Journal of Human Development and Communication
Volume 8, 2019 [97-106]

Effects of Visual Approach in Teaching Mathematics for Malaysian Secondary School: A Case Study

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ABSTRACT

Previous studies have shown that students have difficulties when dealing with abstract and lengthy questions. Therefore, the main purpose of this study is to investigate the significant difference in students' performance when using visual approach in teaching and learning mathematics. The population used for this study was students in secondary form two from one of the selected schools in Gombak district. Eighty-five students were selected as respondents for this study. The pre-post design and questionnaire techniques were adapted from previous literature in this study. Firstly, a pre-test was given to all the respondents. Then, the respondents were facilitated with the treatment by using the visual approach. Subsequently, a post-test was administrated. Lastly, a set of questionnaires was distributed to the students in order to get the students' feedback. The raw scores from the pre-test and post-test were analysed by using Sample-Paired T-test. Meanwhile, the descriptive statistic was used to analyse the data from the questionnaires. The results reveal that the visual approach can increase the students' performance in mathematics. Thus, the study strongly recommends further study to be conducted by increasing the number of samples so that the generalization can be made to another school as well. It is also recommended that the study should take the students' backgrounds into consideration such as gender, ethnicity and cultures.

Keywords: Visual Approach, Mathematics Achievement.

1. BACKGROUND OF THE STUDY

Despite the intensive efforts that have been taken by the government, non-government organisation (NGOs), teachers, and parents to increase students' performance in mathematics, the result from a survey entitled "Trends in International Mathematics and Science Study" (2012) shows that the level of mathematics achievement in Malaysia for secondary levels did not indicate a positive increase from 2007 to 2011. Dean (2007) states that one of the major causes of the decrease in students' achievement is their failure to understand what they have been taught in schools. Students have difficulties to understand when teachers introduce a new topic that requires them to learn a new concept. This problem is the most challenging responsibility encountered by mathematics teachers in the teaching process. Therefore, mathematics teachers are required to generate effective teaching methods in the classroom to increase students' achievements. Furthermore, effective strategies to teach mathematics must be well-developed. According to Small (2013), one of the effective strategies to teach mathematics is using visual approach. Although there are a number of studies on visual approach done on other subjects such as in science, language, and computer programming, there are very few of such studies for mathematics subject for lower secondary students especially in Malaysian context as visual approach is still new in teaching and learning process.

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Another major problem related to effective teaching method is due to the time constraint of the teachers. According to Sheppard (2008), teachers have heavy workloads other than teaching. Most of their time is spent in non-classroom duties, for instance, student counselling, grading students' work, extra-curricular activities, and communications with parents. This situation results in time constraint for teachers to prepare any teaching strategies. Thus, teachers opt to use a textbook method. Due to time constraints, teachers prefer to follow the textbooks not only in terms of the given methods but also the exercises in order to complete the syllabi in the specified time. Obviously, it is easier to teach mathematics by using the textbook approach. However, it is uninspiring for some students because of its dull and passive learning style.

The textbook method is very straightforward without any visualisation of the concepts of mathematics. Hence, students who learn the concepts of mathematics without visual styles cannot learn at their maximum potential. Students not taught by the appropriate learning styles cannot grasp the information from the teacher effectively. When they have to undergo examination, they tend to memorise the concepts of mathematics in order to pass the examination. This contradicts with the objective of teaching mathematics that aims to make logical connections between different facts and concepts, thereafter transform them into new ideas. In contrast, memorising the formulas, definitions, or theorems would not help students understand mathematics, especially at the higher level of education. They may have difficulties when dealing with complicated or lengthy questions. Therefore, teachers must look for alternatives to avoid students from only memorising mathematical concepts instead of understanding it.

In short, there are three major causes of the low students' performance in mathematics, which are a failure to understand the mathematical concepts, teachers' time constraint, and the students' tendency to memorise subject contents.

2. RESEARCH OBJECTIVE

This study aims to address these problems by focusing on one of the teaching strategies of teaching mathematics, which is a visual approach. Therefore, the effectiveness of the visual approach in helping students with hands-on and exploration activities was examined in this study. The objective of this research is as follows:

1. To investigate any significant difference in students' performance using visual approach in learning the content.

3. RESEARCH QUESTION

3.1 Research question 1

1. Is there any significant difference in students' performance using visual approach in learning the content?

4. SIGNIFICANT OF THE STUDY

This study attempted to investigate the potentially significant difference in students' performance using the visual approach in learning the content as opposed to the traditional method. This study can be an eye-opener for teachers to improve mathematics education by examining one of the teaching strategies in mathematics, which is by using visually appealing approach. In addition, visual approach inspires teachers to have systematic objectives,

methodologies, and materials in teaching mathematics. As a result, visual approach is expected to provide more effective learning styles than the traditional method using textbook to the teachers and to make the lesson becomes more attractive to their students.

