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The Use of Visualization Techniques to Enhance Secondary School Students' Ability to Solve Sentence-Based Mathematical Problems

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Abstract

Visualization techniques have been used in educational institutions to enhance the effects of problem-solving methods in the domain of functions and quadratic equations. This study aims to assess the effects of visualization techniques utilized by students in the pure science stream at the Form Four level to solve mathematical problems. The study employed a simple random sampling technique to select a sample of 100 Form Four students as respondents for the research. The pre-experimental approach known as the One Group Pretest-Posttest Design was employed for the study and SPSS version 27.0 was utilized to analyse descriptive and inferential data. Paired *t*-tests were conducted to examine the effects of visualization techniques in the instruction and comprehension of sentence-based mathematics problem-solving within the domain of functions and quadratic equations. The results indicate a statistically significant difference in the mathematics scores of Form Four students before and after implementing the visualization techniques. The results provide there is a significant difference in the Post-Test Score of Functions and Quadratic Equations ($t(98)= -.853$, df=98, p=.019, $p<0.05$) in the mathematics scores of Form Four students before and after implementing the visualization techniques. The findings indicate that the level of perception of Form Four students the use of visualization technics to enhance mathematical problem-solving skills is a high mean score of 4.11 and a standard deviation of .3161. The study's findings indicate that Form Four students' mathematical problem-solving skills were enhanced through visualisation. After using the visualization strategy, students' ability to solve mathematical problems was improved. It can be conclude that this visualization technique can provide an alternative to the learning and facilitation process. This learning method is one of the teaching and learning media that is effective and has the potential to improve students' understanding of learning.

Keywords: Visualization Techniques, Mathematical Learning, Mathematical Problems, Teaching and Learning, Secondary School

Introduction

Mathematics education is a field of knowledge that trains students to think creatively and critically, especially in solving mathematical problems. Malaysia's goal is to produce a generation skilled in the application of mathematical knowledge. Therefore, mathematics education must encompass fundamental, conceptual, and theoretical knowledge. According to the research of Hassan et al. (2019) and Dowker et al. (2019), the ability to solve mathematical problems is an essential component of the mathematics curriculum in Malaysia. This is because students frequently view mathematics as a difficult subject that has no relevance to their daily lives.

According to a study conducted by Patton et al. (1997), proficiency in solving sentence-based mathematics problems is an essential skill that indirectly assumes significance within the mathematics curriculum in Malaysia. Students are required to engage in critical thinking, strategic planning, and decision-making processes utilizing suitable methodologies. To facilitate the comprehensive development and exploration of mathematical concepts among students, it is imperative to convey the importance of grasping these concepts prior to engaging in problem-solving activities within the realm of mathematics education. According to the research conducted by Onal et al. (2017), as well as the findings of Sujadi and Masamah (2017), it is emphasized that encouraging and developing an understanding among students regarding the interrelationships and necessity of studying mathematics is important.

According to Gavita Kanapathy's (2016) research, a visualization technique is a cognitive process or an individual's action that connects internal constructs with external events. This study is supported by Battista and Clement's (1996) opinion that the use of visualization techniques in learning produces the best results. Reisberg (1997) defines visualization as "creating and repeating an image of an object or phenomenon in the mind without seeing it." Bishop (1989) considers visualization to be a phenomenon in mathematical activities that employ various visual images in a variety of learning situations. Furthermore, Horgan (1993) stated that visualization is an extremely useful technique for solving mathematical problems. According to Moses (1982), the use of visualization assists students in learning and increases students' understanding of mathematics.

The visualization methods used in mathematics classes are communication tools. These tools are used to explain basic mathematical concepts. According to Rita and Mulia's (2016) research, visualization techniques are an important teaching and learning strategy in high school mathematics classes. They help students develop their information-processing abilities, which include the ability to receive verbal cues, store information, and recall it visually.

