Effect of Using Logo on Pupils' Learning in Two-Dimensional Shapes

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ABSTRACT

The integration of technology in mathematics instruction is an important step in the 21st century learning style. At the primary level, some studies have explored how technology could help in mathematics learning. The purpose of this study is to determine the effect of using Logo on pupils' learning of the properties of two-dimensional shapes. A total of 36 mixed ability Year 4 pupils from a primary school in Pahang, Malaysia participated in this study using the quasi experimental research design. The experimental group was taught using Logo while the control group was taught with the traditional method. The difference in achievement between the experimental group and control group was measured by pre-test and post-test. Results showed that the experimental group students performed better than the control group. Pupils' perception toward using Logo was measured by using a questionnaire with close-ended items. The findings of this study indicated that using Logo improved pupils' understanding of two-dimensional shapes. In addition, pupils have positive perception toward learning the properties of two-dimensional shapes using Logo.

Keywords: *Logo; effect; properties; two-dimensional shape; primary mathematics*

INTRODUCTION

In 21st century learning, technology integration in the teaching and learning process is essential as it stimulates the critical and logical thinking capabilities of pupils (Idris, 2006). Technology use in the teaching and learning process will help pupils learn at their own pace, with teachers acting as facilitators rather than direct content providers (Ministry of Education, 2000). According to Noeth and Volkov (2004) pupils learn faster with greater retention using current technology. However, without the use of technology this could affect students learning and achievement in the classroom (Al-Bataineh & Brooks, 2014).

Technology should be a tool to help educators meet the educational needs of all children. The idea that technology is an essential tool for teaching and learning mathematics has also been supported by the National Council of Teachers of Mathematics (2000). Educators also play a significant role in facing the enormous challenges in mathematics education especially in integrating the useful dynamic educational software into the teaching and learning process to help provide useful learning resources to pupils. The challenge is even more complex in the teaching and learning of disciplines such as mathematics, where teachers have to balance the use of mental, paper-and-pencil and digital tools in both teaching and assessing activities involving abstract mathematical concepts, often difficult to understand for pupils (Prietor, Juanena, & Star, 2014). Some examples of dynamic educational software used in mathematics instruction include Geometers Sketchpad (GSP), TinkerPlots, Logo Programming Language, GeoGebra, graphic calculator and so on. Further, Noraini Idris (2006) also stated that in mathematics, most topics would need to be aligned to new technologies and innovations so that the pupils can function with optimal advantage with their surroundings. The use of dynamic educational software will change how students learn and teachers teach in the mathematics classroom.

Recently, the usage of Logo has created additional challenges and opportunities in the mathematics classroom. Research has shown that the programming language, Logo, originally was developed as a conceptual framework for understanding children's construction of knowledge about mathematics and problem solving (Clements & Meredith, 1992; Liu & Cummings, 2008; Papert, 1980). According to Papert (1980), Logo offers an easy entry into programming since it provides a concrete and meaningful idea for children to construct systems with thinking about geometry. Clements and Meredith (1997) also determined that Logo could be an effective means of learning mathematics and is able to promote higher order thinking, creativity and social-emotional development. Furthermore, Logo increases the sophistication of children's thinking about geometric concepts and facilitates meaningful learning about mathematics (Liu & Cummings, 2008).

The study of geometry is important as it has been recognized as a basic subject area of school mathematics (NCTM, 2000) and it is important to learn the properties and relationship between shapes (Ministry of Education, 2013). For example, pupils learning the properties of two to three-dimensional and the relation with geometric shapes are the most important part of geometric thinking (NCTM, 2000). It is essential for pupils to be able to imagine, construct and understand construction of shapes in order to connect them with related facts (Shadaan & Leong, 2013) especially in geometry.

Need of Study

Geometry is an important topic in the primary mathematics curriculum in Malaysia (Ministry of Education, 2003). Despite knowing its importance, primary pupils still performed poorly on the geometry questions in the public examination (Malaysian Examinations Syndicate, 2013). In the preliminary report of Malaysia (Executive Summary Malaysia Education Blueprint 2013-2025), research had shown that when Malaysia first participated in TIMSS in 1999, its average pupils score was higher than the international average in both Mathematics and Science. But further research done in 2007 found the pupils' performance had slipped to below the international average in both subjects.

