Improving Students' Van Hiele Level Of Geometric Thinking Using Geometer's Sketchpad

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ABSTRACT

The objective of this study was to examine the use of the Geometer's Sketchpad on students' van Hiele level of geometric thinking. A total of 31 Year Three students from a primary school in Pahang, Malaysia, participated in this study which was carried out over two weeks. The experimental group (N=16) was given the intervention using Geometer's Sketchpadfor six lessons while the control group (N=15) was taught using the traditional approach of chalk and talk. Quantitative data of the study were obtained through pre and post tests. A questionnaire was also used in this study. Paired samples t-test results indicated that the improvement of van Hiele level of geometric thinking for both the students in the experimental group and control group between all the pre and posttests is significant at the level of . However, the difference of van Hiele level of geometric thinking between students in the experimental group and in the control group were not significant for the postests. The study also found that there was no correlation between students' literacy in using Information and Communications Technology (ICT) and their van Hielelevel of geometric thinking after using Geometer's Sketchpad.

Keywords: *van Hiele level of geometric thinking; Geometer's Sketchpad; primary mathematics*

INTRODUCTION

The study of geometry enhances students' thinking skills using visual imagery. (Clements & Battista, 1992).Chew and Lim (2013) stressed on the importance of learning geometry as an essential skill to learn other topics in mathematics such as fractions, decimals, percentage, functions and calculus. Liu and Cummings (2001) suggested the use of new software technology in developing children's thinking about geometry, including abstract reasoning skills, required for higher levels of mathematical thinking. Olkun, Sinoplu and Deryakulu (2005) emphasized the pertinence of improving students' geometric thinking levels in teaching and learning process since geometric thinking is vital in many scientific, technical and occupational areas as well as in mathematics.

Usage of technology tools in the teaching and learning process were found to have helped the students to gain better understanding and increase their motivation of learning mathematics in class (Dogan, 2010). This is especially useful when students learn collaboratively and constructively through social interaction and self-exploration (Shadaan&Leong, 2013).Many studies had reported success in the teaching and learning of geometric topics with the Geometer's Sketchpad in enhancing students' Van Hiele's levels of geometric thinking (Chew &Idris, 2012; Chew & Lim, 2013; Abdullah &Zakaria, 2013). In this study, the researcher attempted to investigate whether the use of Geometer's Sketchpad waseffective in the teaching and learning of angles for Year Three pupils in a rural school in Pahang.

OBJECTIVES OF THE STUDY

The objective of my study was to examine the usage of Geometer's Sketchpad on primary pupils' van Hiele level of geometric thinking. Specifically, the study intended to achieve:

1. Investigate the effectiveness of using the Geometer's Sketchpad on students' van Hiele level of geometric thinking.
2. Describe the implementation and usage of the Geometer's Sketchpad in the teaching and learning of angles.
3. Examine the correlation between students' Information and Communications Technology (ICT) literacy and their van Hiele level of geometric thinking after the intervention.

Research Questions

Specifically, this study aimed at answering the following research questions:

1. Is there any significant differences in the students' van Hiele level of geometric thinking between experimental group and control group before the intervention using Geometer's Sketchpad?
2. Is there any significant effect of using the Geometer's Sketchpad on students' van Hielelevel of geometric thinking on the topic of angles?
3. Is there any significant effect of using the traditional approach on students' van Hiele level of geometric thinking on the topic of angles?
4. Is there any significant differences in the students' van Hiele level of geometric thinking between experimental group and control group after the instruction using Geometer's Sketchpad?
5. Is there any correlation between students' ICT literacy and their van Hiele level of geometric thinking?

Significance of Study

This study attempts to show examples of mathematics instruction using the Geometer's Sketchpad to enhance the mathematical thinking, mathematical communication, and mathematical reasoning of the students. This study is consistent with learning theories that encourage the learning through exploration and the cooperative learning theory that encourage students to work together and help each other in order to achieve specific academic goals. It is important for the students to acquire the skills of learning independently on their own pace rather than waiting to be taught by the teachers.