Furthermore, visual approach also helps the teachers to develop students' understanding of mathematical concepts. Some of the students especially the visual learners have difficulties to understand mathematical concepts if they are being taught verbally. Since the visual approach encourages students to deal with the real objects and hands-on activities, this approach helps students who have weak mathematical skills to develop problem-solving and reasoning by themselves. The instruments of the visual approach such as the pictures and manipulatives methods assist students to make a connection between the abstract mathematical concept and the actual world. According to Small (2013), by using visual approach, students will be able to measure the quantity without using a written calculation. Therefore, it is vital to recognise the use of visual approach as it can lead to effective teaching methods.

4.1 Representation Systems in Mathematics

According to Guillermo (2005), there are five representation systems used by the teachers in the teaching and learning of mathematics to represent the mathematical concepts. The five representation systems are as follows:

1. Experience-based; system, which refers to the real-world problems as examples.
2. Manipulative or concrete models; which refer to teaching aids such as Base-10 blocks, films, and cards.
3. Pictures or diagrams; that denote the collective data by using graphs, figures, and bar modelling.
4. Spoken languages; i.e., the teacher writes the mathematics concepts on the board rather than just saying it verbally.
5. Written symbols; which refer to an English alphabet to represent mathematical expressions. For example, the term $x + 2$ where x is representing an unknown number.

The first four representation systems were applied in this study in the visual approach. Firstly, the experience-based system was used to connect all the learners' relevant life experiences to the mathematical concepts. Teachers can use real-life examples while teaching probability topic. For instance, the probability of the number of girls in the class can be demonstrated by grouping the girls together and counting the number of female students. The number was then divided by the total number of students in the class. Therefore, students can see the concept of probability, rather than just teaching the formula written in the textbook to the students. Secondly, teachers can also use manipulatives or concrete models to teach mathematical concepts such as addition, subtraction, place value, and counting. Base-10 blocks were used during the lesson, thus, students can manipulate the blocks in many ways to express numbers and patterns. Next, pictures or diagrams were used to represent the raw data into organised data. Besides, pictures or diagram also can represent the relationship between two variables. In addition, diagram can help students in understanding mathematical concepts easily. Lastly, spoken language was used to represent the characteristics of the mathematical concepts. Rather than just teaching verbally, the teacher could transform the words in writing form. For instance, the teacher could write the number 127 on the board for students to see instead of just saying the number one hundred and twenty- seven. Thus, students can easily understand the information.

Visual approach is one of the teaching styles applied the representation systems in order to develop an understanding of mathematical concepts. Therefore, it is important for teachers to master this representation system so that they can make an effective connection between graphical symbols and mathematical ideas to be seen visually.

4.2 Visual Approach

Numerous researches have been made by scholars to investigate the effectiveness of the visual approach towards students' achievement. According to Thornton (2001), students use two ways of thinking while attempting to solve mathematical questions, which are by using verbal logical and visual pictorial. Verbal logical thinkers do not need a diagram or picture to understand the information. They absorb information by engaging with reading materials and by discussing and debating ideas. On the other hand, visual pictorial thinkers need to form a diagram or picture to complete the tasks given. They learn the most from pictures, diagrams, and other visual aids. In addition, students with this way of thinking learn most effectively by drawing or visualising things using the mind's eye. The teacher guides this kind of students to draw or design the subject matter, and then write or create the written draft. As a result, the details in the drawing will lead to details in the writing.

On the other hand, Dixon (1983) defines visualisation as "the ability to recognize detailed information in picture-like images" (p. 6, as cited in Dean, 2007). Presmeg (1997) defines visualisation as a "process of constructing and transforming both visual mental imagery and the entire inscription of a spatial nature that may be implicated in doing math" (p.2). Dixon and Presmeg believe that the students attempt to understand and analyse the mathematical concepts by transforming the ideas into visual information and solve the problems using visual reasoning. Stokes (1999) defines visual literacy as "the ability to interpret images as well as to generate images for communicating ideas and concepts" (p. 10). Ana (2011) agrees that visual approach is recommended for teachers in making the interaction of mathematical concepts and its application using human senses in order to create concrete learning experiences. Both Stokes (1999) and Ana (2011) believe that any visual information will assist students in their learning since such stimulation will use their whole senses while engaging in the lesson. In this study, visual approach was used in teaching mathematics because the approach assisted the teacher in developing the new mathematical concepts and provided an active activity during the learning process. The teacher was required to stimulate all the students' senses especially their visual sense.

