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Effectiveness of Using Circle Geometry (CG-Board) Strategy in Learning Circle Geometry towards Form Four Students' Performance

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ABSTRACT: *The study aims to determine the effectiveness of Circle Geometry Board (CG-Board) strategy in learning Circle Geometry towards Form Four students' performance. The Nonequivalent Control Group Pretest-Posttest Quasi Experimental design was used. Fifty-two students from two classes were selected using the cluster probability sampling and were divided equally to control and experimental group. A three-week intervention was conducted using prior knowledge test, pre-test and post-test. The independent t-test was used to describe the students' performance and the differences between the teaching strategies used. From the analysis, the treatment group students' performance gained significantly higher than the control group. The study shows that the CG-Board strategy can improve the effectiveness of teaching and facilitating of Circle Geometry among students.*

KEYWORDS: *Circle Geometry, Students' Performance, Physical Manipulative, Teaching Strategies*

I. INTRODUCTION

Geometry is one of many components taught in the Malaysian syllabus. Though these students were taught since the primary school, they still have problems in recognizing the shapes of the geometry, finding the perimeter and the area of a given shape. This problem persists in their secondary schooling where the students have problem in visualizing and solving problems in Circle Geometry [1]. The students' prior knowledge from Form 2 and Form 3 has deterred the students' ability to perform in the Circle Geometry questions. The students fail to grasp the geometry concept, reasoning and solving problems [2], [3]. The students were unable to link more than one concept in geometry [4]. Based on [3], the students who face problem in learning geometry has lead students to acquire poor performance. The teaching methods used too, have influenced the students' performance [5].

Interactive tools like Geometer's Sketchpad, GeoGebra and Cabri have been introduced to help their visualization and these interactive tools have brought positive learning achievements [6]. However, [7], emphasize that the students need to understand the mathematics before they interact with the software. Many schools in Malaysia too, face problem of not having updated computers in their classrooms to use this software. Therefore, the teacher shows the use of this software using projectors and not helping the students to find the knowledge hands-on. Since the students do not explore their own understanding then the students are incompetent to visualize and explore the concept of geometry. These have led students to have misconception in learning Circle Geometry as they prefer to observe and memorize the concept [8]. Their minimal understanding has made them not to understand the definition [9] and properties of geometry [10].

The students are also not creative and logical in solving geometry problem [11]. The students solely rely on the text book and their teacher for the knowledge. Learning geometry from the text book hinders the students' problem-solving skills and the development of their spatial thinking, analyzing and conceptualizing the ideas of geometry [12]. They tend to provide irrelevant information which is not useful in problem solving [13]. This is because the students have forgotten the Circle Geometry concept learnt in previous years. They are unable to give reason for each statement made to solve a problem [14].

The students' learning attitude towards mathematics is linked with the teaching method used by the teachers. The students neither interact with their friends nor the teacher to find out the answer. Conventional teaching method in teaching Circle Geometry has caused students not to explore or discover their own knowledge concretely as they become passive and mere observer [15], [16], [17]. Teachers too, do not implement on the use of any kind of manipulatives as their teaching tools because of their time constrain in their daily lesson [18], [19], [20].

1.1 Purpose and Objective of the Research

The purpose and the objective of the study is to develop CG-Board and activity book to be used in teaching and learning Circle Geometry among Form Four students and to study the effectiveness of the usage of CG-board strategy on the students' performance compared to conventional strategy.

1.2 Research Questions

The following are the research questions:

i. What is the difference between the mean scores of the control and treatment group students' performance in Circle Geometry before any intervention is given in learning Circle Geometry?
ii. What is the difference between the mean scores of the control group students' performance after a conventional strategy of learning Circle Geometry is used and the treatment group students' performance in Circle Geometry after the CG-Board is used in learning Circle Geometry?
iii. Are there any significant changes in the mean scores of the control group students' performance before and after the conventional strategy of learning Circle Geometry?
iv. Are there any significant changes in the mean scores of the treatment group students' performance before and after the CG-Board strategy is used in learning Circle Geometry?

1.3 Hypotheses

The hypotheses below are developed according to the research questions.