LITERATURE REVIEW

The availability of projection technology had increased the usage of both static and dynamic representations in teaching mathematics. However, students were not given enough opportunity in exploring geometric constructions in a dynamic geometry environment (DGE) most of the time (Sinclair &Yurita, 2008). Previous studies had investigated that the integration of dynamic geometry software such as the Geometer's Sketchpad into the teaching of geometry is more effective than the traditional approach in stimulating students' mathematical thinking skills (Idris, 2009; Dimakos&Zaranis, 2010; Chew &Idris, 2013; Chew & Lim, 2012).

Sinclair andYurita (2008) had conducted a four-week study in United States if America to investigate the changes of discourse using Geometer's Sketchpad. The study found that Dynamic Geometry Software, specifically the Geometer's Sketchpad had helped the teacher change from static discourse to a dynamic one. The research also mentioned that the practices of dragging and transforming in Geometer's Sketchpad might influence the students in dragging and transforming static shapes in their mind.

Liu and Cummings (2001) conducted a case study in United States of America and observed the learning process of four children using Geometer's Sketchpad and PC Logo to identify their learning process of geometric concepts and their cognitive processes used to learn these concepts. The study asserts that students were able to experience the Concrete-Abstract(CA) and Abstract-Concrete(AC) thinking process while completing the tasks using both the software. From the study, the researchers conceptualized the *Concrete-Abstract-Concrete Model* (C-A-CModel) which combines the CA and AC process to encourage children to think, to explore, and to use different problem-solving methods regardless of their achievement level.

Dimakos and Zaranis (2010) conducted a quasi-experimental research using a pre and post test to determine whether Geometer's Sketchpad assisted secondary students in improving their geometric achievement in class. The study was conducted involving two groups of grade seven studentsin a northern suburb of Athens. The results of the *t*-test indicated that there were significant differences in the mean scores between the experimental and control groups. Furthermore, the study stated that Geometer's Sketchpad would give students the opportunity to investigate geometric properties in a unique way. However, the study concluded that technology should not be seen as a panacea to replace the mathematics teacher but rather to switch the role of mathematics teacher to facilitators.

Idris (2009) conducted a quasi-experimental research to examine the impact of using Geometers' Sketchpad on geometry achievement and the level of van Hiele geometric thinking among Form Three students in a secondary school in Perak, Malaysia. The students sat for the geometry test and van Hiele Geometry Test (VHGT) before and after the intervention to assess their achievements in both areas. Two groups of students went through ten weeks of intervention period.Results of the study suggested that the Geometer's Sketchpad showed promising implications in teaching geometry at the secondary school level.

Chew and Idris (2012) conducted a case study aimed at exploring students' geometric thinking and achievement in solid geometry. The study focused on whether the concepts of cubes and cuboids could be enhanced through phase-based instruction using manipulatives using Geometer's Sketchpad based on van Hiele's theory. The participants selected were eight Form One students from an academic secondary school in Malaysia. They were divided into two groups according to their gender and mathematical achievement. The results of the post-interview indicated that six of the eight participants progressed from Level 1 to Level 3 of the van Hiele theory for cubes and cuboids. The remaining students only progressed from Level 1 to Level 2 for both concepts after the intervention.

Abdullah and Zakaria (2013) utilized the quasi-experimental research design to investigate the effectiveness of van Hiele's phases of learning geometry using the Geometer's Sketchpad among Form Two students in one of the secondary school in Malaysia. This study concentrated on the topic of Transformations. The results of the study indicated that the students' levels of geometric thinking in the treatment group were better than the levels of geometric thinking in the control group. In short, the researcher suggested that instruction using van Hiele's phases of learning geometry with Geometer's Sketchpad had significantly improved students' geometrical thinking when compared to conventional geometry instruction.

Chew and Lim (2013) conducted an exploratory case study research in Selangor, Malaysia. The study was carried outon 26 mixed-ability Year Four pupils to enhance primary pupils' geometric thinking through phase-based instruction using Geometer's Sketchpad based on the van Hiele theory of geometric thinking about equilateral triangle, square, regular pentagon, and regular hexagon. Results showed that there was a significant difference in the pupils' van Hiele levels of geometric thinking for all the regular polygons after the phase-based instruction using Geometer's Sketchpad. The authors suggested that the intervention had significantly enhanced the pupils' geometric thinking about the regular polygons. Currently the research at the primary level on geometrical thinking is insufficient in Malaysia. Thus, this study intends to fill the gap and investigated the improvement of primary students' van Hiele's level of geometric thinking using Geometer's Sketchpad.