From the definitions, it is clearly understood that the visual approach can be used to allow students to understand mathematical concepts and at the same time to make the lesson becomes more interesting. Therefore, aid tools such as manipulatives, graphs, bar modelling, and flashcards can be used. Stokes (1999) mentions that visualisation is important for helping teachers because this approach assists them in making the relationship between the previous knowledge and the new one, changing abstract examples into concrete and avoiding from misinterpretation of the questions that sometimes can be long and complicated. Furthermore, by using visual approach, teachers will also be able to inculcate positive elements such as cooperation and creativity in teacher-student and student-student relationships during the teaching process. D'Souza and Wood (2003) emphasise that the formation of the collaborative study groups may develop higher-level thinking skills and stimulate critical thinking; hence, these study groups together with visualisation approach will be capable to solve the difficulties in mathematics subject among students.

Another research on visualisation was conducted by Moses (1977) with the 5th-grade students as the target group. The study aims to investigate the effectiveness of the visual approach in mathematics towards the group of students. The result of the study shows that the visual approach can assist to increase the 5th-grade students' performance in mathematics. This is due to the advantages of the visual approach that allows the students to see, imagine, and design the strategies for solving the mathematical questions. Consequently, the students find mathematics as an attractive subject, and not only just as a subject has that involved abstract ideas and lengthy questions.

In addition, Thorthon (2001) agrees that visual approach helps students to see the problem as a whole because students have to understand the questions thoroughly when dealing with any mathematical problems. Furthermore, he believes that the visual approach able to make the

students have a clearer picture of the mathematical concepts. Students need to understand the root of the mathematical problem by imagining the whole idea and then draft them out so that they can see the overall picture of the problem. After all of these steps, the students can proceed to solve the problem systematically. Cavendish (2010) also states that students who have difficulties in solving a lengthy question can use a visual approach to solve it. By using visual approach as the way to understand and solve the question, students must make a generalisation of the question and extract information essential information to solve the problem. Later on, students need to build the strategies according to the information obtained and aim to solve the problem using the knowledge that they already have.

Moreover, the study on the effectiveness of visual approach done by Stokes (1999) also recommends using the visual approach in teaching mathematics. Due to the nature of some students who prefer to learn using visual learning style. Some students have the tendency to think in pictures rather than in words. Hence, by teaching using the visual approach, it is not the only motivating students who are the visual thinker, but other leaner styles such as the verbal and kinesthetic thinkers can also benefit from this approach. The visual approach acts as another alternative for the students to understand the mathematical concepts, as well to realise the importance of mathematics in their life.

However, Woolner (2004) in her research disagrees that the visual approach may help to increase students' achievement. When comparing the result of students between learning by textbook and learning using visual approach, she found out that students who learnt using visual approach performed lower than students using the textbook approach. This was due to the fact that students were more comfortable with the traditional textbook method, rather than engaging with the subject in visual, which was very new to them. The textbook method was seen by the teachers and students as simpler and more practical than the visual approach. Moreover, Woolner (2004) also identifies another reason for the low performance of students in mathematics. The reason was due to the fact that the teachers involved in her study were not used to applying the visual approach in their teachings. Without organised teaching strategies, teachers will not teach the visual approach effectively. The visual approach requires a deliberate preparation in terms of appropriate material, effective time management, and mastery of the subject content. Teachers need to give their full commitment to ensure the teaching strategies can be applied successfully.