Using Visualization Techniques to Solve Mathematically Challenging Problems Related to The Topics of Functions and Quadratic Equations

The application of problem-solving techniques in mathematics is facilitated by the integration of knowledge and fundamental mathematical principles. The process of solving mathematical problems pertaining to functions and quadratic equations can be effectively explained through the utilization of various visual aids, including pictures, diagrams, sketches, representations, and symbols. According to research conducted by Gilbert and Leahy (2007), the process of solving mathematical problems requires the utilization of visual-spatial techniques, which are frequently associated with an individual's ability to visualize. The process of solving mathematical problems related to functions and quadratic equations can be divided into four distinct phases, as outlined by Polya (1973). These phases include

comprehending the problem, devising a plan, executing the plan, and reviewing the solution. A comprehensive understanding of all phases is essential as it directly influences the capacity to devise and execute effective strategies for addressing mathematical functions, quadratic equations, and graph visualization. Newcombe and Liben (1982) argue that in order for visualization techniques to be effective, they must generate, choose, and create images that accurately represent the diagram. This will facilitate comprehension of a sentence-based mathematical problem within the context of functions and quadratic equations.

The use of this visualization technique enables students to acquire a comprehensive understanding of the concepts related to functions and quadratic equations, while also presenting them with opportunities to engage in higher-order thinking skills (HOTS) such as knowledge-based application and analysis. The utilization of visualization approaches in teaching and learning facilitates the comprehension of fundamental algebraic concepts, enabling the connection between topics such as quadratic equations, function graphs, and graph paper sketches. This approach aids in the resolution of quadratic equations. The integration of technology in instructional practices has the potential to enhance and facilitate more efficient and impactful learning experiences.

According to the researcher's expertise, the subject matter of functions and quadratic equations is known to be challenging to comprehend. It necessitates the utilization of visual aids, such as graphs, and demands a clear and precise understanding of each step involved in the solution process. The cognitive capacities of students encompass the faculties of creative, critical, and inventive thinking. The practice of exploring mathematical problem-solving in the domain of functions and quadratic equations can be achieved through undertaking various strategies. One of the strategies that has been implemented is the utilization of the SMART TV YouTube Channel within educational institutions. The utilization of SMART TV facilitates interactive learning in the field of mathematics, as it allows students to explore a wide range of acceptable channels. According to a recent study conducted by Susilawati and Ayubi (2022), there is a heightened inclination among students towards visual learning. This preference can be attributed to the perceived advantages of utilizing information and communication technology, as well as engaging in internet browsing, which are believed to enhance the effectiveness of the learning process.

The topic of graphs of functions is thought to be challenging for students. Students believe that sketching a graph needs preparation such as using graph paper, calculating the x- and y-axes, the equations involved, and plotting exact coordinates. According to Ruthven and Hennesey (2002), there is a need for resources that are easy for students to understand, particularly on the issue of functions and graph drawings. The use of appropriate technology, such as the iPad device and the GeoGebra application, can significantly increase students' knowledge of graphs of functions. Because of its ability to illustrate solutions in terms of static or animated images in learning graphs of functions Ochkov and Bogomolova (2015), the visual and audio elements found in the SMART TV YouTube Channel are attracting the attention of students to explore and follow the learning activities that are being investigated by the study of Rahman and Samah (2011). Next, it assists students in grasping mathematical ideas, particularly sketching graphs and plotting coordinates, in order to provide deeper knowledge and better recall of related formulas.

The use of SMART TV YouTube Channel has a range of multimedia content, good audio-visual quality, and a faster network speed than traditional learning. According to Ratten's (2014) research, technology and communication services in the SMART TV YouTube Channel network have an impact on users. Zamri and Sunar’s (2019) research supports the

use of visualization techniques because it is a pedagogical method that uses technology and communication to help students understand mathematical concepts and think quantitatively, such as solving problems, testing assumptions, entering data, and checking answers.

Problem Statement

Solving mathematical problems in the topic of functions and quadratic equations is an important area of learning in the secondary mathematics curriculum. According to Lasiun's (2016) research, all secondary school mathematics topics include learning to solve mathematical problems. Her research is supported by the Malaysian Education Development Plan (PPPM) 2013-2025 statement emphasizing thinking skills, the process of solving mathematical problems capable of enabling students to think creatively and critically, as well as being able to synthesize in finding the right solution.

