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Promoting Students' Numeracy Skills Using Contextualized Word Problems

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A B S T R A C T

Students today often struggle with word problems in Mathematics, leading to challenges in their numeracy skills. This led to this study that attempted to determine the effects of using contextualized word problems, presented in a descriptive and depicted form, on the numeracy skills of the Grade 8 students in a public high school in San Pablo City. A total of sixty students participated, of whom thirty students were exposed to traditional word problems (descriptive form), and the other thirty were exposed to image-rich problems (depicted form). Statistical analysis showed a significant difference in numeracy skills based on the mean pre-test and post-test scores of the two groups. In terms of the post-test scores of the two groups, there is no significant difference in the descriptive and depicted forms in the number and number sense, and measurement skills. While there is a significant difference between the post-test scores in descriptive and depicted form in the Geometry, and Patterns and Algebra categories with the word-word outperforming the image-rich in both categories. Thus, both the descriptive and depicted forms improved the numeracy skills of the students. This suggested that the descriptive and depicted forms significantly enhance the students' mathematical performance across all numeracy skills in number and number sense, measurement, geometry, and patterns and algebra.

Keywords: contextualized word problems, image-rich problems, numeracy skills

1. Introduction

Numeracy skills aid students in the interpretation and solving of real-life problems so as to make informed decisions in a private, academic, and professional setup. As the curriculum is altered with a focus on critical thinking and problem-solving skills for the 21st-century learner, numeracy skills eventually integrate into mathematical proficiency (Smith et al., 2021). However, the majority of students are not applying math concepts to real-life situations which presents an evident failure of the traditional mathematics curriculum (Ng & Tan, 2022). The strategies of teaching in a new manner, like contextualized word problems, should be implemented to integrate mathematical learning into the lived experience and practical reality of students.

Numeracy is a wide range of mathematical skills, which include basic arithmetic operations, problem-solving, and reasoning in everyday contexts such as financial management, data interpretation, and decision-making. It involves a good number sense, computation, and solving problems in many settings. The authors, Goos, Dole, and Geiger (2016), referred to numeracy more than arithmetic. In other words, it is the application of mathematical knowledge to solving real-life problems. Recent research by Ofsted (2018) highlighted that mathematics education in early years could predict future academic outcomes; however, such findings are not sufficient to prevent a failure of students in numeracy.

Contextualized word problems place mathematics in meaningful real-world contexts; this makes it relevant and even interesting for learners. This also not only boosts problem-solving ability but will strengthen critical thinking since abstract ideas of mathematics get connected to a practical application process (Martínez et al., 2023). Based on research findings, contextualized learning enhances conceptual understanding, motivates students, and increases their long-term retention of mathematical ideas (Garcia & Lopez, 2020; Chen & Huang, 2023). Contextualization further recognizes cultural and experiential differences, bringing the classroom to life outside the school (Aguirre et al., 2021).

The Philippines understood how important contextualized learning was to be shown through the K to 12 Curriculum, which aims at churning out globally competitive learners through localization and contextualization in instruction. The Department of Education has underscored the role of mathematics education in developing learners' critical thinking, problem-solving abilities, and decision-making skills, Department of Education (DepEd, 2013). This follows a spiral curriculum where the progression of concepts increases in complexity: number sense, measurement, algebra, geometry, probability, and statistics, within grade levels. This approach, as implemented in the National Learning Recovery Program under DepEd Order No. 13, s. 2022, would improve the performance of students' literacy and numeracy during this nationwide post-pandemic learning recovery.

San Vicente Integrated High School, a school in the barangay San Vicente of San Pablo City, reflects a national challenge to most schools: the low numerical competence of students. Results for the Mathematics Key Stage 3 Assessment conducted during the S.Y. 2022-2023 were quite disturbing since most students had a very low standard of numeracy. At Grade 8, 40.77% were classified as non-numerates while only 6.06% showed full proficiency. This calls for targeted interventions to strengthen the mathematical skills of students, especially through contextualized learning strategies that link mathematics to real-world applications.

Table 1: Pre-test Result of Numeracy in Mathematics – Key Stage 3

Key Stage 3	**Enrolment**	**Numeracy Level**					
		Numerates	**%**	**Instructional**	**%**	**Non-Numerates**	**%**
Grade 7	313	14	4.47	151	48.24	128	40.89
Grade 8	363	22	6.06	192	52.89	148	40.77
Grade 9	304	55	18.09	139	45.72	110	36.18
Grade 10	311	65	20.90	142	45.66	109	35.05
TOTAL	1291	156	12.08	624	48.33	495	38.34

Theoretical perspectives support the effectiveness of contextualized problem-solving in mathematics instruction. Problem-solving has emerged as the core theme in mathematics education, to foster mathematical literacy (Schoenfeld, 2014; Geiger, Goos, & Forgasz, 2015). Verschaffel, Depaepe, and Van Dooren defined word problems as verbal descriptions of problem situations that require mathematical operations to find a solution. Still, many traditional word problems have been met with difficulties by students due to a disconnection between abstract concepts and real-life problems. According to research, the real-life problems of everyday life make math problems more relevant and interesting for students' learning (Reyes et al., 2019; Diago & Dillo, 2022).