H_{0i}: There is no significant difference between the mean scores of the control group students' and the treatment group students' performance in Circle Geometry before any intervention is implemented.

H_{0ii}: There is no significant difference between the mean scores of the control group students' performance after a conventional strategy is implemented and the treatment group students' performance after the CG-board strategy is used in learning Circle Geometry is implemented.

H_{0iii}: There are no significant changes in the mean scores of the control group students' performance before and after the conventional strategy of learning Circle Geometry is implemented.

H_{0iv}: There are no significant changes in the mean scores of the treatment group students' performance before and after CG-board strategy for Circle Geometry is implemented.

II. METHODOLOGY

1.4 Research Design and Sample

This study employed the Nonequivalent Control Group Pretest-Posttest Quasi Experimental. The experimental group went through an intervention where they learnt Circle Geometry using the CG-Board strategy for three weeks while the control group, learnt mathematics using the conventional strategy. Participants for this study were the Form Four students selected from a school in Perak. Two classes consisting of 52 students were selected from a population of 114 students. One class was assigned as an experimental group while the other became the control group. The experimental and control group consists of 26 students each.

1.5 Research Instruments

This study used three instruments. The first instrument used is the prior knowledge test. This test functions to find out the students' ability in understanding the Circle Geometry concepts thought in Form 2 and Form 3. This prior knowledge test is also used to determine the mean scores of each class of the population. Once the two classes of similar mean scores are identified, both classes were tested once more using the pre-test. This instrument helps the researcher to find out the mean score of both control and treatment group. After three weeks of intervention, the post-test was given to both groups. Both pre-test and post-test have items with similar learning objectives. Both tests consist of 20 problems solving structured questions.

III. DATA ANALYSIS AND RESULT

Inferential statistics were used in the analysis of the collected data. The first two research questions were analyzed using the independent *t-test* while the next two questions used the paired sample *t-test*. The hypothesis was tested at 0.05 level of significant.

1.6 Research Question 1: What is the difference between the mean scores of the control and treatment group students' performance in Circle Geometry before any intervention is given in learning Circle Geometry?

Based on Table 1 and 2, an independent sample *t-test* was conducted to compare the mean scores of the control and treatment groups. Based on the Levene's Test for Equality of Variances, the significance value is greater than 0.05. Therefore, the null of the Levene's test is accepted and we can conclude that the variance of the control and the treatment group are not significantly different. In the *t-test* for Equality of Means, the p-value is greater than 0.05. We can conclude that, there is no significant difference in the scores for control group

(M=13.92, SD=2.331) and the treatment group (M=13.92, SD=2.115) conditions; t(50)=0.000, p= 1.000. Since the value of p is greater than 0.05, the null hypothesis is failed to be rejected.

Table 1 Mean Scores for Control and Treatment Group for the Pre-test

Groups	Descriptive Statistics	Statistics
Control	Mean	13.92
	Standard Deviation	2.331
	Standard Error Mean	0.457
Treatment	Mean	13.92
	Standard Deviation	2.115
	Standard Error Mean	0.415

Table 2 Independent Samples Test for the Pre-test

		Statistics
Levene's Test for Equality of Variances	F	0.160
	Significance	0.691
t-test for Equality of Means	t	0.000
	df	50
	Significance (2-tailed)	1.000

1.6.1 Analyzing the Answers of the Control Group and Treatment Group for the Pre-test

Based on Table 3, we know that the students' ability is almost the same. The students could not answer questions five, six, eight, fourteen, nineteen and twenty.

In question five, the students couldn't identify the angles subtended at the circumference or the centre. When the students couldn't answer the question five, they indirectly couldn't answer question eight. As question eight, asks the students to identify the angle in the alternate segment which is subtended by the chord.

In question six, the students are asked to name the interior opposite angles of the cyclic quadrilateral. Many of them are able to identify the interior angle of the cyclic quadrilateral but fail to find the opposite angle of the cyclic quadrilateral.

In question fourteen, nineteen and twenty are questions related to a tangent to a circle. Since the students have not learned this concept of Circle Geometry yet, the students could not answer the questions.