According to Zainuddin and Mohamed (2010), secondary school students' ability to understand non-routine math problems remains limited. Pupils only focus on common questions and there are no lengthy solution steps. According to Norulbiah and Effandi's (2016) study, students do not understand how to solve mathematical problems and there is still room for improvement in terms of ways and methods to explain the topic of functions and quadratic equations. Students must scrutinize, plan, and carry out mathematical problem-solving strategies on the topic of functions and quadratic equations. According to Betihavas et al. (2016), students continue to demonstrate a significant attitude weakness when solving mathematical problems on the topic of functions and quadratic equations. It still occurs during the stages of strategy planning, strategy implementation, and getting the right answer. Butt's (2014) study supports this viewpoint by stating that sentence-based mathematical problem-solving skills cannot be mastered directly from knowledge of the concept of quadratic functions and quadratic equations because students only read questions and do not want to examine appropriate steps and strategies such as sketching function graphs, solving quadratic equations, and factoring quadratic equations. Furthermore, Johnson et al.'s (2014) study discovered that students frequently begin solving mathematical problems without careful planning, and they quickly give up because the answers do not match the actual solutions.

Furthermore, it is worth noting that students frequently encounter difficulties in comprehending and interpreting the given requirements of a question, as well as making errors when attempting to provide solutions to problems involving mathematical sentences related to functions and quadratic equations (Examination Board, LPM 2013). According to a study conducted by Agelyia et al. (2017), it was found that students tend to employ memorization of procedures and mathematical operations, relying on keywords and numerical terms when solving mathematical problems. According to the research conducted by Dale (2002), the utilization of different communication media and information plays a significant role in the resolution of mathematical problems. The comprehension of the concept of graphs of functions is found to be significantly lower when conveyed through verbal learning as opposed to visualization.

According to Mailis et al.'s research from 2020, students' cognitive, affective, and psychomotor abilities will increase in a setting that is conducive to learning. This enables students to make use of the resources the school has made available to them in order to learn mathematical concepts related to functions and quadratic equations. It was implied that for every school to produce high-quality teaching and learning, technological and communicative teaching aids have to be available. They believe that a key factor in determining whether

students are successful learners is the environment. However, research indicates that the learning environment in urban and rural schools differs in terms of facilities. According to Maat and Zakaria's (2010) study, among the factors affecting students' low achievement are a lack of infrastructure, inadequate learning facilities, and an unpleasant and unproductive learning environment. Quadratic equations cannot be mastered as a result and students will stop learning how to solve mathematical problems in the area of functions.

Studies that use visualization techniques in teaching and learning, however, are lacking. Most studies concentrate more on providing examples of visualization materials without giving attention to which topic is suitable to be taught using those visualization techniques. Therefore, it is important to emphasize the study of visualization techniques and incorporate them into meaningful contexts, especially to highlight school subjects that fit the visualization method, and generate a list of teaching tools that are appropriate for 21st-century learning.

Research Objectives

The main objective of this research is to:

i. Study the effects of visualization techniques in enhancing problem-solving abilities in sentence-based mathematical problems.

To examine the difference in scores between pre- and post-mathematics test a) for Form Four students who used the visualization technique.

To examine the level of perception of Form Four students towards the use of b) visualization techniques in sentence-based mathematical problem-solving.

Research Questions

1. Is there a difference in Form Four students' scores between the pre- and post-mathematics test following the implementation of visualization techniques?
2. What is the level of perception of Form Four students towards the use of visualization techniques in solving sentence-based mathematical problems?

Research Methodology

Firstly, respondents participated in a traditional teaching and learning session that was conducted in a classroom. According to the following schedule, the Form Four students engaged in a teaching and learning session in the Educational Technology Unit room that was equipped with SMART TV and high-speed internet. The group of students was taught the method of solving mathematical problems on the topic of Functions and Quadratic Equations. The instructor then employed visualization techniques in the same group according to the schedule for each class. Students were permitted to use iPads to respond to questions related to the topic during the teaching and learning session.