Critical thinking is typically characterized as the ability to think clearly and rationally while engaged in thoughtful and autonomous thought. It is the activity of actively conceptualizing, analyzing, synthesizing, and evaluating knowledge obtained through observation, experience, or conversation in order to guide belief and behavior (Paul & Elder, 2016). Critical thinking includes such intellectual abilities as solving problems, making decisions, and following a logical process of reasoning. The K to 12 Basic Education Curriculum includes five core areas based on the framework developed by MATHTED & SEI (2010): Numbers and Number Sense, Measurement, Geometry, Patterns and Algebra, and Probability and Statistics. Knowing and understanding; estimating, computing, and solving; visualizing and modeling; representing and communicating; conjecturing, reasoning, proving, and decision-making; and applying and connecting are the specific abilities and processes to be developed.

Given such challenges and the benefits that contextualized word problems can offer in enhancing numeracy skills, this research asks to what extent this approach might advance mathematical proficiency by students in San Vicente Integrated High School. This research finds its value in a contribution toward evidence-based instructional practices that promote student engagement, conceptual understanding, and long-term retention of mathematical knowledge.

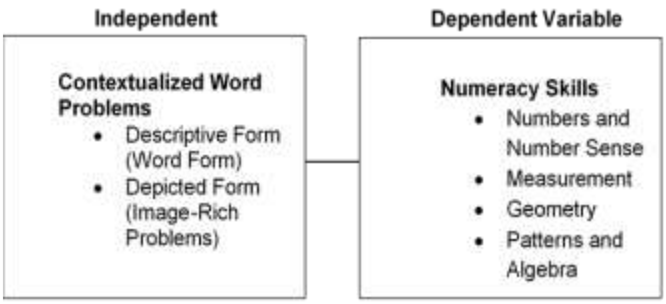

Figure 1: Research Framework

2. Research Problem

Specifically, this study aimed to answer the following questions:

1. How do the respondents perceive the test characteristics in the numeracy skills in terms of:

1.1. number and number sense;

1.2. measurement;

1.3. geometry; and

1.4. patterns and algebra?

2. What are the scores of the students in the numeracy test in Mathematics in terms of before and after using contextualized word problems:

2.1. number and number sense;

2.2. measurement;

2.3. geometry; and

2.4. patterns and algebra?

3. Is there a significant difference between the pre-test and post-test scores of the students in the numeracy test using the contextualized word problems in Mathematics?

4. Is there a significant difference between the post-test scores of the students in the two different forms of contextualized word problems?

3. Materials and Methods

An experimental research design was used to determine the effect of the contextualized word problems on the numeracy skills of the Grade 8 students in Mathematics. According to Key, as cited by Hester (2018), experimental research is the researcher's endeavor to exert control over all aspects that may impact the outcome of the investigation. It entails a framework that allows the researcher to put his theory to the test by making significant decisions about the relationships between free and ward factors. It alludes to the theoretical structure inside which the study is oriented. Pre-test – post-test designs are frequently used to compare and/or quantify changes caused by experimental treatments.

Employing a stratified random sampling strategy, this research embraced a critical approach by implementing the above-mentioned sampling technique to the sixty (60) – Grade 8 students from two sections of San Vicente Integrated High School. Stratified random sampling is a statistical method in which a random sample is chosen from each stratum after the population is divided into subgroups or strata according to specific characteristics. This technique is frequently employed to guarantee that the sample is representative of the population to improve the accuracy of the estimations. Stratifying the population can result in more accurate results since it reduces variability within each stratum (Makwana et al., 2023).

Different instruments were utilized to gather the data needed to answer the research problems. These include four sets of lesson exemplars that were utilized in four weeks. These exemplars introduced the students to contextualized word problems that show depicted and descriptive word problems to determine their effects on the students' numeracy skills. A survey questionnaire was prepared to determine the perception of the students in the test characteristics of the contextualized word problems in Mathematics. The questionnaire includes numeracy skills in Mathematics such as number and number sense, measurement, geometry, and patterns and algebra. To assess the students' numeracy skills, pretest and posttest in the form of learning activity sheets were prepared. The numeracy skills were included in the pretest and posttest where five questions were given for each skill.

The initial phase involved gathering the necessary information for the study by surveying the chosen Grade 8 students about their perception of the test characteristics of contextualized word problems. After conducting the survey, the researcher proceeded to give the pretest on those selected Grade 8 students. Two groups were used. The first group was exposed to the descriptive form (word form) of contextualized word problems, and the other group was exposed to the depicted (image-rich problems). On the last day of the fourth week, a posttest was administered.