5. RESEARCH DESIGN

This study explored the effectiveness of the visual approach in constructing and developing the new mathematical concepts to the students. Quantitative method was used to conduct the pre-post survey design study. The measurement was taken before and after the respondents received the treatment. According to Creswell (2005), this method could have benefits on students' understanding of mathematical concepts and improve their scores in examinations. In this study, pre-test and post-test were used to obtain the results of the students' achievement. Another instrument used in this study was the questionnaire. The set of questionnaires was employed as an instrument for the collection of data needed for the participants selected in the study. This questionnaire aims to investigate the students' perception of the visual approach in learning mathematics. In fact, surveys are frequently used in social sciences to study people's views and feelings (Graziano & Raulin, 2000). Besides, the questionnaire also helps in gathering the data from quite a number of respondents

6. POPULATION

The population of this research was Form Two students (417 students) from a school situated in the outskirt of Kuala Lumpur. The sample of this study was 85 students from two intermediate classes. In addition, the mixed-gender and ethnics of about the same level of proficiency were used as a sample. Furthermore, purposive sampling was used to select the sample for representing the population. According to Drew, Hardman and Hosp (2008), this sampling is used to represent the population where the samples are selected because of some identical characteristics. The characteristics of this sample were students who had completed the Malaysian National Secondary School (KBSM) mathematics syllabus since Form One and students who have learned from the same teacher in Form Two. It is important to have students learning from the same teacher so that the students were assumed to have gotten equal treatments and taught using similar teaching styles.

7. RESEARCH FINDINGS

The results and findings were intended to answer the following research question:

Research Question 1: Is there any significant difference in students' performance using the visual approach in learning the content?

The results from the pre-test and post-test were used to measure the difference of scores after the students went through the treatments. The difference of the results would indicate whether the visual approach was able to help the students in building the new mathematical concepts. The minimum test score for each student would be zero (0) and the maximum score would be thirty-five (35). The scores and the analysis of the scores for students in Class A are illustrated in Table 1 and Table 2.

Table 1 Mean scores for class A

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	posttest	20.68	31	7.382	1.326
	pretest	7.06	31	3.586	.644

Table 2 Paired- sample test for class A

Paired Samples Test									
		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Dev	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	posttest pretest	-13.613	7.805	1.402	10.750	16.476	9.711	30	.000

Table 1 and 2 present the results of paired- samples t-test that was conducted to evaluate the impact of the visual approach on achievement in mathematics for students in Class A. Table 1 shows the comparison of mean scores between the pre-test and post-test. The post-test scores were found to be higher (mean = 20.68, SD = 7.382) compared to the pre-test score (mean = 7.06, SD = 3.586). Next, Table 2 presents that there was a statistically significant increase in the

mathematics scores from before the treatment (mean = 7.06, SD = 3.586) than after the treatment (mean = 20.68, SD = 7.382), *t(30) = 9.711*, *p < .05* (two-tailed). The mean increase in mathematics scores was 13.613 with a 95% confidence interval.

Next, Table 3 and Table 4 present the test results for the students from Class B.

Table 3 Mean Scores for Class B

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	posttest	3.69	29	3.557	.660
	pretest	.97	29	1.636	.304

Table 4 Paired-Sample Test for Class B

Paired- Samples Test									
		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Dev	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	posttest pretest	-2.724	2.914	.541	1.616	3.833	5.034	28	.000

Table 3 and 4 present the results of paired-samples t-test that was conducted to evaluate the impact of the visual approach on achievement in mathematics for students in Class B. Table 4 shows the comparison of mean scores between the pre-test and post-test. The post-test scores were found to be higher (mean = 3.69, SD = 3.557) compared to the pre-test scores (mean = .97, SD = 1.636). Next, Table 5 reveals that there is a statistically significant increase in the mathematics scores from before the treatment (mean = .97, SD = 1.636) than after the treatment (mean = 3.69, SD = 3.557), *t(28) = 5.034*, *p < .05* (two-tailed). The mean increase in mathematics scores was 2.724 with a 95% confidence interval. Table 5 shows that the scores between pre-test and post-test for both classes are summarised in Table 5.

Table 5 results of pre-test and post- test for both classes

	Class A		**Class B**	
	Pre- A	**Post- A**	**Pre-B**	**Post-B**
Mean Score	7.06	20.68	.97	3.69
Std. Dev.	3.586	7.3282	1.636	3.557
Sig. (2-tailed)	.000		.000	

8. CONCLUSION

The analysis in the previous section indicates that the visual approach could assist students to score better in their post-test. After being taught using the visual approach, the students were able to solve the mathematical problems more easily. They were also able to transform and develop an intangible fact into the concrete information. Consequently, the visual approach helped the students to have a thorough understanding of the mathematical concepts that they learnt. In dealing with the mathematical problems given, they tried to change and manipulate the abstract concept into concrete understanding. It was easier for them to understand the problem and then effectively solve it. This finding is contradictory to the finding by Woolner (2004) as this study found that visual approach helped to increase the students' achievement.

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