VanHiele's level of geometric thinking

Battista (2002) stated that van Hiele theory of geometric thinking best describes students' thinking about two-dimensional shapes. The van Hiele model consists of five levels of geometric thought, which include recognition, analysis, ordering, deduction, and rigor (Van Hiele, 1986). The levels of geometric thinking in Year 4 Mathematics syllabus is only up to Level 2 (KementerianPendidikan Malaysia, 2013). Clements and Battista (1992) had suggested Level 0 as an indicator for the students who had not mastered van Hiele's Level 1 of geometric thinking. In this study, Level 0 were given to the students who were unable to distinguish between different types of angles. Level 1 was awarded to the students who were able to recognize figures, name figures and discriminate figures from the others visually. Level 2 were given to the students who were able to identify the figures based on their specific geometric properties.

METHODOLOGY

Research Design and Sample

The study was an experimental study equivalent pretest-posttest design. 31 Year Three students (nine years old) from an intact mixed-ability classroom were selected as participants of this study. Participants were then randomly assigned into two groups. The students in the control group learned the geometry subjects in a traditional way while the students in the experimental group learned the same geometry subjects using the Geometer's Sketchpad. The researcher taught both the groups.

Instrumentation

The researcher had developed three sets of pre and post test to assess the pupils'van Hiele levels of geometric thinking before and after the intervention period. Pre and posttest 1 assessed the students on knowing the right angle, pre and posttest 2 assessed the students knowledge on the acute angle while pre and posttest 3 assessed the students on identifying the obtuse angle. The distribution of items in the pre and post van Hiele level test are as shown in Table 1.

Table 1 *Distribution of Items in the Pre and Post van HieleLevel Test*

Concept	Level	Question Type	Question Number	Criterion for Level
Right Angle (Pre and Post Test 1)	Level 1	Visualize the angle	1 2 3	2 of 3
	Level 2	Concluding the properties of angle	4 5	2 of 2
Acute Angle (Pre and Post Test 2)	Level 1	Visualize the angle	1 2 3	2 of 3
	Level 2	Concluding the properties of angle	4 5	2 of 2
Obtuse Angle (Pre and Post Test 3)	Level 1	Visualize the angle	1 2 3	2 of 3
	Level 2	Concluding the properties of angle	4 5	2 of 2

The students were also required to answer a questionnaire consisting of five items about the students' ICT literacy. The questionnaire used a 4-point Likert scale, where (a) 1 was for Strongly Disagree, (b) 2 for Disagree, (c) 3 for Agree, and (d) 4 for Strongly Agree. The questionnaire was only distributed to the students in the experimental group to find out whether the students who were good in ICT skills would possess a higher van Hielelevel of geometric thinking after instruction using the Geometer's Sketchpad.

Reliability and Validity of Instruments

In order to ensure the content validity, the instruction was carried out towards Year Six pupils who had not learned about angles. They faced difficulties in understanding the concept of angles in a short time using the Geometer's Sketchpad. They needed more time to get familiar with the software. They could hardly imagine the occurrence of angles in their daily life. Thus, the researcher made some adjustments on the time provided for the students to get used to the Geometer's Sketchpad and the instructional material so that the lesson would be simpler for the Year 3 students. In addition, the instructional materials were checked by an experienced senior lecturer before conducting the research. The valuable suggestions from the lecturer was used to improve the instructional materials for exploration purpose.

Procedure

The pre-tests were conducted before the intervention period to determine the initial van Hiele levels of geometric thinking, specifically about the right angle, acute angle and obtuse angle. The students were then introduced to theGeometer's Sketchpad.

The students in the experimental group were given instruction using the Geometer's Sketchpad based on two pre-constructed activities. This is importantfor the students to visualize the angles and identify the properties of angles. The students in the control group completed the same activities without using Geometer's Sketchpad. After the lesson on angles, the post testwas given to all of the students to be completed individually. Table 2 summarized the research procedures.

