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EXPLORING STUDENTS' CONCEPTUAL UNDERSTANDING OF PARALLELOGRAMS BASED ON GEOGEBRA

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Abstract

This study used a mixed mode approach and aimed to explore students' conceptual understanding in geometry using GeoGebra. The focus of this study was on the concept of parallelograms. This study was conducted in an Iranian governmental boys' school using ten grade two lower secondary school students as participants. These students were randomly divided into two groups. The first group underwent the lesson using the GeoGebra whereas the other group was taught using the traditional approach. This research findings focused more on the qualitative section and less on the quantitative section in which detailed observation were executed as well as the mean scores and standard deviation of both groups were compared. Non-equivalent pre-test and post- test were administered respectively to evaluate students pre-requisite knowledge and conceptual understanding of the concepts of parallelograms. The findings of this research will be useful to mathematics' teachers in planning for their geometrical activities.

Keywords: GeoGebra; parallelograms; conceptual understanding

Introduction

Nowadays, in educational policy and research document there is a shift of thinking about different ways of teaching that focus on students as the center of the teaching and learning processes (Ayele, Schippers, & Ramos, 2007). The National Council of Teachers of Mathematics (NCTM, 2000 as cited in Myers Sr, 2009) mentioned students should learn mathematics with conceptual understanding. This is because the memorisation of facts and procedures does not necessarily lead to students' awareness of how and when to use their knowledge. Therefore, technology is an essential and highly recommended tool in the teaching of mathematics.

Computer applications have appeared throughout all aspects of the education system as a pedagogic tool, which might improve higher order thinking and might provide learners with a new perspective and vision. In particular, Dynamic Geometry Software (DGS) are designed to provide a learning environment where students can explore and reach an understanding of powerful mathematical ideas independently (Eley, 2008).

Technology software programs aid the formation of visual images, which fosters students' success in mathematics. Habre (2001) supposes that students who are good at responding to mathematical questions are better at visualising, whereas the ones who are less capable in performing this task are recognised to be weak in visualising images. Thus, Dynamic Geometry Software by providing those images, helps students better understand abstract concepts. A study by Vincent (2005 as cited in Abi Saab, 2011) stated that students working with Dynamic Geometry Software formed valid proofs because the activities they went through on the software offered a confirmation of the truth of their conjectures and a justification in respect of why the connection works the way it does.

Objective of Research

The purpose of this study was to explore students' conceptual understanding in geometry using GeoGebra, which is a type of interactive dynamic geometry software that gives students a hands-on and visual approach to learning mathematics. The focus of this study was on the concept of parallelograms.

Literature review

According to the principles of the constructivist approach, the teacher in the classroom should be a facilitator who encourages learners to take responsibility for their learning and play an active role in their process of acquiring knowledge. This process can be catalysed in a computer environment through the interactive process of conjecture, feedback, critical thinking, exploration and cooperation (Kul, 2011). Besides, Scher (2005 as cited in Abi Saab, 2011) noted that the use of technology software together with a meaningful class discussion may lead to a deep conceptual understanding.

Funkhouser (2002) found that integrating technology with a constructivist teaching pedagogy leads to more constructivist, student-centred teaching approach. In another study on the effects of technology on learning mathematics, Galbraith (2006) found that it enables students to collaboratively communicate, conjecture, rationalise, and generalise findings The dynamic nature of the software aids the process of "doing mathematics", as the constructivist theorists express. The features such as measuring, moving, dragging can enhance the exploration process. Therefore, dynamic geometry software, such as GeoGebra, can play an important role in giving educators the opportunity to create learning situations that are explorative, visually attractive, and motivating (Abi Saab, 2011).

In addition, Ng &Leong (2009) highlighted that Dynamic Geometry Software have some remarkable characteristics which allow users to drag specific points of constructed objects. Besides that, the feature presented by dynamic geometry software contributes users to monitor their construction whether it has preserved the main properties or not. These tell us that dynamic geometry software provides possibilities for the students to learn the concepts of geometry by investigating through their mistakes. To illustrate, in order to construct the parallelograms students are required to consider perpendicularity and parallelism principals in their performing otherwise their constructed shape will not be a parallelogram.