In addition, Malaysian Year 4 pupils (10-year-old pupils who are in the primary level) had performed poorly in geometry and failed to meet the minimum proficiency levels in Mathematics and Science in 2007. The research also reported that Malaysian students were identified as possessing only limited mastery of basic mathematical and scientific concepts. The rankings in TIMSS 1999, 2007 and 2013 indirectly reflected the lack of geometric understanding among the Malaysian students (Chew & Noraini Idris, 2012). In addressing this concern, it is important that primary pupils are provided with a firm foundation of geometry concepts in order to develop their geometric thinking (Chew & Lim, 2013). Hence, Year 4 pupils and the Geometry topic were selected for this study.

Research has shown that phase-based instruction using Logo could help to enhance pupils' understanding of concepts, relations and calculations in mathematics (Khasawneh, 2009; Liu & Cummings, 1997; Liu & Kaino, 2007; Stagerz, 1997). More specifically, research also has shown that the effectiveness of using Logo based on van-Hiele theory of geometric thinking could significantly improve pupils' geometric thinking (Clements & Meredith, 1997). Van Hiele (1986) proved that Logo activities facilitate pupils' progression to higher levels in the van-Hiele hierarchy of geometric thinking. Research by Liu and Cummings (1997) showed that phase-based instruction using Logo could enhance pupils' van Hiele levels of geometric thinking about shapes such as equilateral triangle and right-angled square. Unfortunately, research is still lacking that specifically examines if Logo has potential for enhancing primary pupils' understanding of two-dimensional shapes properties based on the van Hiele theory of geometric thinking.

Significance of Study

The finding of the study would contribute to all primary teachers when looking at the effect of utilizing technology for teaching mathematics, especially geometry. This study would also provide information to teachers about students' understanding and learning processes when using the Logo software in relation to the geometry topic in mathematics. The findings also reveal that Logo is one of the dynamic educational software which can be used for teaching and learning mathematics. However, the potential of using Logo in primary school has not yet been achieved in Malaysia. The result of this research would be very useful for our Malaysia Ministry of Education in order to implement or recommend the use of Logo in all primary schools in future. Besides that, the study also showed how learners of different abilities would utilize the technology and their perception when interacting with the task using Logo. This information would be very useful to teachers or researchers who had the intention to do experimental research or an intervention to enhance pupils' understanding about geometric thinking.

Objectives of Study

The main objectives of this study are:

1. To investigate the effect of using Logo on pupils' understanding in properties of two-dimensional shapes.
2. To gather pupils' perception in learning the properties of two-dimensional shapes using Logo.

The study aimed at addressing the following research questions:

1. What is the effect of using Logo on pupils' understanding in properties of two-dimensional shapes between the experimental and control group?
2. What are the perceptions of pupils toward using Logo in learning the properties of two-dimensional shapes?

Theoretical Framework

Battista (2002) stated that van Hiele theory of geometric thinking best describes pupils' thinking about two-dimensional shapes. According to Van Hiele (1986), there are five sequential and hierarchy levels such as, level 1 (recognition), Level 2 (analysis), Level 3 (ordering), Level 4 (deduction) and Level 5 (rigor). Clements and Battista (1992) also proposed the existence of Level 0, which is called pre-recognition. However, according to the Malaysian Ministry of Education (2003), the topic of geometry content of the Year 4 mathematics syllabus is only up to Level 2 which is also stated in the research of Chew and Lim (2013). Therefore, only level 0 until level 2 will be discussed in this study.

Level 0: *Pre-recognition*

Pupils are able to notice the visual characteristics of shapes.

Level 1: *Recognition*

Pupils are able to recognize the figures and name the properties of geometric figures. But, they still do not see the relationships between these geometric figures.

Level 2: *Analysis*

Pupils are able to identify the relationship between properties and different geometric figures. At this level, students are also able to give meaningful definitions and justify their reasoning for each figure given

Literature Review

As our society becomes more dependent on technology and employment shifts from manual to automated positions, there is an increasing need to raise the quality of mathematics teaching and learning around the world (Verhoef, Coenders, Pieters, Smaalen, & Tall, 2015). The National Council of Teachers of Mathematics (NCTM) Principles and Standards for School Mathematics (PSSM) technology principle stated that "technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances pupils' learning" (NCTM, 2000, p. 24). Through the last decades, many different types of dynamic educational software have been developed for use in teaching and learning mathematics. One of the important characteristics of dynamic educational software is that users would be able to interact with the software in a way that makes it possible to get an immediate feedback on their work (Mehanovic, 2011).

