THE EFFECT OF GEOGEBRA ON STUDENTS' MISCONCEPTIONS OF LIMIT FUNCTION TOPIC

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Abstract: A quasi-experiment was conducted to determine the effects of using the GeoGebra software as a teaching aid to reduce misconceptions of limit function among Form Two students. The experimental study was conducted on 284 Form Two students. A total of 138 students were grouped in the treatment group, while another 146 students were grouped in the control group. Data were analyzed using Anates 4 software and SPSS 23.0. The findings of the study showed that there were no significant differences in the misconceptions of students based on the type of group. The results showed that the use of the GeoGebra software as a teaching aid could reduce misconceptions of limit function better than the traditional method. Moreover, learning mathematics with the help of GeoGebra software allows an active interaction between teachers and students. Such interaction cannot be fully realized in traditional learning settings.

Keywords: *Conceptual knowledge, GeoGebra, Misconception, Quasi experiment, Technology*

INTRODUCTION

Many countries currently encourage the use of technology in teaching and learning. In mathematics teaching, the use of technology allows students to master and gain an improved understanding of the fundamental skills required in the study of mathematics. Hence, teachers should have access to comprehensive support and training as part of the effort to improve the necessary skills in exploring the maximum potential of information technology. Mathematics is a dynamic subject that entails the application of numerous methods and strategies to ensure an effective teaching and learning process. The use of technology in teaching and learning Mathematics can help students understand mathematical concepts and develop intuition on mathematical problems (Tarmizi et al., 2009). In fact, the use of technology could contribute to enhancing students' conceptual and procedural knowledge in Mathematics. GeoGebra software is the best software among other extensive software packages tailored to the study of calculus. Integrating such fundamental software into teaching calculus, algebra, and geometry is deemed favorable. Given that this free software can be easily downloaded by students, it can be used as an inexpensive, computer-based homework for students. Other support materials for the software are readily available, extensive, and effective as teaching resources. In particular, GeoGebra software can be adopted in teaching and learning geometry, algebra, and calculus (Antohe, 2009; Haciomeroglu et al., 2009; Rincon, 2009). The use of GeoGebra software in teaching and learning mathematics is one method to create a meaningful learning experience for both teachers and students.

One of the aspects of technology-based learning is its capability to provide support services for a diverse set of students through the free sharing of ideas and a certain learning focus. One tool for such idea sharing is the learning software called GeoGebra. GeoGebra software is the best software among other extensive software packages tailored to the study of calculus. Integrating such fundamental software into teaching calculus, algebra, and geometry is deemed favorable. Given that this free software can be easily downloaded by students, it can be used as an inexpensive, computer-based homework for students. Other support materials for the software are readily available, extensive, and effective as teaching resources. In particular, GeoGebra software can be adopted in teaching and learning geometry, algebra, and calculus (Antohe, 2009; Haciomeroglu, 2009; Hutkemri & Effandi, 2010; Rincon, 2009). The use of GeoGebra software in teaching and learning mathematics is one method to create a meaningful learning experience for both teachers and students. Most people agree that the software is best used to explain various concepts and procedures in mathematics through the use of graphics, visuals, images, and symbols. GeoGebra software is also a type of interactive software that enables a two-way interaction between students and the software. This software is student-centered, and thus, enables students to control their own learning pace through sample questions, practices/exercises, and steps to solve mathematical problems. GeoGebra provides detailed steps and guidance on concepts and calculation in the process of helping students master every topic. Students or users are given sufficient time to answer the questions in the exercises.

A misconception is an inaccurate assumption and description developed by an individual about a phenomenon based on his personal experiences (Martin et al., 2002). Arnida (2007) defines misconception as a model of thinking, understanding, or a wrong idea developed by students which is the opposite of real theory and concepts. Misconceptions occur when ideas are wrongly visualized or translated during the idea development process. Misconceptions happen when one is confused or lack of understanding on the information he receives from his daily experiences, formal and informal conversations, and distortion of instructions that he receives either formally or informally before he develops his own ideas. Misconceptions of students are not solely due to the applied method of learning. Misconceptions can be caused by learners, teachers, textbooks, contexts, and teaching methods (Suparno, 2013). If there is a mistake in understanding a concept, it is impossible for students to be able to analyze these concepts and will affect learning objectives. In this study, misconceptions refer to how students develop wrong ideas, misunderstand definitions, and concepts, which happens because of confusion or lack of knowledge on the limit function topic.