Research Design

This research employed a quantitative approach by utilizing the One Group Pretest-Posttest research design. The research design is also known as a quasi-experimental design that is conducted on only one group. The group involved in the study is an experimental group without the use of a comparison group or a control group. This study was conducted on a group of students who were chosen randomly. No non-random selection as conducted on the group of students.

Respondents and Location

The respondents were 100 Form Four students from a boarding school in a district in Negeri Sembilan. The researcher chose this school because of the convenience for the researcher to contact the school and obtain data. The study sample was chosen using a simple random sampling technique. This technique was used to select respondents for the study because it ensured each student had an equal chance of being chosen as a respondent for this study.

Instruments

Respondents were asked to complete a questionnaire adapted from a previous study in order to determine the impact of using visualization techniques in solving sentence-based mathematical problems. The scale is organised to ensure that a rating of 1 corresponds to the interpretation of "strongly disagree," a rating of 2 corresponds to "disagree," a rating of 3 corresponds to "not sure," a rating of 4 corresponds to "agree," and a rating of 5 corresponds to "strongly agree." Part I is the Profile of Respondents, Part II is Students' Perceptions of the Use of Visualization Techniques in Improving Mathematical Problem-Solving Skills in Secondary Schools, and Part III is Pupils' Perceptions of the Use of Visualization Techniques in Improving Mathematical Problem-Solving Skills in Mathematics Subject.

Data Analysis

This study used the internal consistency method by determining Cronbach's alpha reliability coefficient in the questionnaire. Most researchers utilize Cronbach's alpha value in survey studies to evaluate the dependability of questionnaire items that use a five-level scale (Darusalam and Hussin, 2016). According to Chua (2012), the Cronbach's alpha value can also be used to gauge an item's internal consistency. For example, Chua (2012) notes that items with high correlation values with test index scores have high reliability, while items with low correlation values with test index scores have low reliability and should be disregarded. The Levene's homogeneity test is applied to indicates that the data is homogeneous. This study applied the independent samples t-test to analyse the difference in scores between pre- and post-mathematics test for form four students who used the visualization technique.

Table 1.0:

Research Instrument Reliability

Value (r)	Reliability	Action
Below 0.50	Too low and unsatisfactory	Instrument not suitable
0.50 to 0.64	Low and unsatisfactory	Some items need to be modified
0.65 to 0.79	Satisfactory	Item suitable for use
0.80 to 0.95	High and Satisfactory	Item suitable for use
0.96 to 1.00	Unsatisfactory	Items overlap and need to be modified

Source: Chua (2012)

The collected data were analyzed using SPSS version 27.0 to obtain a descriptive statistical analysis of the effects of visualization techniques in solving sentence-based mathematical problems involving functions and quadratic equations. Table 1.0 shows that Cronbach's Alpha coefficient was used to assess the study's reliability. This study's analysis

reveals a high reliability value of 0.901, and the questionnaire is suitable and acceptable for use. The mean score used to identify students' perceptions of the use of visualization techniques in improving their mathematical problem-solving skills is shown in Table 2.0. Table 2.0 shows the mean score interpretation table used, which is based on Nunnally and Bernstein (1994).

Table 2.0
Mean Score Interpretation

Mean Score	Interpretation
1.00 – 2.00	Low
2.01 – 3.00	Medium Low
3.01 – 4.00	Medium High
4.01 – 5.00	High

Source: Nunnally and Bernstein (1994)

The Pre-Test and Post-Test

Data was collected for the pre- and post-tests over a seven-week period. To determine the students' level in their basic understanding of the topic, the teacher gave 100 Form Four students pre-test questions based on their respective classes. The pre-test and post-test each have a two-hour time limit.