Khasawned (2009) found that teaching geometry using Logo programming language could help to enhance pupils' learning and develop problem-solving processes. According to Clements and Meredith (1992), Logo programming language was originally developed as a conceptual framework for understanding children's construction of knowledge about mathematics and problem solving. By using Logo, pupils were able to build on their creative ideas about paths that may help them develop their ideas of two-dimensional shapes. The results had shown that Logo can help children develop higher levels of geometric thinking through van-Hiele's theory of geometrical thinking.

Ratcliff and Anderson (2011) conducted a case study with a group of nine 4th grade children with the use of Logo programming language. The study demonstrated that a classic version of Logo captured the pupils' interest. The results of this study showed that Logo had provided pupils with a great deal of pride, intrinsic reward, enjoyment and the sense of ownership of learning. Furthermore, the study also concluded that pupils were able to use basic commands, applying their knowledge of geometry to make procedures. Hoyles and Noss (1987) asserted that when a positive learning effect had taken place, this accessible Logo programming language should be integrated into the mathematics curriculum. This is because its systematic writing basic command should be developed throughout the school experience between programming and paper-pencil activities in the process of teaching and learning mathematics.

Liu and Kaino (2007) conducted a study comparing the use of Logo and Geometer's Sketchpad in mathematics classroom instruction. The findings showed that both software were able to enhance pupils' competencies of constructing rotational symmetry figures and allowed pupils to implement their understanding of mathematical concepts. In this case, the researchers also found that the concepts, relation, and calculations are reflected in the procedures when using Logo. However, Logo requires the pupil to construct the figure first followed by the discovery of the properties of the shapes. This study concluded that both software can be used to achieve the same objectives. The comparison between Logo and Geometer's Sketchpad found that pupils using Logo require more thinking skills during the writing of the syntax commands whereas pupils using Geometer's Sketchpad only need to click and drag the correct functions.

METHODOLOGY

Research Design

The research design of this study is a non-equivalent quasi-experimental research. Pupils were from two mixed ability classrooms. One classroom was assigned as the (1) experimental group while the other classroom was the (2) control group. The experimental group learned the properties of two-dimensional shapes using Logo programming language software while the control group learned the properties of two-dimensional shapes using traditional method, "paper-and-pencil" without using Logo programming language software.

Participants

Participants for this study were Year 4 (10 years old) students from a primary school in Pahang, Malaysia. A total of 36 pupils were selected for this study from a population of 61 pupils. Both experimental group and control group consists of 18 mixed ability pupils. The participants consist of equal number of boys and girls and their mathematics achievement was based on their final examination marks. The researcher taught both the groups for two weeks.

Table 1. Participant's mathematics achievement

Group	High	Average	Total
Experimental	9	9	18
Control	13	5	18
Total	22	14	36

Instruments and Data Collection

This study used two instruments for the purpose of data collection. The first instrument was the achievement tests containing the: (1) pre-test and (2) post-test. The second instrument was a survey questionnaire.

(a) Achievement test

The purpose of conducting the achievement tests is to identify pupils' understanding in learning the properties of two-dimensional shapes. At the beginning of the study, both experimental group and control group took a pre-test to test their understanding of geometric shapes. The pre-test and post-test consists of similar items. At the end of the treatment, both the experimental group and control group took a post-test to test their understanding on the properties of two-dimensional shapes. The Cronbach alpha value is .71 indicating that the reliability of the achievement test is appropriate.

(b) Survey Questionnaire

The survey questionnaire was used in this study to elicit pupils' perception on using Logo in the learning of two-dimensional shapes. This questionnaire consists of 10 dichotomous items. At the end of the treatment, pupils in the experimental group completed the questionnaire.