On the contrary, the students could answer questions one, two, four, seven and fifteen. Seven out of twenty-six students from the control group and nine out of twenty-six students from the treatment group could explain what a circle is (Question 1). Almost all the students from the control group and treatment group could identifying a cyclic quadrilateral (Question 2). This is the basic for the concept of cyclic quadrilateral. Eight students from the treatment group could answer question seven on identifying the exterior angles and the corresponding interior opposite angles of cyclic quadrilateral. Finally, eight students from the control group and six students from the treatment group could answer question fifteen. It is surprising to see that the students are able to verify the relationship between the angle formed by the tangents and the chord with the angle in the alternate segment which is subtended by the chord, even though they have not learned yet. When investigated, it is found that the students literally guessed the answer based on the question in the pre-test as the diagram shows a formation of perpendicular bisector.

Many questions were attempted by the students; however, they were unable to complete the given task as they do not remember what they have learned previously.

Table 3 Control Group and Treatment Group Question Analysis Based on Pre-test

Question Number	Learning Outcomes from Pre-test	Control Group	Treatment Group
1.	Identifying circle as a set of point equidistant from a fixed point	7	9
2.	Identifying cyclic quadrilateral	17	21
3.	Identifying tangent to a circle	3	1
4.	Identifying parts of a circle (centre, circumference, radius, diameter, chord, arc, sector and segment)	4	14
5.	Identifying angle subtended by an arc at the centre and at the circumference of a circle	0	0
6.	Identifying interior opposite angle of cyclic quadrilateral	0	0

7.	Identifying the exterior angles and the corresponding interior opposite angles of cyclic quadrilateral	1	8
8.	Identifying the angle in the alternate segment which is subtended by the chord through the contact point of the tangent	0	0
9.	Determining that angles subtended at the circumference by the same arc are equal	4	1
10.	Determining that angles subtended at the circumference, at the centre by arcs of the same length are equal	3	0
11.	Determining the relationship between angle at the centre and angle at the circumference subtended by an arc	0	3
12.	Determining the relationship between interior opposite angles of cyclic quadrilateral	1	0
13.	Determining the relationship between exterior angles and corresponding interior opposite angles of the cyclic quadrilateral	0	1
14.	Making inference that the tangent to a circle is a straight line perpendicular to the radius that passes through the contact point	0	0
15.	Verifying the relationship between the angle formed by the tangents and the chord with the angle in the alternate segment which is subtended by the chord	8	6
16.	Determining the size of an angle subtended at the circumference in a semicircle	2	2
17.	Solving problems involving angles subtended at the centre and angles at the circumference of circles	3	0
18.	Solving problem involving angles of cyclic quadrilateral	1	2
19.	Solving problem involving tangent to a circle	0	0
20.	Solving problem involving tangent to a circle and angle in alternate segment	0	0

1.7 Research Question 2: What is the difference between the mean scores of the control group students' performance after a conventional strategy of learning Circle Geometry is used and the treatment group students' performance in Circle Geometry after the CG-board is used in learning Circle Geometry?

Based on Table 4 and Table 5, an independent sample *t-test* was conducted to compare the mean scores of the control and treatment groups. Based on the Levene's Test for Equality of Variances, the significance value is smaller than 0.05. Therefore, the null of the Levene's test is rejected and we can conclude that the variance of the control and the treatment group are significantly different. In the *t-test* for Equality of Means, the p-value is smaller than 0.05. We can conclude that, there is significant difference in the scores for control group (M=18.96, SD=4.025) and the treatment group (M=24.04, SD=1.843) conditions; t(35.038)=-5.848, p= 0.001. Since the value of p is smaller than 0.05, the null hypothesis is rejected.