The statistical treatment of the data in this study was concentrated on the refined analysis of the perception of the test characteristics on the contextualized word problems, and the analysis of the pretest and posttest, utilizing descriptive statistics. Inferential statistics effect size calculations to discern the effect of contextualized word problems to the numeracy skills of Grade 8 students.

Frequency count was used to determine the scores of the respondents subjected to the assessment tools. A paired samples t-test was employed to determine if there was a significant difference between the pre-test and post-test scores of the two groups as exposed to word problems. An Independent t-test was used to find out if there is a significant difference between the post-test scores of the two groups of students as exposed to contextualized word problems as to their numeracy skills in terms of number and numbers sense, measurement, geometry, patterns and algebra. This analytical approach allowed for a precise assessment of whether the changes are statistically meaningful, providing robust evidence of the effect of contextualized word problems on numeracy skills.

Throughout the statistical treatment, validity and reliability checks were conducted to ensure the integrity and credibility of the analyses. These checks contributed to the overall trustworthiness of the findings, affirming the soundness of the statistical procedures explicitly employed for the perception of the test characteristics and the pretest and posttest assessment.

4. Result and Discussions

The table below shows that the students viewed very favorably the test features regarding numbers and number sense with a general mean score of 3.22, which falls in the range of "Agree." This shows that the contextual word problem allowed for creating an environment that is supportive of motivating, boosting confidence in, and understanding mathematical concepts by the students. It had been noticed that relating numerical concepts to everyday situations increased understanding and appreciation. These results show the importance of applying contextualized word problems in raising numeracy proficiency among students.

According to the evaluation made by Siegler and Braithwaite (2019) on instruction strategies for teaching number sense, students' problem-solving skills and numerical skills are considerably bettered under contextual learning conditions. Boaler (2021) pointed out that real-world contexts make mathematics more accessible and meaningful and agrees with the increased motivation and understanding of the students.

Table 2: Perceived Test Characteristics in terms of Number and Number Sense

Statements		Mean	SD	VI
1.	The utilization of real-life situations in contextualization improves my comprehension of mathematical concepts.	3.30	0.53	Agree
2.	I understand numerical concepts better when I do word issues incorporating numbers than when I solve solitary arithmetic questions.	2.97	0.52	Agree
3.	My confidence in doing mathematical operations increases when I understand how numbers relate to real-life situations.	3.47	0.62	Agree
4.	Using number sense in real-world contexts (such as budgeting and measuring) helps me better understand mathematical ideas.	3.35	0.52	Agree
5.	My motivation to go deeper into mathematical concepts comes from incorporating real-life settings into number-related tasks.	3.00	0.69	Agree
Overall		3.22	0.28	Agree

Legend: *3.50-4.00 (Strongly Agree); 2.50-3.49 (Agree); 1.50-2.49 (Disagree); 1.00-1.49 (Strongly Disagree).*

Table 3 below indicates that, in general, students had a positive perception of the test characteristics related to numeracy skills in measurement. All of the responses, with an overall mean of 3.30 and a standard deviation of 0.34, are classified as "Agree". In particular, students discover that learning measuring principles through real-world examples improves their comprehension (mean = 3.38, SD = 0.61). Similarly, with the greatest mean of 3.40 and the lowest standard deviation of 0.56, using measuring techniques in real-life situations is viewed as beneficial. Real-world scenarios inspire motivation (mean = 3.25, SD = 0.60), and practical applications boost confidence in addressing measuring issues (mean = 3.27, SD = 0.69). Positive feedback on improving comprehension using contextual examples, such as recipes, was also obtained (mean = 3.18, SD = 0.47).

As per the findings of Chavarría-Arroyo and Albanese (2023), it has been shown that students engage with concepts related to measurement more comprehensively when they are presented in situations that are based on real-life scenarios. Specifically, the effects of contextualized mathematics tasks are investigated in this study. Not only does this approach improve comprehension, but it also increases self-assurance and the desire to apply mathematical concepts to situations that are based in the real world.

The table below shows the perceived test characteristics in terms of Geometry. It can be gleaned the last indicator that states the respondents' motivation to learn geometry concepts increases when they investigate real-life applications—carries the greatest mean.

Table 3: Perceived Test Characteristics in terms of Measurement

Statements		Mean	SD	VI
1.	Learning measurement principles (length, weight, and volume) is made easier by using examples from everyday life.	3.38	0.61	Agree
2.	Using measurement techniques in real-world situations improves my understanding of measurement principles.	3.40	0.56	Agree
3.	My confidence in handling measurement challenges increases when I understand the practical applications of measures.	3.27	0.69	Agree
4.	Better comprehension is aided by placing measurement concepts in context (e.g., measuring components for a recipe).	3.18	0.47	Agree
5.	My motivation to acquire measurement abilities is sparked by investigating practical applications of measurement.	3.25	0.60	Agree
Overall		3.30	0.34	Agree

