identify relevant information, analyze data, and make informed decisions in the problem-solving process.
viii. **Promoting precision and accuracy in problem-solving processes**: By using the appropriate mathematical vocabulary, problem solvers can avoid ambiguity and ensure that their solutions are

precise and accurate. This helps in minimizing errors and increasing the reliability of the problem-solving process. Moreover, consistent use of mathematical language promotes a standardized approach to problem-solving, allowing for easier collaboration and comparison of solutions among different individuals or groups.

Challenges of Understanding Mathematics Vocabulary in Problem-solving

Mathematics, though considered simple by some, can be quite challenging when it comes to understanding its vocabulary in problem-solving. This is because mathematical language often uses specialized terms and symbols that may not be familiar to everyone. Additionally, the way mathematical problems are presented and solved requires a specific set of skills and logical thinking, which can be difficult for some individuals to grasp. Therefore, according to Xu et al. (2022), the following challenges can make understanding mathematical vocabulary difficult for many students: (1) language barriers; (2) lack of prior knowledge; (3) abstract concepts; (4) complex notation; and (5) limited practice opportunities.

Language barriers: Language barriers can hinder students' understanding of mathematical vocabulary, especially for those who are non-native speakers or have limited proficiency in the language of instruction. This can lead to confusion and misinterpretation of mathematical terms and concepts. Additionally, language barriers can make it challenging for students to effectively communicate their mathematical ideas and reasoning, further hindering their learning experience.

Lack of prior knowledge: Without a solid foundation of basic Mathematics vocabulary, students may struggle to understand more complex mathematical concepts. This can hinder their ability to solve problems and effectively apply mathematical principles in real-world situations. Additionally, a lack of prior knowledge can make it difficult for students to make connections between different mathematical concepts, further impeding their overall understanding of the subject.

Abstract concepts: Abstract concepts in Mathematics refer to ideas that are not easily visualized or directly experienced in the physical world. Without a solid foundation in basic mathematical concepts, students may find it difficult to comprehend mathematical vocabulary and apply abstract concepts to problem-solving. For example, understanding the concept of a variable in algebra requires a strong grasp of basic arithmetic operations and number sense. Without this foundation, students may struggle to manipulate variables and solve equations, hindering their ability to progress in more advanced mathematical topics. Additionally, abstract concepts often build upon each other, so a lack of understanding in one area can have a cascading effect on a student's overall mathematical comprehension.

Complex notation: Complex notation in Mathematics can be challenging to understand due to its use of symbols, Greek letters, and mathematical expressions. It requires a deep understanding of the underlying concepts and the ability to interpret and manipulate these notations accurately. Additionally, complex notation often involves abstract concepts that may not have direct real-world representations, making it difficult for learners to grasp their meaning and application. Thus, when students have a grasp of mathematical vocabulary and a solid foundation in algebraic and geometric principles, they are better equipped to tackle complex notation with confidence and accuracy.

Strategies for Improving Students' Mathematics Vocabulary

Interestingly, just like every other language and its vocabulary, Mathematics vocabulary can also be improved for better expression. However, strategies to improve students' Mathematics vocabulary may differ from those used in language learning and can be effective for students at the primary and post-primary levels.

The strategies for improving students' Mathematics vocabulary as reported by Giles (2012), Bulos (2021), and Xu et al. (2022) include: 1. Incorporating vocabulary-building activities into regular math lessons, such as word walls, flashcards, and vocabulary games 2. Providing explicit instruction on mathematical terms and their meanings, ensuring students understand the precise definitions and usage, 3. Encouraging students to use mathematical vocabulary in their explanations and discussions fosters a deeper understanding of mathematical concepts. 4. Integrating real-world examples and contexts to help students make connections between math vocabulary and its practical applications

i. Incorporating vocabulary-building activities into regular math lessons, such as word walls, flashcards, and vocabulary games: This entails engaging students in activities that focus on learning and practicing math-specific terms and concepts. These activities can help students develop a deeper understanding of mathematical language and enhance their ability to communicate their thoughts and ideas effectively on the subject.
ii. Providing explicit instruction on mathematical terms and their meanings, ensuring students understand the precise definitions and usage: This entails teaching students the specific terms used in Mathematics and their meanings, as well as how to use them correctly in mathematical contexts. This can be done through activities such as vocabulary quizzes, word games, and real-life problem-solving scenarios that require students to apply their understanding of mathematical terms.
iii. Encouraging students to use math vocabulary in their explanations and discussions fosters a deeper understanding of mathematical concepts: This entails encouraging students to actively participate in class discussions and problem-solving activities, where they can utilize mathematical terms and phrases to articulate their thoughts and reasoning.
iv. Integrating real-world examples and contexts to help students make connections between math vocabulary and its practical applications: This approach allows students to see the relevance of mathematical vocabulary in their everyday lives, making it more meaningful and memorable. Additionally, incorporating hands-on activities and interactive games can further engage students and enhance their understanding and retention of math vocabulary.

Conclusion

Based on the discussion of the study, it is concluded that the relevance of Mathematics vocabulary to students' performance in Mathematics problem-solving is significant. By understanding and using the appropriate mathematical language and terminology, students are better equipped to comprehend and solve complex mathematical problems. This not only enhances their problem-solving skills but also promotes a deeper understanding of mathematical concepts, leading to improved overall performance in the subject.
For students who struggle with learning Mathematics, developing a strong vocabulary can be particularly beneficial. By familiarizing themselves with key terms and concepts, these students can gain confidence and overcome their difficulties in understanding mathematical problems. Additionally, having a solid grasp of mathematical vocabulary can also facilitate effective communication and collaboration with peers and teachers, further enhancing their learning experience in Mathematics.

Suggestions

1. By practicing mathematical vocabulary in real-world contexts, students can see the relevance and application of mathematical concepts in their everyday lives.
2. Incorporating technology and interactive tools into the teaching of mathematical vocabulary can provide students with a more engaging and interactive learning experience.
3. There should be a wide range of mathematical vocabulary incorporated into the curriculum to ensure that students are exposed to a variety of concepts and can develop a strong foundation in mathematical language.

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