Table 4 Mean Scores for Control and Treatment Group for the Post-test

Groups	Descriptive Statistics	Statistics
Control	Mean	18.96
	Standard Deviation	4.025
	Standard Error Mean	0.789
Treatment	Mean	24.04
	Standard Deviation	1.843
	Standard Error Mean	0.362

Table 5 Independent Samples Test for The Post-test

		Statistics
Levene's Test for Equality of Variances	F	12.502
	Significance	0.001
t-test for Equality of Means	t	-5.848
	df	35.038
	Significance (2-tailed)	0.001

1.7.1 Analyzing the Answers of the Control and Treatment Group for the Post-test

From Table 6, the students can recognize parts of the circles. This is seen in the question one and four, where most of the students could identify circle as a set of point equidistant from a fixed point and identify parts of circles like centre, circumference, radius, diameter, chord, arc, sector and segment.

In understanding and using the properties of angles in circles, the students did show some improvement in certain questions. The students still have problem in identifying angle subtended by an arc at the centre and at the circumference of a circle. Both control group and treatment group were not able to answer this question five in pre-test and in post-test. The students did show improvement in determining the angles subtended at the circumference by the same arc. They could understand that the values of angles subtended from the same arc are the same. In question ten and eleven, the students did not show much improvement comparing to the pre-test. They still have difficulty in determining the angles that is subtended at the circumference or at the centre by arcs of the same length are equal and determining the relationship between angle at the centre and angle at the circumference subtended by an arc. When the students could not recognize the properties of an arc subtended from the circumference or centre, they indirectly could not determine the size of an angle subtended at the circumference in a semicircle. Only three students from the control group and five students from the treatment group could answer the question number sixteen. However, none of them could solve problem involving the angle subtended at the centre and angles at the circumference of circles (Question 17).

In measuring the students understanding and using the properties of angles in circles, question two, six, seven, twelve, thirteen and eighteen were given. In question two, twenty students from control group and all twenty-six students from treatment group could identify the cyclic quadrilateral. The students did not improve much in question six. The students still have problem in identifying interior opposite angles of cyclic quadrilateral. When the cyclic quadrilateral is drawn differently with two lines in the cyclic quadrilateral, they could not name the angles correctly. In question seven, fourteen students from the treatment group could answer the question. Analyzing the question, it is found that most of the students who failed to answer this question can identify the exterior angle but could not identify the correct corresponding interior opposite angle for it. Since the students could not do question seven, they did not perform well in question twelve and thirteen. Not many students could determine the relationship between interior opposite angles of cyclic quadrilateral and they were unable to determine the relationship between exterior angles and corresponding interior opposite angles of cyclic quadrilateral.

In the fourth learning objective of understanding and using the concepts of tangents to a circle, the students in the control group and treatment group did fairly well. In question three, almost all the students from control group and treatment group could identify tangent to a circle. Although, they are able to identify tangent to a circle, the students from the control group and treatment group while doing the pre-test and post-test failed to make inference that the tangent to a circle is a straight line perpendicular to the radius that passes through the contact point. In question fifteen, the students from both groups did show improvement from the pre-test. Eleven students from the control group and seventeen students from the treatment group could verify the relationship between the angle formed by the tangents and the chord with the angle in the alternate segment which is subtended by the chord. Looking at the question three, fourteen and fifteen, we can conclude that the students have problem in making inference using words or sentences.

Finally, the fifth learning objective is to understand and use the properties of angles between tangent and chord to solve problem. The questions relating to the objectives are question eight, nineteen and twenty. The students did not show much improvement comparing to the post-test. These questions are related with the second and the third learning objectives. Since the students have difficulties in grasping the concept of understanding the properties of angles in circles and cyclic quadrilateral, they failed to use their knowledge to answer the questions in the fifth learning objectives. Only about two to three students from control group and treatment group could identify the angle in the alternate segment which is subtended by the chord, solve problem involving tangent to a circle and solve problems involving tangent to a circle and angle in the alternate segment.