Legend: *3.50-4.00 (Strongly Agree); 2.50-3.49* (Agree); *1.50-2.49 (Disagree); 1.00-1.49 (Strongly Disagree).*

This means that even as geometric concepts are being acquired, there tends to be a massive pull towards practical applications. Although not as crucial as other criteria, the least mean score of 3.12, SD = 0.49 which falls still within the "Agree" category, shows that knowledge of geometric principles will be bettered if it is applied to real-world contexts. With a mean score of 3.21, SD = 0.31, overall, people seem to agree in common sense that the application and use of examples and common applications bring better understanding, motivation, and interest in geometry. Incorporation of real-life situations in the geometry activities interests and understanding students with geometric ideas. This is because, according to Vos (2018), students tend to understand the content better and make it relevant if they can see the application in real use in places such as architecture or everyday commodities. Additionally, consistent with Chavarría-Arroyo & Albanese (2022) revealed that teachers who applied contextualized problems within mathematics witnessed an uptrend in students' motivation and scholastic performance. The presentation of mathematical problems in real life makes the curriculum more interesting and meaningful so that students relate to it much better.

Table 4: Perceived Test Characteristics in terms of Geometry

Statements		Mean	SD	VI
1.	**My understanding is improved when real-world examples are incorporated into geometry problems.**	**3.15**	**0.61**	**Agree**
2.	**My comprehension of geometric principles is improved when geometry concepts are applied to practical situations.**	**3.12**	**0.49**	**Agree**
3.	**My ability to solve geometric problems is improved when geometry is contextualized, such as by using shapes in real-world scenarios.**	**3.30**	**0.53**	**Agree**
4.	**Geometry is made more interesting for me when it is understood in relation to common objects or structures.**	**3.18**	**0.65**	**Agree**
5.	**My motivation to learn geometric concepts is increased when I investigate real-life applications of geometry.**	**3.28**	**0.58**	**Agree**
Overall		**3.21**	**0.31**	**Agree**

Legend: *3.50-4.00 (Strongly Agree); 2.50-3.49 (Agree); 1.50-2.49 (Disagree); 1.00-1.49 (Strongly Disagree).*

The respondents generally perceive the test characteristics in the numeracy skills of Patterns and Algebra positively, as indicated by the overall mean score of 3.32 (SD = 0.37), which falls within the "Agree" range. The statement, "I learn math better when I use its concepts to tackle real-world situations," has the highest mean score 3.42 (SD = 0.65), indicating that comprehension is especially aided by practical applications of math. The statement, "My understanding of algebraic patterns is improved when I can identify patterns in everyday situations," is associated with the lowest mean score 3.22 (SD = 0.69), which suggests that everyday pattern recognition has a relatively smaller but still significant influence on algebra understanding. Mean scores for all statements indicate agreement, with the emphasis being on how contextualizing mathematical problems, seeing real-world patterns, and comprehending practical applications all contribute to improving algebra comprehension and confidence. The standard deviations, which range from 0.54 to 0.69, indicate that there is moderate variability in respondents' levels of agreement. Overall, the statistics point to the benefits of integrating practical applications and real-world situations into algebra training for students.

Contextualized word problems also have a positive impact on high school mathematics, particularly on algebra and patterns. When such problems are related to real life, students' understanding and retention of algebraic rules are greatly enhanced. According to Diaz et al. (2020), students' understanding of complex patterns and relationships is developed and their problem-solving skills and interest in the subject matter are heightened when they use real-life applications. In addition, according to Diaz, V., et al. (2020), it is proven that applying real life into the curriculum drives students' interests and confidence in mathematics.

Table 5: Perceived Test Characteristics in terms of Patterns and Algebra

Statements		Mean	SD	VI
1.	My comprehension of algebra is aided by contextualizing algebraic issues (e.g., by using real-life scenarios).	3.32	0.54	Agree
2.	My understanding of algebraic patterns is improved when I can identify patterns in everyday situations.	3.22	0.69	Agree
3.	I learn math better when I use its concepts to tackle real-world situations.	3.42	0.65	Agree
4.	My confidence in my ability to solve algebraic equations increases when I comprehend how algebra is applied in practical settings.	3.28	0.56	Agree
5.	Examining practical uses for algebra inspires me to acquire algebraic ideas efficiently.	3.38	0.61	Agree
Overall		3.32	0.37	Agree

Legend: *3.50-4.00 (Strongly Agree); 2.50-3.49 (Agree); 1.50-2.49 (Disagree); 1.00-1.49 (Strongly Disagree).*

The data in Table 6 show how performance scores were distributed across the four numeracy skills: Number and Number Sense, Measurement, Geometry, and Patterns and Algebra. Scores in each domain are divided into five categories: 90 and higher, 85-89, 80-84, 75-79, and less than 75. The frequency and percentage of students who scored within each range, both before and after being exposed to contextualized problems in word form, are shown in the table.