Table 2 Research Procedures

Groups	Research Procedures
Experimental Group	Pre-test 1, 2 and 3 Introductory lesson of the Geometer's Sketchpad Instruction using the Geometer's Sketchpad Activity 1: Identify the right angles through visualization Activity 2: Identify the properties of the right angles Posttest 1 - Right Angles Instruction using the Geometer's Sketchpad Activity 3: Identify the acute angles through visualization Activity 4: Identify the properties of the acute angles Posttest 2 - Acute Angles Instruction using the Geometer's Sketchpad Activity 5: Identify the obtuse angles through visualization Activity 6: Identify the properties of the obtuse angles Posttest 3 - Obtuse Angles
Control Group	Pre-test 1, 2 and 3 Instruction using traditional method Activity 1: Identify the right angles through visualization Activity 2: Identify the properties of the right angles Posttest 1 - Right Angles Instruction using traditional method Activity 3: Identify the acute angles through visualization Activity 4: Identify the properties of the acute angles Posttest 2 - Acute Angles Instruction using traditional method Activity 5: Identify the obtuse angles through visualization Activity 6: Identify the properties of the obtuse angles Posttest 3 - Obtuse Angles

Data Analysis

Data obtained from the pre and post van Hiele levels of geometric thinking test were analyzed using the Statistical Package for the Social Sciences (SPSS) software version 20.00. The quantitative data were analyzed using the *t*-test, correlational and ANOVA(Analysis of Variance) method to answer all the research questions.

FINDINGS

Question 1: Is there any significant differences in the students' van Hiele level of geometric thinking between the experimental group and control group before the intervention using Geometer's Sketchpad?

Independent samples t-test was carried out to answer the first research question. The results of the t-test (as shown in Table 3) for pretest 1 (right angles) indicated that there is nosignificant difference in the mean of van Hiele level of geometric thinking between the experimental group (M = 0.56, SD = 0.73) and the control group (M = 0.67, SD = 0.72), t (29) = -0.40, p = 0.69 at the significance level of .05. The effect size is 0.01. It indicated that both the groups had only a small effect on the pupils' achievement in pre-test 1 according to Cohen (1988).

Table 3 Independent t-test for the experimental group and control group

		M	SD	SEM	Df	t-values	P	Effect size
Pre-test 1 (Right Angles)	Experimental (n = 16)	0.56	0.73	0.18	29	-0.40	0.69	0.01
	Control (n = 15)	0.67	0.72	0.19				
Pre-test 2 (Acute Angles)	Experimental (n = 16)	0.75	0.86	0.21	24.88	0.86	0.40	0.03
	Control (n = 15)	0.53	0.52	0.13				
Pre-test 3 (Obtuse Angles)	Experimental (n = 16)	0.44	0.51	0.13	29	-2.07	0.05	0.13
	Control (n = 15)	0.93	0.80	0.21				

The results of the *t*-test for pretest 2 also indicated that there is nosignificant difference between the mean van Hiele's level of geometric thinking of the experimental group (*M*= 0.75, *SD* = 0.86) and the control group (*M* = 0.53, *SD* = 0.52), *t* (24.88) = 0.86, *p* = 0.40 at the significance level of .05. The effect size is 0.03. This showed that both the groups had only a small effect on the pupils' achievement in pre-test 1 according to Cohen (1988).

However, the results of the *t*-test for pretest 3 showed that there is a significant different between the mean van Hiele's level of geometric thinking of the experimental group (*M* = 0.44, *SD* = 0.51) and the control group (*M* = 0.92, *SD* = 0.80), *t* (29) = -2.07, *p* = .05 at the significance level of .05, with the control group performing better than the experimental group on van Hiele's level of geometric thinking. This result indicated that the students in both groups possessed similar ability in van Hiele's level of geometric thinking. The effect size is 0.13. This means that both the groups had moderate effect (Cohen, 1988) on the pupils' achievement in pre-test 1.

Question 2: Is there any significant effect of using the Geometer's Sketchpad on improving students' van Hiele's level of geometric thinking on the topic of angles?

Paired samples *t*-tests and one way repeated measure ANOVA were carried out to answer the second research question. The paired samples *t*-test analyzed showed that the experimental group van Hiele level of geometric thinking on the right angles post test (*M* = 1.31, *SD* = 0.79) is significantly higher than the pre test on right angles (*M* = 0.56, *SD* = 0.73), *t* (15) = 3.00 with a *p*-value of .01. The effect size is 0.38. It indicated that Geometer's Sketchpad had only a small effect (Cohen, 1988) on the pupils' achievement on the concept of right angles.