At present, mathematics is still considered a challenging subject in school and is dreaded by most students. It is also regarded as difficult and uninteresting. Although this subject, particularly calculus, statistics, and geometry, is beneficial in life, most people do not realize its benefits and practical applications. Consequently, students are not motivated to learn mathematics, and mathematics education fails to make a significant contribution to school education in general, particularly in terms of developing the thinking ability, personality, and attitude of students. There are many reasons that cause students to have misconceptions in learning Mathematics (Mehmetlioğlu, 2014; Aygor & Ozdag, 2012). The teacher may be at fault, when a teacher teaches the wrong concept and does not even realize that the concept have been delivered wrongly (Williams & Ryan, 2000). Another reason is that students could have difficulties developing their own conceptual knowledge, thereby resulting misconceptions via their own attempt, because their attempt is built from wrong personal analogies (Saleh & Ismail, 2000). Students commonly ignore any evidence not aligned with their own thoughts or description, and thus, may simply interpret any new knowledge based on their own initial conception. Previous studies have revealed the advantages of using GeoGebra software in various ways including enhancing students’ understanding on the concepts and procedures, solving mathematical problems, and improving achievement (Aizikovitsh & Radakovic, 2011; Bu et al., 2011). However, there are still not enough studies conducted to examine the effects of using GeoGebra in reducing misconceptions commonly displayed by students. Based on the problems mentioned above, this study seeks to determine the effects of teaching through the use of the GeoGebra software to reduce misconceptions on the limit functions topic among Form Two students.

METHOD

Participants

The study is a quasi-experimental study that used non-equivalent pretest and posttest control group designs. A total of 284 Form Two students were involved in this study. Wiersma (2000) used quasi-experiments of non-equivalent pre-test and post-test control groups of available classes to determine the effects of using technology in the real situation. The students were grouped into two: 138 students (48.6%) were placed in a treatment group and another 146 students (51.4%) were placed in the control group. The GeoGebra software was introduced and used by teachers and students for a period of 4 weeks equivalent to 20 hours. In the early stages of teaching, the teachers used the GeoGebra software to explain the concept of limit function. Students in the control group were taught using the traditional method, at the same time students in the treatment group were using the GeoGebra software. The use of GeoGebra in this study involved two teachers who were selected and trained to teach the limit Function topic to both groups.

Measurement

Five items (questions) in the instrument were used to measure the students’ conceptual knowledge of the limit function topic. The test questions were adapted from previous studies conducted by Bell (2001), Teachey (2003), and Jensen (2009). The marking was schemed according to the number of questions for measuring conceptual knowledge. The ideal score was 20 marks. Students who scored 0, 1, and 2 are categorized as those who have misconceptions. The pilot study was done on 60 Form three students to determine the validity of discrimination and difficulty index of each question. The Anates software was used to determine the discriminant index and the difficulty level index of the conceptual knowledge test. The discriminant index of each item to test the conceptual knowledge were ranged from 35.94% to 76.56%. These ranges indicate that the discriminant index of each item was at a good level. The difficulty index of each item to test the conceptual knowledge were in the range of 39.84 to 62.50. Each item to test conceptual knowledge were at a very good yet moderate level. Therefore, the difficulty and discriminant of the questions are balanced and near perfect (To, 1996). The reliability value of the questions to test conceptual knowledge was 0.83 relatively, indicating that the reliability of the questions to test the students' conceptual knowledge on the limit function is at a good level (Lim, 2007).

Data analysis

Research data were analyzed using SPSS 23.0 software. Descriptive analysis involving frequency, percentage, and mean was used to compare any differences of misconception between the experiment and control groups. The ANCOVA test was performed for inferential analysis.