Table 6: Performance Before and After Using Contextualized Word Problems (Word Form)

Score	Number and Number Sense				Measurement				Geometry				Patterns and Algebra				
	Before		After		Before		After		Before		After		Before		After		
	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	VI
90 and above	7	23.3	24	80.0	0	-	21	70.0	0	-	13	43.3	0	-	22	73.3	O
85 - 89	5	16.7	5	16.7	0	0.0	1	3.3	0	-	8	26.7	3	10.0	4	13.3	VS
80 - 84	6	20.0	1	3.3	14	46.7	2	6.7	2	6.7	5	16.7	12	40.0	2	6.7	S
75 - 79	5	16.7	0	-	5	16.7	6	20.0	11	36.7	4	13.3	6	20.0	2	6.7	FS
Below 75	7	23.3	0	-	11	36.7	0	-	17	56.7	0	-	9	30.0	0	-	DME
Total	30	100	30	100	30	100	30	100	30	100	30	100	30	100	30	100	

In the area of number and number sense, there is a noticeable presence of higher-range scores, particularly those above 85, both before and after the intervention. Before using word form problems, a significant percentage of students scored below 75 across all domains and also there are still 7 students who were unable to meet the expected score. Some students were unable to determine the solution to a ratio problem. Some were unable to use their prior knowledge to understand the key concept of percentages and there is a deficiency in solving problems related to percentages. Some students know what operation to use but during the solution, they tend to commit errors in calculations using the four fundamental operations. However, after being exposed to the word problems, most of the students obtained the correct answer by applying the strategies that were shown during the application of contextualized word problems which helped in making fewer errors.

Moving on to measurement, before the use of contextualized word problems, none of the students scored 90 and above, and 36.7% scored below 75. After contextualized word problems were introduced, 70.0 % of the students were able to score 90 and above, and no students scored below 75. Before using the contextualized word problems, students were having a hard time solving that used conversion of units and due to unfamiliarity with some words, the students were unable to solve for the right answer. Some students were able to identify the operations to be used, such as multiplication and division, and had an idea of how to convert, but they made errors while solving the problem. Also, some can start the solution but were unable to continue completing the task. After exposing and becoming familiar with the basic conversion and careful analysis of contextualized word problems, most students were able to obtain the correct answer. Also, problems that often relate mathematical concepts to real-life situations, help to be more engaging and relevant. It also helped the students to think more critically finding the problems interesting or applicable to their lives.

There is a mixed pattern in the geometry category. Following the intervention, scores below 75 decreased, whereas scores falling within the 85 and above range increased. After the intervention, scores between 80 and 84 do, however, slightly increase. The scores of the students in geometry mostly did not meet the expectations, mostly below 75 before being exposed to contextualized word problems. The students were unable to use their prior knowledge in the concept of area and volume, such as applying specific formulas, resulting in some students not answering the questions and leaving them blank. Some students have ideas on how to compute, but during the process of making the solution, they tend not to continue the task. After the exposure and becoming familiarized with the concept of area and volume, the students were able to analyze the problem correctly and apply appropriate problem-solving strategies leading students to attain mostly outstanding levels.

Scores improve in all ranges for patterns and algebra following the introduction of contextualized tasks. Scores below 75 show a noticeable decline, whereas scores between 85 and above show a noticeable increase. Before exposing students to word problems related to Patterns and Algebra, no students were able to attain outstanding level. Some were unable to analyze the problem that focuses on patterns or sequences. Also, most of the students were unable to use their prior knowledge of algebra focusing on adding polynomials. However, after the exposure to word problems in patterns and algebra, the students were able to think critically and were able to solve and use strategies to make no errors in answering.

Word form problems involve expressing numerical concepts through words that help the students to develop a deeper understanding of numbers and their relationships. Contextualized word problems help students grasp the relevance and practical utility of measurement. In geometry, students were encouraged to articulate geometric concepts, enhancing their conceptual understanding. Lastly, word problems in patterns and algebra often require identifying, describing, and extending numerical patterns or solving equations within real-world contexts. Working with word problems reinforces algebraic reasoning and problem-solving skills.

According to Boaler, J. (2016), word form problems can improve students' math performance and comprehension. High-achieving schools need contextualized learning, including word problems, according to Darling-Hammond, L., et al. (2019). Word problems improve mathematical problem-solving skills by providing context and helping pupils understand mathematical concepts, according to Fuchs (2018).