Table 6 Control Group and Treatment Group Question Analysis Based on Post-test

Question Number	Learning Outcomes from Post-test	Control Group	Treatment Group
1.	Identifying circle as a set of point equidistant from a fixed point	20	25
2.	Identifying cyclic quadrilateral	20	26
3.	Identifying tangent to a circle	16	25
4.	Identifying parts of a circle (centre, circumference, radius, diameter, chord, arc, sector and segment)	17	22
5.	Identifying angle subtended by an arc at the centre and at the circumference of a circle	0	0
6.	Identifying interior opposite angle of cyclic quadrilateral	0	5

7.	Identifying the exterior angles and the corresponding interior opposite angles of cyclic quadrilateral	1	14
8.	Identifying the angle in the alternate segment which is subtended by the chord through the contact point of the tangent	0	2
9.	Determining that angles subtended at the circumference by the same arc are equal	6	9
10.	Determining that angles subtended at the circumference, at the centre by arcs of the same length are equal	0	2
11.	Determining the relationship between angle at the centre and angle at the circumference subtended by an arc	0	4
12.	Determining the relationship between interior opposite angles of cyclic quadrilateral	1	3
13.	Determining the relationship between exterior angles and corresponding interior opposite angles of the cyclic quadrilateral	0	4
14.	Making inference that the tangent to a circle is a straight line perpendicular to the radius that passes through the contact point	0	0
15.	Verifying the relationship between the angle formed by the tangents and the chord with the angle in the alternate segment which is subtended by the chord	11	17
16.	Determining the size of an angle subtended at the circumference in a semicircle	3	5
17.	Solving problems involving angles subtended at the centre and angles at the circumference of circles	0	0
18.	Solving problem involving angles of cyclic quadrilateral	2	3
19.	Solving problem involving tangent to a circle	1	2
20.	Solving problem involving tangent to a circle and angle in alternate segment	1	3

1.8 Research Question 3: Are there any significant changes in the mean scores of the control group students' performance before and after the conventional strategy of learning Circle Geometry?

From Table 7 and Table 8, it is shown that a paired-sample *t-test* was conducted to compare the pre-test and post-test mean scores after the conventional strategy of learning Circle Geometry is implemented. There is a significant difference in the mean scores for pre-test (M=13.92, SD=2.331) and in the mean scores for the post-test (M=18.96, SD=4.025) conditions; t(25)=-6.009, p= 0.001. With the p value is less than 0.05, the null hypothesis can be rejected. The standard deviation of the control group post-test is larger than the pre-test. This shows that the marks in the post-test has a large variation in the mark comparing to the pre-test. The students have shown some improvement with the mean score increasing by 5.04 from the pre-test. These results suggest that the conventional strategy of learning Circle Geometry does have an effect to the students' performance after three weeks of intervention.

Table 7 Mean Scores for Control Group for the Pre-test and Post-test Using Paired Sample Statistics

Control Group's	Descriptive Statistics	Statistics
Pre-test	Mean	13.92
	Standard Deviation	2.331
	Standard Error Mean	0.457
Post-test	Mean	18.96
	Standard Deviation	4.025
	Standard Error Mean	0.789

Table 8 Paired Sample Test for Control Group

		Statistics
Paired differences	Mean	-5.038
	Standard Deviation	4.275
	Standard Error Mean	0.838
t-test	t	-6.009
	df	25
	Significance (2-tailed)	0.001

1.9 Research Question 4: Are there any significant changes in the mean scores of the treatment group students' performance before and after the CG-board strategy is used in learning Circle Geometry?

From Table 9 and Table 10, it is shown that a paired-sample *t-test* was conducted to compare the pre-test and post-test mean scores after the CG-board is used in learning Circle Geometry. There is a significant difference in the mean scores for pre-test (M=13.92, SD=2.115) and in the mean scores for the post-test (M=24.04, SD=1.843) conditions; t(25)=-19.294, p= 0.000. With the p value is less than 0.05, the null hypothesis can be rejected. The students have shown some improvement with the mean score increasing by 10.12 from the pre-test. These results suggest that using the CG-board strategy in learning Circle Geometry does have an effect to the students' performance after three weeks of intervention.