Functions and Quadratic Equations were the subject of the eight structured questions in the pre-test. The format of the sentence-based mathematical problem-solving questions on the subject of functions and quadratic equations is organized based on the Polya Model (1973). The eight different types of structured questions are categorized into three different difficulty levels according to Bloom's Taxonomy (1956). The levels include knowledge, comprehension, application, analysis, synthesis, and evaluation in the creation of sentence-based mathematical problem questions pertaining to functions and quadratic equations. The questions were designed to assess students' proficiency in solving mathematical issues related to the subject of functions and quadratic equations. Furthermore, the eight questions were divided into three levels with the easy level containing three questions, the moderate level containing three questions, and the difficult level containing two questions. The questions were presented as a series of mathematical issues related to the topic of functions and quadratic equations. The pre-test consisted of questions that asked students to solve quadratic equation-based problems, solve functions, graphs of functions, and identify the factors of quadratic equations.

Research Findings

This chapter reports the findings of the data analysis and a description of the respondent profile, followed by answers to the study's questions and hypotheses. Researchers employ descriptive statistics as well as inferential data.

Profile of Respondents

This section shows the distribution of the Form Four respondents from a secondary school in Labu, Seremban, Negeri Sembilan.

Table 3.0
Profile of Respondents

Background	Respondent	Frequency (f)	Percentage (%)
Class Name	4 Ar - Zarqali	22	22.0
	4 Ar - Razi	20	20.0
	4 Al - Muqaffa	18	18.0
	4 Al - Batani	20	20.0
	4 Ibn - Haitham	20	20.0
	Total	**100**	**100.0**
Gender	Female	52	52.0
	Male	48	48.0
	Total	**100**	**100**

The distribution of Form Four students at the secondary school in Labu, Seremban, Negeri Sembilan is shown in this section. According to Table 3.0, the majority of respondents, 42 in the 4 Ar-Zarqali class, equals 22.00%, followed by the 4 Ar-Razi and 4 Ibn-Haitham classes, each with 20 students, equals 20.00%. Furthermore, 4 Al-Muqaffa has the fewest students, with only 18 students. The analysis also discovered that female students from the five classes made up 52.00% of the respondents.

Inferential Analysis
To Analyse the Difference in Scores Between Pre- And Post-Mathematics Test for Form Four Students Who Used the Visualization Technique.

Research question 1: Is there a difference in Form Four students' scores between the pre- and post-mathematics test following the implementation of visualization techniques?
The study's null hypothesis is as follows:

$H_0$1: There is no significant difference in Form Four students' scores between the pre- and post-mathematics test following the implementation of visualization techniques

Descriptive Analysis

Table 4.0
Pre-test and Post Test Score

Form Four Students Test Score For The Implementation Of Visualization Techniques	Descriptive			
	N	Mean	Variance	Standard Deviation
Pre-test	100	3.00	.687	.5945
Post-test	100	4.05	.533	.8382

Table 4.0 shows the mean of the pre-test and post-test scores of the Form Four students. The detailed findings indicate a significantly higher mean score (M=4.05, SP=.8382) for the post-test, compared to a moderately lower mean score (M=3.00, SP=.5945) for the pre-test. The findings indicate that the average score is relatively high, suggesting that Form Four students possess a satisfactory level of comprehension regarding functions and quadratic equations. This conclusion is supported by the study's findings that the implementation of visualization techniques in teaching and learning facilitates their understanding of the topic.

Normality Test
Table 5.0
Normality Analysis

Normality Test		Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Test Score Form Four Students For The Implementation Of Visualization Techniques	**Pre-test**	.083	100	.083
	Post-test	.060	100	.200*

Homogeneity Test

Table 6.0
Homogeneity Analysis

The Effects Of Visualization Techniques In Enhancing Problem-Solving Abilities In Sentence-Based Mathematical Problems		Levene's variance test
		Sig.
Test Score Form Four Students For The Implementation Of Visualization Techniques	Equal variances assume	.920

Based on Tables 5.0 and 6.0, the Levene's homogeneity test obtained (Sig>0.05) indicates that the data is homogeneous and the Kolmogorov-Smirnov normality analysis test obtained (Sig >0.05) indicates that the data distribution is normal. Therefore, parametric analysis can be applied to evaluate the hypotheses. This study apply the independent samples t-test analysis to analyse the difference in scores between pre- and post-mathematics test for form four students who used the visualization technique.