RESEARCH FINDINGS

Difference of misconception between treatment and control groups

Analysis of covariance (ANCOVA) was performed to identify the difference between the misconception of the treatment and the control groups in which the pre-test was used as covariate. Prior to ANCOVA, certain requirements for the test needed to be met, such as normality and homogeneity of variance between groups. The normality test shows that the skewness and kurtosis value for the mathematical belief pre-test for the treatment group and the control group is (.05, -.10) and (-.46, .53), respectively. For the post-test of misconception, the treatment group has (-.47, .87), and the control group has (-.57, .80). This result shows that the normality requirement was met. Pallant (2007) stated that data are considered normal if the skewness and kurtosis value is between -1.96 to +1.96. Levene's test was performed with a value of F = 4.62, sig = .53 (p>.05) to determine the homogeneity of variance between groups. This finding shows that the data have similar variance between the groups. Therefore, ANCOVA can be performed to identify the difference in the misconception between the treatment group and the control group as shown in the table below.

Table 1
ANCOVA: difference of misconception between treatment and control groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	154.668a	2	77.334	20.864	.000	.129
Intercept	426.328	1	426.328	115.017	.000	.290
Pre	121.473	1	121.473	32.772	.000	.104
Group	10.623	1	10.623	2.866	.092	.010
Error	1041.568	281	3.707			
Total	28155.000	284				
Corrected Total	1196.236	283				

The ANCOVA test result in Table 1 shows a no significant difference in the mathematical belief between the treatment and the control groups with pre-test as a covariate [F (1,281) = 2.866, sig = .092 (p>.05)]. However, students in the treatment group (mean = 10.08) have a higher misconception than students in the control group (mean = 9.39), which means that the GeoGebra has a better effect on the decrease in the misconception of students than the use of the traditional method. Such differential effect is small (partial eta square = .010) (Cohen, 1988).

Misconceptions of the limit functions topic in mathematics between students in the treatment and control groups

The results of the descriptive analysis involving frequency and percentage of the misconception of the limit functions topic in Mathematics, are described in the table below.

Table 2
Frequency and percentage of misconceptions of the limit functions topic in mathematics between students in the treatment and control groups

Question	Treatment group (n=138)			Control group (n=146)		
	Scores frequency and percentage			Scores frequency and percentage		
	0	1	2	0	1	2
Question 1	-	-	10 (7.2%)	-	-	15 (10.3%)
Question 2	-	6 (4.3%)	30 (21.7%)	-	-	32 (21.9%)
Question 3	1 (.7%)	4 (2.9%)	28 (20.3%)	2 (1.4%)	6 (4.1%)	41 (28.1%)
Question 4	-	8 (5.8%)	57 (41.3%)	3 (2.1%)	13 (8.9%)	70 (47.9%)
Question 5	-	-	52 (37.7%)	8 (5.5%)	11 (7.5%)	67 (45.9%)

Based on the first question, 10 students (7.2%) from the treatment group and 15 (10.3%) students from the control group have misconceptions the question. 36 students (26.0%) from the treatment group and 32 (21.9%) students from the control group have misconceptions the second question. Next, 33 students (23.9%) of the treatment group and 49 students (33.6%) of the control group have misconceptions the third question. 65 students (47.1%) from the treatment group and 86 students (58.9%) from the control group have misconceptions the fourth question and 52 students (37.7%) from the treatment group and 86 students (58.9%) from the control group have misconceptions the fifth question. Overall, the treatment group had less misconceptions than control group.

DISCUSSION

A larger number of students from the control group had more misconceptions than students from the treatment group. Misconceptions among students from both groups occurred only because students obtained half correct concepts or students stopped the calculation without explaining their answers. Misconceptions among students from the treatment group on the limit function topics were lower than that of students from the control group. The treatment group had lesser misconceptions because they had the advantage of using GeoGebra. GeoGebra explains the concepts in the limit functions topics in daily life, which strengthened the students' knowledge on the concepts, thereby reducing misconceptions. Students from the control group were not familiar with the concepts, and many of them had yet to fully master the concepts of the limit function topic; therefore, many of them had misconceptions. Results of this study is supported from the findings of Marquel and Thompson (1997) who stated that misconceptions in mathematical learning could occur when students form wrong assumptions, do not have sufficient information, and receive wrong data. When students form the wrong assumptions in understanding a lesson, they also develop the wrong concept. Hence, they fail to master the lesson and consider the subject to be too difficult to learn.