The paired samples *t*-test found that the experimental group van Hiele level of geometric thinking on acute angles post test (*M* = 1.81, *SD* = 0.54) is significantly higher than the pre test of students' van Hiele's level of geometric thinking on acute angles (*M* = 0.75, *SD* = 0.86), *t* (15) = 4.98, *p*< .01).The effect size is 0.62. It showed that using Geometer's Sketchpad had a moderate effect(Cohen, 1988) on the pupils' achievement on the concept of acute angles.

Table 4 Paired Samples t-Test Results for Experimental Group Before and After Intervention

		M	SD	SEM	df	t-values	P	Effect size
Pair 1 (Right Angles)	Pretest 1 (n = 16)	0.56	0.73	0.18	15	3.00	0.01	0.38
	Posttest 1 (n = 16)	1.31	0.79	0.20				
Pair 2 (Acute Angles)	Pretest 2 (n = 16)	0.75	0.86	0.21	15	4.98	0.00	0.62
	Posttest 2 (n = 16)	1.81	0.54	0.14				
Pair 3 (Obtuse Angles)	Pretest 3 (n = 16)	0.44	0.51	0.13	15	12.20	0.00	0.91
	Posttest 3 (n = 16)	2.00	0.00	0.00				

The paired samples *t*-test analysis showed that the students' van Hiele level of geometric thinking on obtuse angles after the intervention using Geometer's Sketchpad (*M* = 2.00, *SD* = 0.00) was significantly higher than the students' van Hiele level of geometric thinking regarding obtuse angles before the intervention using Geometer's Sketchpad (*M* = 0.44, *SD* = 0.51), *t* (15) = 12.20 with a *p*-value smaller than 0.01. The effect size is 0.91 which indicated that 91% of the variance in students' achievement in obtuse angles was accounted for by Geometer's Sketchpad. It showed that using Geometer's Sketchpad had a great effect on the pupils' achievement on the concept of obtuse angles according to Cohen (1988).

A one-way ANOVA (Analysis of Variance) repeated measure was conducted to look at the differences in van Hiele's level of geometric thinking among students in the experimental group in the three posttests. The results indicated that there weresignificant differences in the students' van Hiele's level of geometric thinking during posttest 1 (*M* = 1.31, *SD* = 0.79), posttest 2 (*M* = 1.81, *SD* = 0.54), and posttest 3 (*M* = 2.00, *SD* = 0.00), *F* (1.29, 19.29) = 5.71, *p* = .02. The results illustrated thatthe intervention using Geometer's Sketchpad helped the students improve their van Hiele level of geometric thinking.

Question 3: Is there any significant effect of using the traditional approach in improving students' van Hiele level of geometric thinking on the topic of angles?

The researcher carried out another paired samples *t*-test to identify whether there is any significant effect of using the traditional approach in improving students' van Hiele level of geometric thinking. Based on the results of paired samples *t*-test as shown in Table 5, the students in the control group acquired a mean score of 0.67 and standard deviation of 0.72 in pretest 1 and improved significantly after the learning of right angles using the traditional approach in posttest 1 (*M* = 1.33, *SD* = 0.72), *t* (14) = 2.87, *p* = .01.The effect size is 0.37. It indicated that traditional instruction had only a small effect (Cohen, 1988) on the pupils' achievement on the concept of right angles.

Table 5 Paired Samples t-Test Results for Control Group Before and After Traditional Instruction

		M	SD	SEM	Df	t-values	p	Effect size
Pair 1 (Right Angles)	Pretest 1 (n = 15)	0.67	0.72	0.19	14	2.87	0.01	0.37
	Posttest 1 (n = 15)	1.33	0.72	0.19				
Pair 2 (Acute Angles)	Pretest 2 (n = 15)	0.53	0.52	0.13	14	4.80	0.00	0.62
	Posttest 2 (n = 15)	1.67	0.62	0.16				
Pair 3 (Obtuse Angles)	Pretest 3 (n = 15)	0.93	0.80	0.21	14	5.12	0.00	0.65
	Posttest 3 (n = 15)	1.93	0.26	0.07				

The results of paired samples *t*-test also indicated that there was a significant difference in the mean score of students between pretest 2 (*M* = 0.53, *SD* = 0.52) and posttest 2 (*M* = 1.67, *SD* = 0.62), *t* (14) = 4.80, *p*< .01. These findings were obtained after the learning of the acute angles using traditional approach of the control group. The effect size is 0.62. It indicated that traditional instruction had only a moderate effect (Cohen, 1988) on the pupils' achievement on the concept of acute angles.