Independent t-test
Table 7.0
Independent Sample t-Test

	Independent Sample t-Test		
Test Score Form Four Students For The Implementation Of Visualization Techniques	t	df	Significant
	-.853	98	.019

Table 7.0 shows the difference between pre-test and post-test mathematics scores for Form Four students implementation visualization techniques. The results provide sufficient evidence to reject the H_0 because there is a significant difference in the Post-Test Score of Functions and Quadratic Equations ($t(98)= -.853$, df=98, p=.019, p<0.05). In conclusion, there is a significant difference between Form Four students' pre-test and post-test mathematics scores after the implementation of visualization techniques. By implementing visualization techniques into mathematics teaching and learning, students obtain a better understanding.

Level of perception of Form Four students towards the use of visualization techniques in sentence-based mathematical problem-solving

Research question 2: What is the level of perception Form Four students towards the use of visualization techniques in solving sentence-based mathematical problems?

Table 8.0
Level of Perception of Form Four Students

No.	Item	Mean	Standard Deviation	Interpretation
1.	Perception of the Use of Visualization Techniques in Problem-Solving in the Topic of Functions and Quadratic Equations.	4.42	.519	High
2.	Perception of Using Visualization Techniques to Improve Mathematical Problem-Solving Skills in Mathematics Subjects.	4.50	.596	High
Overall Mean		**4.46**	**.558**	**High**

According to Table 8.0, the majority of respondents showed a high level of perception toward the use of visualization techniques in solving mathematical problems. The findings of the study show that the level of perception Form Four students towards the use of visualization techniques in mathematical problem-solving shows that the mean score is high (M=4.46, SD=.558). There is a high interpretation of the mean score (M=4.42, SD=.519) for the item Perception of Using Visualization Techniques to Improve Mathematical Problem-Solving Skills in Mathematics Subjects. Moreover, the item Perception of the Use of Visualization Techniques in Problem Solving in the Function and Quadratic Equation topic (M=,4.50 SD.596=.) is medium high. This demonstrates that the visualization technique can indirectly assist students in learning mathematics, as it can help Form Four students solve mathematical problems related to the topic of functions and quadratic equations.

Table 9.0
Frequency, Percentages, Mean Score and The Interpretation Level Of Perception Of The Use Of Visualization Techniques In Problem-Solving In The Topic Of Functions And Quadratic Equations

Perception of the Use of Visualization Techniques in Problem-Solving in the Topic of Functions and Quadratic Equations								
No.	**Item**	**Frequency and Percentages %**						
		Strongly Disagree	**Disagree**	**Not Sure**	**Agree**	**Strongly Agree**	**Mean**	**Interpretation**
1.	The use of visualization techniques captured my interest in solving sentence-based mathematical problems.	0 (0.0)	0 (0.0)	0 (0.0)	48 (48.0)	52 (52.0)	4.52	High
2.	I like learning about solving sentence-based mathematical	0 (0.0)	0 (0.0)	3 (3.00	66 (66.0)	31 (31.0)	4.28	High

	problems using visualization techniques.							
3.	I easily understand visualization techniques.	0 (0.0)	0 (0.0)	0 (0.0)	47 (47.0)	53 (53.0)	4.53	High
4.	I can easily apply visualization techniques in sentence-based mathematical problem-solving.	0 (0.0)	0 (0.0)	2 (2.0)	54 (54.0)	44 (44.0)	4.42	High
5.	I know that I will be left behind if I do not apply visualization techniques.	0 (0.0)	0 (0.0)	1 (1.0)	39 (39.0)	60 (60.0)	4.59	High
6.	I know that a lot of topics in mathematics can be learned through visualization techniques.	0 (0.0)	1 (1.0)	1 (1.0)	57 (57.0)	41 (41.0)	4.38	High
7.	I know that visualization techniques can help improve my academic achievements.	0 (0.0)	0 (0.0)	0 (0.0)	57 (57.0)	43 (43.0)	4.43	High
8.	I realize that I must use visualization techniques while I am at home.	0 (0.0)	0 (0.0)	1 (1.0)	70 (70.0)	29 (29.0)	4.28	High
9.	Visualization techniques greatly assist in enhancing the ability to solve sentence-based mathematical problems.	0 (0.0)	0 (0.0)	1 (1.0)	72 (72.0)	27 (27.0)	4.26	High
10.	I have knowledge of ICT.	0 (0.0)	0 (0.0)	4 (4.0)	39 (39.0)	57 (57.0)	4.53	High