Table 7: Performance Before and After Using Image-Rich Problems

Score	Number and Number Sense				Measurement				Geometry				Patterns and Algebra			
	Before		After		Before		After		Before		After		Before		After	
	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%
90 and above	12	40.0	24	80.0	2	6.7	21	70.0	0	-	7	23.3	2	6.7	17	56.7
85 - 89	5	16.7	2	6.7	0	-	2	6.7	1	3.3	8	26.7	1	3.3	4	13.3
80 - 84	4	13.3	3	10.0	9	30.0	5	16.7	8	26.7	11	36.7	8	26.7	5	16.7
75 - 79	3	10.0	1	3.3	8	26.7	2	6.7	10	33.3	3	10.0	9	30.0	4	13.3
Below 75	6	20.0	0	-	11	36.7	0	-	11	36.7	1	3.3	10	33.3	0	-
Total	30	100	30	100	30	100	30	100	30	100	30	100	30	100	30	100

Table 7 presents a comprehensive view of students' performance in numeracy skills, including Number and Number Sense, Measurement, Geometry, and Patterns and Algebra.

Before the implementation of image-rich problems, the performance across the different numeracy skills varied. In Number and Number Sense, there were varied scores, with some students scoring 90 and above, while others fell below that range. A similar pattern was observed in the Measurement, Geometry, and Patterns and Algebra categories. Some students excelled, scoring in the highest range, while others struggled to reach the same level.

Before implementing image-rich problems, in Number and Number Sense where most of the students are in the outstanding level, the students were able to utilize the images in each problem. Using images, it provided insights into their prior knowledge and understanding of mathematical concepts. But still, some students tend to commit mistakes in calculations using the four fundamental operations. In measurement, students were unable to utilize their prior knowledge in the conversion of units, leading them to still not answer some of the problems even when images were presented. Some students could identify the operations to be used but, in the solution, they were unable to continue with the computation due to their lack of mastery of basic operations.

In geometry, images were presented to help students to solve the problems. However, due to the lack of prior knowledge of area and volume, the students were unable to utilize the images. Also, in Patterns and Algebra, students were even presented with images were unable to utilize in solving problems that show patterns and sequences.

After implementing image-rich problems, students were able to utilize them to their advantage. Students used the images as clues or hints to solve some of the problems presented to them. Exposure to image-rich problems helps them to utilize each image. Students were able to solve and think critically, for example in Number and Number Sense, students can use the images to check if their solution is correct. In measurement, students were able to think what will be the operation to be used. In geometry, most of the students were able to attain scores higher than 74. Utilizing the images and exposure to how to solve for the area and volume helped the students to commit fewer mistakes in their computations. While in Patterns and Algebra, students were able to use the images to their advantage. Some students made their way of computation but still, obtained the correct answer.

On the other hand, after exposing to image-rich problems, most of the students moved to an outstanding level. Students used the images provided to make abstract concepts more concrete which helped them to solve problems. Students were also able to analyze the problems correctly and apply the appropriate strategy, such as students can closely examine the image before jumping into solving the problems. However, one student was unable to a higher level in the area of geometry, this suggests that the student might have focused too much on the visual aspects and missed important details or misinterpreted the images.

Image-rich problems provide visual representations of numerical concepts, which can aid in comprehension and retention. In measurement, visuals offer concrete representations of abstract measurement concepts, facilitating comprehension and problem-solving. In geometry, image-rich problems include figures, diagrams, or models that enable students to visualize geometric concepts, identify patterns, and make connections between abstract ideas and concrete objects or shapes. Lastly, in patterns and algebra, images help students recognize patterns, understand relationships between variables, and make connections between algebraic symbols and real-world situations.

In the course of several investigations (Lee & Zhan, 2018; Van Meter et al., 2020), visual aids such as diagrams and images were found to enhance students' understanding and recall ability of mathematical concepts. By presenting abstract ideas in concrete form, visual aids also link non-related mathematical concepts together (Hegarty & Kozhevnikov, 2018). It also supports the ideas of cognitive load theory, which asserts that information can be conveyed in a way that lessens cognitive load by the use of different modalities such as verbal and visual to enhance the learning process (Sweller et al., 2019). The use of images in mathematics activities supports more students with various learning styles and abilities, hence giving them more support in mathematics (Gallagher & De Lisi, 2021).

Spatial visualization Lowrie et al. (2019) explained how the practice of spatial tasks could help students construct mental models that aid in problem-solving, which leads to strong gains in geometry and math word problems.

Research has also shown that image-rich problems increase students' interest and engagement with mathematics aside from a sharp rise in academic performance (Vorderman et al., 2020). Visual stimuli are believed to provoke a student's curiosity and attention to subsequently foster investigation and engagement (Kang & Pashler, 2019).