Procedures

This study used the instructional activities that integrates the Logo programming language software to help pupils' learning on the properties of the two-dimensional shapes. The experimental group pupils were exposed to the construction of the two-dimensional shapes by writing the basic commands in Logo. Therefore, pupils must be able to write the Logo commands so that the turtle moves.

Data Analysis

The Statistical Packages for the Social Sciences (SPSS) software version 18 was used to analyze the data of this study. For the first research question, independent *t*-test was used to analyze the significant difference in student achievement between the experimental group and control group on the properties of two-dimensional shapes. Descriptive statistics were used to analyze pupils' perception of using Logo in learning the properties of two-dimensional shapes.

RESULTS

Research question 1: What is the effect of using Logo on pupils' understanding on the properties two-dimensional shapes between the experimental and control group?

To answer the first research question, an independent samples *t*-test was conducted to determine whether the mean score of the pre-test differed between the control and experimental group. Review of the Shapiro-Wilk test of normality ($S\text{-}W$ = .96, df = 36, p = .19) and skewness (-.61) and kurtosis (-.17) indicated that normality assumption was reasonably met.

Table 2. Results of the independent *t*-test on the pre-test of both groups

Pre-test				
Group	Mean	*SD*	*t*-value	Sig (2 tailed)
Experimental (n=18)	54.28	5.42	-1.72	0.09
Control (n=18)	57.17	4.66		

t-value significant at $p < 0.05$

Table 2 shows that experimental group obtained a lower mean score (M = 54.28, SD=5.42) but larger data spread when compared with the control group (M = 57.17, SD=4.66). The independent *t*-test indicated that the pre-test mean scores were not statistically significant for the control and experimental group, $t(34) = -1.72$, $p = .09$. Thus the null hypothesis that the pre-test mean scores were the same cannot be rejected. The results showed that pupils in experimental group and control group having similar achievement in two-dimensional shapes before the treatment was conducted.

Table 3. Results of the independent *t*-test on the post test of both groups

Post-test				
Group	Mean	*SD*	*t*-value	Sig (2 tailed)
Experimental (n=18)	73.28	5.92	6.23	0.00*
Control (n=18)	60.06	6.23		

t-value significant at $p < 0.05$

The independent samples *t*-test determined whether the post test mean score differed between control and experimental groups. The Shapiro-Wilk test of normality ($S\text{-}W$ = .98, df = 36, p = .78) and skewness (-.31) and kurtosis (.35) indicated that normality assumptions were adequately met. Table 3 shows that the experimental group had a higher mean score (M = 73.28, SD = 5.92) and smaller data spread than the control (M = 60.06, SD = 6.23). The independent *t*-test found statistically significant difference in post-test mean scores between the control and experimental group, $t(34) = 6.23$, $p < .05$). Thus the null hypothesis that the post-test mean scores were not different can be rejected; pupils in the experimental group performed better than the control group. This suggests that Logo had a positive effect on learning two- dimensional shapes for the experimental group. Using Cohen's (1988) criteria, the effect size (2.17) is large since the difference between means exceeds one standard deviation.

Research question 2:What are the perceptions of pupils towards the use of Logo in learning the properties of two-dimensional shapes?

Frequency table and bar chart were used to answer second research question.

Table 4. Student perceptions of Logo

		Y	N
1.	I was so happy when using Logo.	16 (88.9%)	2 (11.1%)
2.	I was able to understand the properties of 2D shapes using Logo.	16 (88.9%)	2 (11.1%)
3.	I was able to think creatively when constructing the 2D shapes using Logo.	13 (72.2%)	5 (27.8%)
4.	I was able to visualize the image when writing the commands using Logo.	15 (83.3%)	3 (16.7%)
5.	I could share my ideas with friends in a group discussion when using Logo.	14 (77.8%)	4 (22.2%)
6.	I wanted to learn Logo more than other subjects.	15 (83.3%)	3 (16.7%)
7.	I was confident in learning the properties of 2D shapes using Logo.	14 (77.8%)	4 (22.2%)
8.	I could learn independently when doing construction using Logo.	10 (55.6%)	8 (44.4%)
9.	I found it takes a longer time to construct 2D shapes using Logo.	5 (27.8%)	13 (72.2%)
10.	I was excited to explore other mathematical concepts using Logo.	9 (50.0%)	9 (50.0%)