11.	I know that visualization techniques are a necessity.	0 (0.0)	0 (0.0)	1 (1.0)	47 (47.0)	52 (52.0)	4.51	High
12.	I will use visualization techniques more often.	0 (0.0)	0 (0.0)	5 (5.0)	60 (60.0)	35 (35.0)	4.30	High
Overall Mean							**4.42**	**High**

Table 9.0 shows interpretation level perception of the use of visualization techniques in problem-solving in the topic of functions and quadratic equations. It shows that the overall result is a high mean score (M=4.42). Item 5 "I know that I will be left behind if I do not apply visualization techniques" has the highest mean score (M=4.59). While item 9 "Visualization techniques greatly assist in enhancing the ability to solve sentence-based mathematical problems" shows the lowest mean score (M=4.26) but still a high mean interpretation. In conclusion, this shows that the perception of the Use of Visualization Techniques in Problem-Solving in the Topic of Functions and Quadratic Equations is very good and the students can solve problems effectively.

Table 10.0

Frequency, Percentages, Mean Score And The Interpretation Level Of Perception Of Using Visualization Techniques To Improve Mathematical Problem-Solving Skills In Mathematics Subjects

Perception of Using Visualization Techniques to Improve Mathematical Problem-Solving Skills in Mathematics Subjects								
No.	**Item**	**Frequency and Percentages %**						
		Strongly Disagree	**Disagree**	**Not Sure**	**Agree**	**Strongly Agree**	**Mean**	**Interpretation**
1.	I like using the visualization techniques approach in learning.	0 (0.0)	0 (0.0)	0 (0.0)	53 (53.0)	47 (47.0)	4.47	High
2.	I am uncomfortable with the use of visualization techniques in learning.	0 (0.0)	0 (0.0)	3 (3.0)	39 (39.0)	58 (58.0	4.55	High
3.	I feel happy when using visualization techniques.	0 (0.0)	0 (0.0)	7 (7.0)	43 (43.0)	50 (50.0)	4.43	High

4.	I lack interest in using visualization techniques.	0 (0.0)	1 (1.0)	5 (5.0)	39 (39.0)	55 (55.0)	4.48	High
5.	I receive encouragement from the teacher to use visualization techniques.	0 (0.0)	0 (0.0)	5 (5.0)	33 (33.0)	62 (62.0)	4.57	High
6.	I consider visualization techniques as my preferred way of learning.	0 (0.0)	0 (0.0)	4 (4.0)	35 (35.0)	61 (61.0)	4.57	High
7.	I receive encouragement from the school to use visualization techniques.	0 (0.0)	0 (0.0)	9 (9.0)	42 (42.0)	49 (49.0)	4.40	High
8.	I think that visualization techniques can save learning time.	0 (0.0)	0 (0.0)	7 (7.00	30 (30.00	63 (63.0)	4.56	High
Overall Mean							4.50	High

Table 10.0 shows the perception of using visualization techniques to improve mathematical problem-solving skills in mathematics subjects. It shows that the overall result is a high mean score (M=4.50). Item 5 and 6 " I receive encouragement from the teacher to use visualization techniques" and “I consider visualization techniques as my preferred way of learning” were the highest mean score (M=4.57). While item 7 "I receive encouragement from the school to use visualization techniques" shows the lowest mean score (M=4.40) but still a high mean interpretation. In conclusion, this shows that the perception of the Use of Visualization Techniques in Problem-Solving in the Topic of Functions and Quadratic Equations is high because students can solve problems easily through this technique. Learning mathematics is more effective and can improve students' understanding about the topic easily.