Table 8: Test Difference in the Pre-test and Post-test Scores

		Pretest		**Posttest**		**t**	**df**	**p**
		Mean	**Std. Deviation**	**Mean**	**Std. Deviation**			
word	Number and number sense	82.47	7.70	94.67	4.85	-7.043	29	0.000
	Measurement	77.33	5.21	90.20	7.65	-8.854	29	0.000
	Geometry	74.13	3.01	89.33	7.27	-10.530	29	0.000
	Patterns and Algebra	78.13	5.51	91.73	5.63	-11.488	29	0.000
image	Number and number sense	84.60	8.99	94.53	6.62	-5.052	29	0.000
	Measurement	77.33	6.44	90.53	6.19	-8.117	29	0.000
	Geometry	76.47	4.51	85.40	5.61	-6.372	29	0.000
	Patterns and Algebra	77.60	6.20	88.33	5.97	-6.719	29	0.000

Table 8 illustrates the significant improvements in student performance across various mathematical areas from the pretest to the posttest, resulting from the use of word- and image-based methods of instruction. Number and Number Sense, Measurement, Geometry, Patterns, and Algebra all show a noticeable rise in mean scores over the course of the study period, suggesting positive learning and comprehension increases. Mayer (2019) found that combining verbal and visual materials improved understanding and retention more efficiently than either strategy alone. This is consistent with the findings of Wu and Rau (2018), who stressed the usefulness of visual aids in learning mathematical concepts, implying that imagery can help bridge gaps in knowledge for visual learners. According to Bowers and Hearn (2019), instructional diversity, which encompasses both visual and textual modalities, appeals to a wider range of learners while still maintaining engagement and comprehension. This helps to explain the consistent improvements observed across all areas and teaching modalities in the data.

The mean pretest score for Number and Number Sense for word-based instruction was 82.47, with a standard deviation of 7.70. This score improved dramatically, with a smaller standard deviation of 4.85 and a posttest mean of 94.67. A statistically significant improvement is indicated by the t-value of -7.043 and the p-value of 0.000. Similarly, in the Measurement area, observed an increase in mean score from 77.33 to 90.20, with a strong statistical significance indicated by the t-value of -8.854 and the p-value of 0.000.

Additionally, there was a noticeable improvement in geometry, with pretest averages of 74.13 and posttest averages of 89.33. This case's t-value of -10.530 and p-value of 0.000 support the efficacy of the word-based approach. With mean scores rising from 78.13 to 91.73 and a t-value of -11.488, Patterns and Algebra followed this pattern, confirming the significance with a p-value of 0.000.

The findings hold true when looking at image-based education as well. The mean score for Number and Number Sense on the pretest was 84.60, and it rose to 94.53 on the posttest. A significant improvement was shown by the t-value of -5.052 and the p-value of 0.000. With a t-value of -8.117 and a p-value of 0.000, measurement scores likewise showed a significant increase, rising from 77.33 to 90.53.

A t-value of -6.372 and a p-value of 0.000 show that geometry scores improved from a pretest mean of 76.47 to a posttest mean of 85.40. Finally, the results in Patterns and Algebra improved to 88.33, with a t-value of -6.719 and a p-value of 0.000, demonstrating the substantial benefits of image-based instructions once more.

Student performance has increased significantly and constantly in both instructional methods applied, as well as in all the areas involved. All of the p-values are very low (<0.000), which indicates that the positive shifts recorded are not due to chance but statistically significant. This indicates that students' mathematics understanding and performance can indeed be enhanced with the employment of both word- and image-based teaching methodologies. In general, the standard deviations of the post-test scores are smaller than those of the pre-test, showing that students' performance is both increasing and more stable. The loss of variance indicates that students grasp the subject matter more constantly.

The study on contextualized mathematics teaching by Ashcraft and Kirk (2016) showed that such methods enhanced the understanding and use of mathematical concepts. A meta-analysis study conducted by Cohen et al. (2017) deals with contextualized mathematics interventions regarding a variety of students and concluded that these interventions improved mathematical proficiency in most cases significantly. In a similar vein, Baker et al. (2020) study on the impact of contextualized word problems in mathematics on classroom curriculum concluded that it improved students' ability to reason mathematically and solve problems.

According to Hoogland et al.'s (2018) study, students' performance varied depending on the task representation's complexity and the content domain, suggesting that image-rich issues can enhance performance in specific mathematical domains like geometry and measurement.

Verschaffel et al. (2016) tested the effects of realistic contextual problems and showed that problem-solving skills and engagement increased for students by adding a touch of real-life situations, whether through presentation in the form of word problems or visual aids.

Gravemeijer (2017) compared the performance of word problems and image-rich problems and concluded that visual representation can be beneficial in problem-solving by improving understanding as well as reducing cognitive challenges.

Otten et al. (2020) studied the integration of visual aids with contextual problems, that showed a combination of visual aids with contextual problems enhances the conceptual understanding of the students and retention power for mathematical topics.

This shows how instruction based on pictures and words enhances significantly the performance of students in mathematics in all domains. Most areas show somewhat larger effects with instruction based on words, particularly in geometry, patterns, and algebra, which shows its strong effect in those areas. At the same time, however, there is also strong evidence that instruction based on pictures works well, especially number sense and measurement when the scores of the students are raised significantly. The two approaches of teaching promote mathematical understanding, as attested by p-values that remain constant across comparisons, all 0.000 indicating statistical significance for each change.