Table 9 Mean Scores for Treatment Group for the Pre-test and Post-test Using Paired Sample Statistics

Treatment Group's	Descriptive Statistics	Statistics
Pre-test	Mean	13.92
	Standard Deviation	2.115
	Standard Error Mean	0.415
Post-test	Mean	24.04
	Standard Deviation	1.843
	Standard Error Mean	0.362

Table 10 Paired Sample Test for Treatment Group

		Statistics
Paired differences	Mean	-10.115
	Standard Deviation	2.673
	Standard Error Mean	0.524
t-test	t	-19.294
	df	25
	Significance (2-tailed)	0.000

IV. DISCUSSION

The CG-board was developed based on the idea of locus. The CG-board gives the students a hands-on experience as they use the physical manipulative to develop their understanding in Circle Geometry concept. As the CG-board cannot be a standalone manipulative, therefore, the activity book was developed to assist the learning of Circle Geometry concept.

As the lessons of Circle Geometry concept were divided into twelve lessons, and with an average lesson conducted for thirty-five to seventy minutes, students were able to grasp the concept of Circle Geometry. The students' ability to participate and learn Circle Geometry through hands-on learning, have brought few positive impacts on them. As the lesson in the activity book were done as task-based, the students need to work together with their group mate to construct and deduce a Circle Geometry concept [21]. The use of CG-board is suitable for them as most of the students in the treatment group have short attention span [22]. The use of physical manipulative like CG-board has helped to increase the mean scores of the treatment group on retention and problem solving [23]. This kind of learning gave the students the opportunity to engage in the learning that they could visualize the Circle Geometry concept [22].

When the CG-board is used, the students communicate and work out the problems in the activity book in their respective group [24]. The treatment group students were no more mere observers as they take the challenge to participate in the group activity to answer the questions in the activity book with the use of CG-board. The activity book has many diagrams that help the students to visualise. The visualisation that is seen in the activity book and built in the CG-board can enhance the students understanding better than the conventional method [25].

As the CG-board strategy was something new, the students were enthusiastic in using the CG-board and the activity book. The CG-board strategy gave the students a concrete display of the abstract mathematical ideas [26].

V. CONCLUSION

The research was done to investigate the effectiveness of using CG-board strategy for Circle Geometry for the Form Four students. Through the three weeks intervention given to the treatment group showed a greater mean score comparing to the control group. While going through their pre-test and post-test too, this research has confirmed that the students were facing problem in learning the Circle Geometry concepts. The students were facing problem of misconception and lack of prior knowledge in Circle Geometry, they were demotivated to learn geometry, they were also not creative in exploring the questions regarding Circle Geometry and solely rely on text book and teacher for knowledge.

Using this physical manipulative like CG-board has helped students to engage in their learning process. As using physical manipulatives can increase students' motivation to learn Mathematics, the students should be given more opportunity to use it. I believe that the students could grasp the Mathematics concept better when they are directly involved in finding the answers. The teachers must be more the willing to use manipulatives to teach as it produces higher achievement in mathematics lesson taught without using manipulatives [27], [28].

VI. RECOMMENDATION

This study has attributed to some recommendations that may be implemented for the improvement of the students' performance in geometry. Below are some suggestions for further research.

Firstly, the use of CG-board should be implemented early. The students should be given the opportunity to use the CG-board as early as they are in Form Two. Form Two is chosen because the Circle Geometry concept is learned by the students subsequently from Form Two, Three and Four. By using the CG-board early, we do not need to waste time teaching the students or the teacher on how to use all the tools presented in the CG-board strategy. Therefore, a research on an early study on the usage of CG-board should be done.

The teachers should be more open minded to try out new teaching method. The teachers of Malaysia should be more innovative and motivated for their own betterment. Sticking to the old way of teaching is definitely not suitable for this generation as they are easily bored with routine learning. Seeing something new every day from the teacher's effort could actually encourage students to learn better. A study on the use of different teaching styles and techniques should be research further.

Finally, the students too, should be given the opportunity to explore their own knowledge, while doing this research, I have seen that the students were much interested to explore the Circle Geometry concept on their own without the help of their teachers. The students only ask for assistance when in doubt if the outcome of their deduction on a Circle Geometry concept is right. The teacher too, showed encouragement for students who explored earlier and gave the students the responsibility to teach and explain to their fellow classmates who are struggling to learn a Circle Geometry concept. This indirectly helps the teacher to conduct the learning as the number of students in the class is large. A research on effectiveness of student mentor can be done to see if it has any improvement to the students' performance.

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