The result from Table 4 showed that generally pupils from the experimental group gave positive feedback toward the use of Logo. Majority of pupils (88.9%) showed that they were very happy when using Logo and were also able to understand the properties of 2D shapes using Logo. About 72.2% of pupils agreed that they were able to think creatively when constructing the 2D shapes using Logo. In addition, 77.8% of pupils were able to share their ideas with friends in a group discussion when using Logo while 88.3% of pupils wanted to learn Logo more than other subjects. They were also confident in learning the properties of 2D shapes using Logo. About 50% of pupils were excited to explore other mathematical concepts using Logo. However, some pupils reported that it took a longer time to construct the 2D shapes when using Logo.

DISCUSSION

From the results, the pupils in the experimental group showed improved achievement in learning the properties of 2D shapes using Logo. Several explanations can be discussed in this study. One of the use of instructional activities was conducted based on van Hiele Theory. During the activities conducted, the participants named the figures and recognized all the shapes given. Next, they need to think how to write commands to make the turtle move or turn. Then, pupils observed the properties of 2D shapes in Guided Orientation. During the stage of Explication, pupils were given opportunity to present their ideas about the properties of 2D shapes in front of the class. Pupils also gave feedback to their friends and discussed alternative ways to make the turtle move quickly. In the Free Orientation stage, pupils constructed any models involving the properties of 2D shapes. Finally, they had to summarize the properties of all 2D shapes in the stage of Integration. In a nutshell, after undergoing treatment the experimental group students showed confidence in using Logo and were able to perform better in the post-test. This result also indicated the effectiveness of Logo for enhancingpupils' understanding in learning the properties of 2D shapes.

Results from the questionnaire suggest the conclusion that pupils' perception toward the use of Logo in learning the properties of two-dimensional shapes was positive. The result indicated that pupils enjoyed using Logo to construct 2D shapes and gained better understanding about their properties. Besides that, children can use Logo as a design environment for teaching others mathematical concepts (Stagerz, 1997).

Some pupils claimed they would like to explore other mathematical concepts using Logo. This result had clearly shown that pupils would like to challenge themselves when using Logo to construct geometric figures. However, due to the short period in learning new innovation like Logo, pupils took a longer time to think and write down the commands. When they understand the properties of 2D shape, they would be able to write the commands quickly and construct a proper 2D shape.

CONCLUSION

From the results and discussion, it could be concluded that the effectiveness of using Logo could enhance pupils' understanding of 2D shape properties. Using Logo improves pupils' perception in learning the properties of 2D shapes. According to Liu and Cummings (2001), when children are required to provide instructions to the Logo turtle to draw the figure, they must think about how to identify and execute the sequence of small steps necessary to solve the larger problem. Logo requires pupils to think creatively and promotes higher order thinking skills (NCTM, 2000) in order to help them interact with their partner in a group discussion and explain the reasoning of mathematical ideas with positive learning attitude.

The findings of this study have brought some implications for teachers and pupils as well. Teachers could explore innovative technology to teach mathematics concepts in the classroom. When teachers master the Logo programming language, they could guide pupils to think creatively to visualize the mathematical concepts in an alternative way. Besides that, teachers could save time in preparing the teaching aids. Teacher could use Logo as a teaching tool to create a meaningful lesson for pupils and also design instructional activities using Logo to increase pupils' interest in learning mathematical concepts. In other words, the pupils who are the future leaders are ready to integrate technology in their education if they find that the software is beneficial for them and it has the potential to enhance their knowledge and skill as well (Rajagopal, Ismail, Ali, & Sulaiman, 2015). Logo could be an effective tool to help pupils learn independently by exploring, analyzing and creating mathematical ideas. However, pupils should be given more time to experience learning mathematics with the use of Logo.

It is recommended that more study on integrating Logo turtle into primary school especially in Malaysia should be carried out in future. It should provide encouragement and support primary teachers who had negative perception toward the use of Logo in school as it is necessary and important to explore a new innovation like Logo to improve primary school mathematics teaching and learning. Logo could give primary school teachers opportunity to observe how pupils integrate mathematical exploration with ICT tools; students may learn and develop new strategies to enhance geometric thinking with the use of Logo.

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