Misconceptions in learning and teaching Mathematics is also reduced when they use GeoGebra because GeoGebra involves graphics that help users strengthen their conceptual knowledge of Mathematics, particularly for the limit function topics. The images or visuals from the GeoGebra software help teachers explain concepts and easily deliver information that is relevant to the topic. Abstract concepts are easily explained to students through clear steps and the real correlation of the knowledge of students with their surroundings. This finding supports the research findings by Contreras (2002) who found that students have better understanding of the concepts of limit function when they use graphic materials. Graphics help students answer functional questions and misconceptions on the limit function. Misconception means a concept is defined differently than the real meaning of the concepts learned in class. It can happen to students with low mathematical competencies, as well as those with average and high mathematical competencies. When students have misconceptions certain concepts, they encounter problems and commit errors in the process of solving a problem. Therefore, students have to strengthen their conceptual knowledge at the very beginning of their lesson to prevent prolonged misconception (Yahaya & Savarimuthu, 2008).

Students who use GeoGebra provided various answers from the same mathematical problem. In contrast, students who learned traditionally had almost the same answer. Students are constantly provided with opportunities and sufficient time to explore and deliver the best task through the use of GeoGebra software. Interventions from teachers are minimal, particularly when students are fulfilling their respective tasks productively. During such explorations, the role of teachers involves giving simple instructions, facilitating lessons, and assisting students who face problems or difficulties in exploring the software on their own. The same findings have also been obtained in a study conducted by Teuscher (2008), where the subjects of the study had the ability to solve the mathematical problem of the calculus topic, but their answers were almost the same. Students who use the GeoGebra software can provide various answers, because the software helps them understand the abstract concepts and relate and have better understanding of the topic (Antohe, 2009). Students who learn the same topic using the traditional method are more passive in receiving information from their teachers, which causes them to be unable to develop the concepts that they have learned and fail to understand the basic concepts.

The present review encourages educators to use GeoGebra for reducing or eliminating the common problems faced by students in acquiring conceptual knowledge. Students must be intellectually involved in their mathematics work. In this way, they are required to articulate their answers (in writing or hard copy) or verify their mathematical ideas. Using GeoGebra is the best approach for improving the knowledge of students in producing concepts and delivering solutions to solve mathematical problems as easy as possible. Apart from determining that the software can enhance the conceptual knowledge of students, this study also found that the GeoGebra provides students and teachers with a natural interaction during the learning and teaching process. Consequently, the learning environment improves and the teaching scope enhances. Specifically, teachers are offered with various ways to develop and deliver their lesson. Meanwhile, students are personally involved in their own learning process. Teachers and students can therefore achieve the objective of independent learning using GeoGebra.

CONCLUSION

The use of the GeoGebra software in the learning process can reduce misconceptions. The use of GeoGebra software in the learning process of students can definitely help them master mathematics. It is an alternative learning method that can be used in classroom or laboratory settings. In addition, using GeoGebra software reduces misconceptions that are commonly committed by students. GeoGebra software is an easy-to-use technology application that provides students with the opportunity to visualize their ideas using certain concepts and even graphic illustrations. GeoGebra software also facilitates the teaching of mathematics. Teachers can freely apply the software in their teaching and learning process. In particular, the GeoGebra teaching module suggests several teaching ideas for mathematics teachers. The images or visuals from the module help teachers explain concepts and easily deliver information that is relevant to the topic. Abstract concepts are easily explained to students through clear steps and the real correlation of the knowledge of students with their surroundings. Although GeoGebra software is an alternative teaching method in itself, the school should manage a mathematics laboratory and encourage the full implementation of GeoGebra in the teaching and learning process. The software supplements a variety of teaching techniques, particularly those used to deliver creative mathematics lessons. In addition to the commitment of the school administration, a special training should be conducted to highlight the advantages of GeoGebra and to explain its use to achieve its maximum benefits for students. The school administration should eliminate the negative paradigm toward the use of technology in teaching and learning, particularly among teachers.

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