At the same time, the students obtained a mean of 0.93 in the van Hiele level of geometric thinking in pretest 3 and standard deviation of 0.80 before the teaching of obtuse angles using the traditional approach.They improved significantly after the teaching of obtuse angles using traditional approach in posttest 3 (*M* = 1.93, *SD* = 0.26), *t* (14) = 5.12, *p*< 0.01. The effect size is 0.65. It indicated that traditional instruction had only a moderate effect (Cohen, 1988) on the pupils' achievement on the concept of obtuse angles.

A one way ANOVA repeated measure was used to analyze the difference in the van Hiele level of geometric thinking of the students in the control group in the three posttests. Results indicated that there was a significant difference in the students' van Hiele level of geometric thinking during posttest 1 (*M* = 1.33, *SD* = 0.72), posttest 2 (*M* = 1.67, *SD* = 0.62), and posttest 3 (*M* = 1.93, *SD* = 2.56), *F* (2, 28) = 4.40, *p* = .02. These results suggested that there is also a change in students' van Hiele level of geometric thinking in the three posttests. Thus, the students in the control group have improved their van Hiele's level of geometric thinking on the topic of angles.

Question 4: Is there any significant differences in the students' van Hiele's level of geometric thinking between experimental group and control group after the instruction using Geometer's Sketchpad?

Three independent samples *t*-test were carried out using to analyze the data. The results of the independent samples *t*-test are shown in Table 6.

Table 6 Independent t-test for the experimental group and control group after intervention

		M	*SD*	SEM	Df	t-values	p	Effect size
Posttest 1 (Right Angles)	Experimental (n = 16)	1.31	0.79	0.20	29	-0.08	0.94	0.01
	Control (n = 15)	1.33	0.72	0.19				
Posttest 2 (Acute Angles)	Experimental (n = 16)	1.81	0.54	0.14	29	0.70	0.49	0.02
	Control (n = 15)	1.67	0.62	0.16				
Posttest 3 (Obtuse Angles)	Experimental (n = 16)	2.00	0.00	0.00	14.00	1.00	0.33	0.07
	Control (n = 15)	1.93	0.26	0.07				

Results showed that the mean score of the students in the experimental group in posttest 1 (*M* = 1.31, *SD* = 0.79) is less than mean score of students in the control group (*M* = 1.33, *SD* = 0.72). At 5% significance level, the difference is not significant, t (29) = -0.08, p = .94. This result indicated that there was no statistical difference between the two teaching methods after the students carried out Activity 1 and Activity 2. The effect size is 0.01. It indicated that teaching methods had only a small effect (Cohen, 1988) on the student achievement on the concept of right angles.

After the students underwent the lesson using Activity 3 and Activity 4, the results of independent samples *t*-test for posttest 2 showed that the mean van Hiele level of geometric thinking of the students in the experimental group (M = 1.81, SD = 0.54) was not statistically significantly higher than the mean van Hiele level of geometric thinking of the students in the control group (*M* = 1.67, *SD* = 0.62), t (29) = 0.70 at the significance level of α = 0.05. The difference of the mean score between the control and experiment group in post test 2 is larger than the difference in post test 1. This result indicated that the instruction using Geometer's Sketchpad seemed to be more effective in improving students' van Hiele's level of geometric thinking when used for a longer time. The effect size is 0.02. This showed that teaching methods had only a small effect (Cohen, 1988) on the pupils' achievement on the concept of acute angles.