One of the greatest software advancements being used in today's classrooms is the dynamic geometry software called GeoGebra which was created by Markus Hohenwarter in 2001/2002. As dynamic mathematics software, GeoGebra has the potential to help teachers implement teaching test conjecture on geometry, algebra, and calculus. GeoGebra is a dynamic learning environment that enables its users to create mathematical objects and interact with them. GeoGebra users, mostly teachers or students, can use this environment to explain, to explore, and to model mathematical concepts and the relationships between them, or mathematics in general (Hohenwarter & Jones, 2007).

Hohenwarter, Hohenwarter, Kreis, & Lavicza (2008) pointed out that GeoGebra was a Dynamic Mathematics Software for schools that joined geometry, algebra, and calculus, which forms an interactive classroom among students. Zerrin & Sevinc (2010) stressed that by incorporating GeoGebra into mathematics teaching, students became active performers instead of just passive listeners. Thus, higher and desired achievements were obtained by implementing GeoGebra in the classroom.

Zulnaidi & Zakaria (2010) found that GeoGebra effectively distribute knowledge that consists of planning, delivery, guidance, and evaluation that aims to spread the knowledge or skills to students. As well as GeoGebra not only empower students to grasp mathematics concept profoundly, but also enable Students to change objects in the dynamic setting, which is provided by GeoGebra. This exploration and investigations through free objects allow students to reach the problem solving skills (Dikovic, 2009).

Furthermore, Ely (2008) stated that students learn the difference between constructing figures versus drawing them when using dynamic software such as GeoGebra. Students who construct figures instead of drawing them can easily test conjectures in this dynamic environment. This allows students to develop their own learning at their own pace through exploring different ways to create a construction where all of the properties of that geometric figure are present.

Some researchers have been conducted in Malaysia regarding the effectiveness of GeoGebra. To illustrate, Bakar, Ayub, & Tarmizi (2002) indicated that GeoGebra makes learning the topic of transformation more understandable for secondary school students, as well as Saha, Ayub, & Tarmizi (2010) mentioned the use of GeoGebra enhanced the students' performance in learning Coordinate Geometry.

However, research still needs to analyse the full effect it could have on how secondary school students can strengthen their reasoning and conceptual understanding in geometry. This study therefore aimed to explore how one specific type of software, GeoGebra, could have an effect on how students' learn major concepts and reasoning skills in geometry.

Methodology

Participants

There are two Iranian governmental schools in Malaysia, which are separated with regard to students' gender as a boys' and girls' school. In each school the levels of education start from grade 1 to grade 13 ,which are categorised as primary levels ,lower secondary or middle levels and high levels. Lower secondary school starts from grade 7 to grade 9. Participants in this research were students from grade 8, which were categorised as students in 2th grade of lower secondary school. Iranian boys' school in Malaysia had 150 students where one class was allocated to each grade in this school. Therefore, there was only one class of 2th grade of lower secondary in the school, which comprised 10 students. These students were randomly divided into two groups. The first group underwent the lesson using the GeoGebra whereas the other group was taught using the traditional approach.

Instruments

Electronic Applets

GeoGebra 4.2 was used to develop Applets representing the geometrical concepts taught in this research intervention. Five Applets were presented in this research considering the instructional activities to represent the intended geometrical concepts.

Worksheets

In order to support students‟‟ work with the applets, five worksheets were developed.

Each of the worksheets contained tables, the tasks and the questions, which required students to use applets in order to obtain the proper and relevant responses. The tables were supposed to be filled with the appropriate values or numbers as well as describing the relationship between objects and their states after dragging the geometrical constructions in the applets.

Procedure

All the intended geometry instructional activities of GeoGebra group were held in the computer laboratory at Iranian boys' school in Kuala Lumpur, the capital of the Malaysia. The condition of the laboratory was satisfactory. Five-laptop computers were provided for students in order to each student in GeoGebra group could work and use GeoGebra individually.

The participants in the research were ten grade 2 students (13-14 years old) who were randomly divided in two groups. Students(1,4,6,7,and9) distributed in the GeoGebra group whereas students(2,3,5,8,and10) distributed in traditional approach group. The sequence of the data collection activities was tabulated in Table 1.