Discussion

The usefulness of using visualization approaches in improving mathematical problem-solving skills in secondary schools may be identified by applying pre-tests and post-tests in this study. The study's findings reveal that, after introducing visualization techniques, students' accomplishment in the post-test is higher than their achievement in the pre-test. According to Augustine and Affendi's (2020) results, applying visualization techniques is a facilitator of learning to solve mathematical issues by assisting and transferring crucial information to a more suitable and easier-to-comprehend visual representation.

Kumuthavalli and Muhammad Sofwan (2022) explained that visualization techniques can help students solve sentence-based mathematical problems because they can help

students express the meaning and problems given based on images or visual representations that are easy for students to see, particularly in Quadratic Functions and Equations for Form Four students. Before being introduced to the visualization technique, the respondents could not solve sentence-based mathematics problems quickly, made many errors, and did not answer the questions. According to Singga and Effandi (2020), pupils are unable to solve difficulties because they do not comprehend the approach to answering questions appropriately. This demonstrates that responders are less adept at planning and implementing problem-solving solutions.

According to Augustine and Affendi (2020), the change in post-test scores after the visualization technique is used in teaching and learning demonstrates that this technique can help improve sentence-based mathematical problems because it is an effective method and attracts students to a conducive and effective learning environment. The findings of Hassan et al. (2019) and Wulandari et al. (2020) demonstrated the necessity of a technique to assist students in learning mathematical problem-solving skills. The 21st-century learning technique is widely promoted, particularly in mathematics, which includes diagrams, films, and examples that are simple for pupils to understand. Students can answer post-test questions correctly, and they can answer diagram-related questions thoroughly and demonstrate a comprehension of the topic.

According to Abdullah (2020); and Maharani et al. (2017), the ability to solve sentence-based mathematics problems has been difficult for students to grasp since elementary school. As a result, students understanding of problem-solving questions and idea generation as diagrams, audio, and illustrations that are interesting and easy to understand, as well as having their creativity in students' understanding in an effective learning environment, should be given an approach in secondary school math. Finally, educators must act as consultants by acknowledging students' difficulties in answering sentence-based mathematics issues and encouraging them to better comprehend and solve the problems (Albert & Muhammad, 2021). As a result, educational institutions and teachers must improve teaching and learning to increase the quality of mathematics learning. This range of visualization approaches should be enhanced as learning becomes more difficult.

Conclusion and Future Recommendations

The purpose of this study was to determine the effects of using visualization approaches to improve sentence-based mathematical problems in secondary schools. Overall, students in Form 4 benefit from the use of visualization techniques when learning sentence-based mathematics problems with Quadratic Functions and Equations. The findings indicate that student involvement in using visualization techniques is ideal and increases students' enthusiasm for teaching and learning. Student perspective indicates that they understand better after using visualization approaches in their learning. The concept of functions and quadratic equations necessitates a diagrammatic and visual representation, and graph drawings can assist students in simply understanding the procedures for solving sentence-based mathematical issues. A study on the use and technology skills of students, particularly relevant devices and appropriate apps for challenging issues in learning mathematics, is a more effective research proposal. This should be emphasized so that students' participation in mathematics teaching and learning sessions is encouraged and attracts students' interest in learning tough themes in mathematics. The utilisation of this visualisation technique becomes advantageous within the field of education, exhibiting significant potential for enhancing student motivation, encouraging creativity, and facilitating understanding through

the process of visualisation. According to Shahan Ahmad Chowdbur et al. (2013), explained the benefits associated with the utilisation of technology in educational sector, specifically in terms of its impact on cognitive learning. The authors emphasise the significance of integrating pedagogy and technology within the field of education. The utilisation of technology in mathematics education is important to improving the learning experience for students. It is imperative that technology is extensively integrated into mathematics programmes in order to achieve the objective of enhancing students' mathematical knowledge and understanding.

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