Table 9: Independent Samples Test of Two Post-test Scores

		M	SD	t	df	Sig. (2-tailed)
Number and number sense	Word	94.67	4.85	0.089	58	0.929
	Image	94.53	6.62			
Measurement	Word	90.20	7.65	-0.185	58	0.854
	Image	90.53	6.19			
Geometry	Word	89.33	7.27	2.347	58	0.022
	Image	85.40	5.61			
Patterns and Algebra	Word	91.73	5.63	2.271	58	0.027
	Image	**88.33**	**5.97**			

Table 9 shows the findings of an independent samples test comparing the post-test scores of two groups in four mathematical domains: Number and Number Sense, Measurement, Geometry, and Patterns and Algebra. One group used a word-based learning method, while the other used an image-based learning method. The mean scores (M), t-values, degrees of freedom (df), standard deviations (SD), and significance levels (Sig. 2-tailed) for each domain are shown in the table.

For the word group, the mean score was at a level of 94.67 with a standard deviation of 4.85, while the mean for the image group was 94.53, with a standard deviation of 6.62. With a df of 58, the t-value was 0.089, and the p-value was 0.929. Since the p-value is substantially higher than 0.05, the two groups do not differ significantly in their Number and Number Sense scores.

However, in Geometry, there was a difference. The image group scored 85.40 with an SD: of 5.61, whereas the word group scored 89.33 with an SD: of 7.27. The df here was 58 and the p-value was 0.022. Here, the t-value of 2.347 denotes that the groups have a statistically significant difference. In Geometry, the word group performed significantly better than the image group.

With a mean score of 91.73 and a standard deviation of 5.63, the word group outperformed the image group in the Patterns and Algebra area once more. The image group's mean score was 88.33 with a standard deviation of 5.97. This means that there was a statistically significant difference as the p-value was 0.027 and the t-value was 2.271 with df = 58. This means that learning Patterns and Algebra was facilitated more by the word-based method than by the image-based method.

The results of this experiment have indicated that word-based methods of learning are easier than image-based methods of teaching geometry, patterns, and algebra, even though there was no appreciable difference in the areas of number and number sense and measurement. This result is in keeping with a wide array of cognitive science and educational psychology research that emphasizes the value of verbal representations to build an understanding of mathematics and solve math-related problems.

For instance, Fyfe et al. (2018) found that children solved better than those who had only visuals alone as explanations in mathematics problem-solving activities when they received both vocal and visual representations. Additionally, verbal teaching facilitates the process of internalizing abstract mathematical concepts; hence it becomes easier for students to understand and use them in most situations according to a report by Rittle-Johnson and Schneider (2019).

In addition to the aforementioned earlier, while visual strategies-based interventions were compared with Zhang and Stephens' 2020 meta-analysis, it showed that interventions that relied on verbal methods actually helped students develop better performance in algebraic reasoning and geometric visualization. This justifies the findings from the Geometry, Patterns, and Algebra domains of the current study.

In a sense, then, Siegler and Ramani's (2018) findings indicate how interactive, multimodal learning can be a powerful tool in the improvement of children's number sense and measuring skills. This could explain why in the study at hand, there were no significant differences between the word group and the image group on those two domains. According to their study, for a complete understanding of mathematical ideas, verbal and visual elements need to be integrated together.

Finally, a study by Ozel et al. (2021) demonstrated that verbal methods are necessary to have deep learning and retain mathematical concepts in the long run even though image-based learning may attract students and help in the initial understanding process. The current study findings clearly bring out this distinction, where the scores of verbal methods are better than those of image-based methods for more abstract and complicated mathematical areas.

As a concluding note, this analysis reveals that although word-based instructions are vital for enhancing students' comprehension and competency regarding the more abstract concepts of mathematics, such as algebra and geometry, image-based instructions are not anathema in mathematics education. Taken together, the findings indicate that making use of both word- and image-based methods of instruction is crucial to achieving optimal learning outcomes in mathematics education.

5. Conclusions

The study revealed a significant difference between the pre-test and post-test scores of students in the numeracy test when using contextualized word problems. However, no significant difference was found between post-test scores in word form and image-rich problems in the Number and Number Sense, and Measurement categories. In contrast, a significant difference was observed in the Geometry, Patterns, and Algebra categories, where students performed better on word-form problems compared to image-rich problems.

6. Recommendations

Educators might consider integrating both word-based and image-rich problems in their teaching to maximize student learning outcomes across different mathematical domains, such as number and number sense, measurement, geometry, and patterns and algebra. They may adapt the use of these approaches based on the content domain, incorporating more image-rich problems in geometry and measurement to enhance comprehension, while utilizing contextual word problems in algebra to develop problem-solving skills. Additionally, promoting group activities that involve solving both types of problems can foster collaborative learning, enhance problem-solving abilities, and increase student engagement by making problems more relevant to their interests and real-world situations. Furthermore, incorporating manipulatives and hands-on exercises alongside image-rich problems can help students physically interact with mathematical concepts, reinforcing their understanding and application of abstract ideas.

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