The results of the independent samples *t*-test means for posttest 3 showed that the mean van Hiele level of geometric thinking of the students in the experimental group (*M* = 2.00, *SD* = 0.00) was not significantly different than the mean van Hiele's level of geometric thinking of the students in the control group (*M* = 1.93, *SD* = 0.26), t (14) = 1.00, p = 0.33. Therefore, the result indicated that the experimental group performed better in van Hiele's level of geometric thinking than the control group but the difference was not statistically significant. The effect size is 0.07. This means that teaching methods had only a small effect (Cohen, 1988) on the pupils' achievement on the concept of obtuse angles.

Question 5: Is there any correlation between students' ICT literacy and their van Hiele's level of geometric thinking after the intervention?

The data obtained were analyzed using the Pearson Correlation test.Results (as shown in Table 7) showed that there was no significant correlation between the ICT literacy of the students and their van Hiele level of geometric thinking in the posttests, r (14) = -0.01, p =.97. Since the *p*-value is larger than the significant level of $\alpha = 0.05$, then the null hypothesis cannot be rejected. Hence, the students with higher ICT literacy do not necessarily learn geometry using Geometer's Sketchpad better than the students with lower ICT literacy. However, there is a limitation with the results given the small sample size.

Table 7 The Pearson Correlation Test Between ICT Usage and Mean van HieleLevel of Geometric Thinking

Correlations			
		ICT Usage	Mean Post Test
ICT Usage	Pearson Correlation	1	-.010
	Sig. (2-tailed)		.970
	Sum of Squares and Cross-products	14.938	-.042
	Covariance	.996	-.003
	N	16	16
Mean Post Test	Pearson Correlation	-.010	1
	Sig. (2-tailed)	.970	
	Sum of Squares and Cross-products	-.042	1.083
	Covariance	-.003	.072
	N	16	16

DISCUSSION

In this study, the students in the experimental group had improved in their van Hiele level of geometric thinking through the use of Geometer's Sketchpad.However, themean score of the students in the experimental group were not statistically different than the results of the students in the control group in the post test.

Results of the independent samples *t*-test were not significant between the mean score in van Hiele level of geometric thinking of the students in both groups for pretest 1 and pretest 2. However, the results of the independent samples *t*-test for pretest 3 between the mean score of the students in both groups indicated that there was a significant difference between the experimental group (M = 0.44, SD = 0.51) and the control group (M = 0.92, SD = 0.80), t (29) = -2.07, p = .05, where the control group had performed better than the experimental group on obtuse angle. The students in the experimental group had shown greater improvement in van Hiele level of geometric thinking when compared to the control group. This result indicated that the instruction using Geometer's Sketchpad could help students in improving their van Hiele level of geometric thinking.

The results of the independent samples *t*-test between the experimental group and the control group in the three post testsshow that there was nosignificant difference. However, when we looked deeper into the statistical analysis we would notice that the students in the experimental group had performed better in posttest 2 and performed best in posttest 3. The students seemed to be getting more familiar with the Geometer's Sketchpad software over longer time period. Looking at this trend, it can be predicted that the *t*-value will continue to increase and the *p*-value will decrease until it reaches the significant value if the study is carried out in a longer duration.

The paired *t*-test showed significant result for the students in both groups. Therefore, it can be concluded that there is a significant difference in the students' van Hiele level of geometric thinking after the instruction using Geometer's Sketchpad and the traditional approach.

There were eight students could not reach Level 2 in posttest 1 and two students could not reach Level 2 in posttest 2 for the experimental group. The result is consistent with the findings by Chew and Lim (2013). The study explained that not all students can achieve Level 2 in a short period of time after phase-based instruction using Geometer's Sketchpad because the students had different mathematics achievement and language ability.

CONCLUSION

The researcher found that the improvement of students'van Hiele level of geometric thinking using Geometer's Sketchpad was not significantly different when compared to the control group after two weeks of intervention. This may be due to the short period of intervention. However, the students showed great initiative in the learning process. They interacted with their partners about the mathematical ideas and explained the reasoning of their choice of answer when they worked together and justified on their own answers. This helped students in the process of acquiring the knowledge of mathematics with positive learning attitude and practices.

In short, the findings of this study reported the potential and benefits of learning geometry using Geometer's Sketchpad. This result is consistent with the research done by Chew and Lim (2013) whoconcluded that primary pupils can gain better understanding through well-designed phase-based Geometer's Sketchpad instructional activities as well as teacher's guidance and facilitation.

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