Table1

The sequence of the data collection activities

Day	Type of activity	Subject matter	group	periods
First	Pre-test		All students	50 min
First	Instruction	Introducing to the GeoGebra	GeoGebra group	45 min
First	Instruction	Definition of parallelograms (total features and its plotting)	Both groups	9o min

second	Instruction	Exploring the relationships between the properties of parallelograms.	Both groups	9o min
Third	Instruction	"The sum of distances from one optional point in a parallelogram to its sides is always a constant value."	Both groups	Approx 45 min
Third	Instruction	Parallelograms' areas are twice more than the area of a triangle, if they are common in one based and height.	Both groups	Approx 45 min
Fourth	Instruction	"If we connect the midpoints of an optional convex quadrilateral consecutively, then what is the name of the resulted shape"?	Both groups	40 min
Fourth	Post-test		All students	50 min

Findings and Discussion

The strategy to answer the research questions and to determine the state of the hypothesis of this research whether it would be accepted or not, was based on the making analysis of qualitative data collections from students' worksheets and teacher-researcher's observation during each day of the class. The research findings focused more on qualitative section and less on quantitative section. Analyzing the results of pre-test and post-test were based on comparing the mean scores and standard deviations of both groups.

Findings from class observation during using GeoGebra indicated that students were engaged with the each instructional activity. In the first instructional activities in which students explored the general properties of the parallelograms tasks 1 to 5 were applicable even by ruler and protractor whereas tasks 6, 7, and 9 could only be done in GeoGebra setting. Each student in GeoGebra group was engaged and had discussion before filling their worksheets. This allowed them to visualise and listen to their classmates' analysis and after that based on their understanding responded to the each task in their worksheet. This preference assists students in understanding the general properties of the parallelograms conceptually since all students wrote correct description for five common properties of parallelograms in their worksheet. The result was consistent with Scher (2005 as cited in Abi Saab, 2011) noted that, the use of technology software together with a meaningful class discussion may lead to a deep conceptual understanding.

Students' responses in GeoGebra group to the question 5 in post-test indicated that 3 out of 5 students were given completely correct answers and half part of the answers of two other students in this group were correct. In addition, the result of question 1 in pre-test shown that three of students in GeoGebra group gave wrong answer to this question in which assessed students pre-requisite knowledge respecting to diamond properties. However, those three students gave correct answer to question 2 of post-test in which assessed students conceptually understanding concerning diamond properties. Besides, question 4 in post-test assessed students conceptually understanding with regard to the question "can a diamond be a square". Overall students function in this question was not acceptable; nevertheless, students who gave correct answer to this question were 3 out of 5 students in GeoGebra group. The result of this question revealed that GeoGebra help students to understand this concepts profoundly rather than students in traditional approach group.

Furthermore, according to the findings of the question 7 in post-test, 4 out of 5 students gave correct answer to this question. However, only one student in traditional approach group gave correct answer to this question. Again, GeoGebra helped students to grasp the subject conceptually. This outcome took placed for question 9 as well, and is consisted with the Habre (2001) findings that highlighted that students who are good at responding to mathematical questions are better at visualising, whereas the ones who are less capable in performing this task are recognised to be weak in visualising images. Thus, DGS, by providing those images, helps students better understand abstract.

Students' pre-test results indicated that all students in GeoGebra group scored lower than those in traditional approach group did. It should be noted that students were randomly divided in two groups and without considering their pre-test result. However, after intervention the results of the post-test indicated that the GeoGebra group outperformed than those in traditional approach group. The result of the post-test approved that GeoGebra had positive impact on understanding the concept of parallelogram conceptually which means research hypothesis was acknowledged. The mean scores and standard deviations for each group based on their pre test and post-test were tabulated in following table 2.

Table2
Results of descriptive statistics of both groups

Group	Pre- test		Post- test	
	Mean	S.D.	Mean	S.D.
GeoGebra (n=5	4.35	2.559	6.85	2.343
Traditional (n=5	7.45	2.484	4.95	1.708

Conclusion

The purpose of this study was to explore students' conceptual understanding in the concept of parallelograms using GeoGebra. The result obtained through observation and students' responses on their worksheets revealed that GeoGebra efficiently assisted students' conceptual understanding of parallelograms. GeoGebra provided an interactive environment between students and led them to have more discussion during instructional activities. This result is consistent with Zerrin and Sevinc (2010) who stressed that by incorporating GeoGebra into mathematics teaching, students became active performers instead of just passive listeners.

In short, GeoGebra assisted students in understanding conceptually rather than memorising the concepts of parallelogram as this result was appeared in questions of post-tests. As well as students in GeoGebra group outperformed than those in traditional approach group in their post-test, which acknowledged the research hypothesis that GeoGebra had positive impact on understanding the concept of parallelograms conceptually.

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