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Enhancing Students Geometric Thinking through Phase-Based Instruction Using Geogebra to Teach Circle Theorem at Abetifi College of Education

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Abstract
The purpose of this study was to determine the effect of GeoGebra on conceptual and procedural knowledge of Geometry. The study involved about 147 Students of Abetifi Presbyterian College of Education. A total of eighty – four (84) students were involved in both the Pre-intervention and the Post intervention methods for both Science B and Maths F classes and 63 students were in the control group. The data was collected using the Pre and the Post interventions of GeoGebra method and Lecture Methods respectively with the assistance of paired sampled t - test. The results of the Pre – test between Science B and Maths F classes recorded $t = 0.628,\ 0.534 > 0.05$ *which indicates that we retain the* H_0 *and reject the* H_a*. The Pre- test and Post-test between Science B class recorded* $t = 14.351,\ 0.000 \leq .05$*, the Pre-test and Post tests for Maths F class recorded* $t = 10.314,\ 0.000 \leq .05$*, and the Post – test of both Maths F and Science B classes also recorded* $t = -6.716,\ 0.000 \leq .05$*, which is an indication that the null Hypothesis (*H_0*) is rejectedbut retained the alternate Hypothesis (*H_a*). This shows that the Post- test method (GeoGebra) is more preferred than the Pre- test (lecture method) considering their means and standard deviations. The findings of this study revealed that the use of GeoGebra was useful and meaningful to the Mathematics Departments in all the Teacher Colleges across the Country. From the data, it is realized that the introduction of GeoGebra influenced the educational practice in three dimensions, namely: classroom practice, cognitive development, pedagogical development and learning attitudes.*

Keywords: *GeoGebra, conceptual knowledge, procedural knowledge, phase base.*

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I. Introduction

This study sought to intervene, and investigate how technologically oriented teaching methods could improve student achievement in Mathematics. According to [1], students' performance and achievement in mathematics is affected by three factors, namely teacher factor, student factor and environmental factor. [1]argues that the teacher factor is comprised of subject mastery, instructional techniques and strategies, classroom management, communication skills, and personality. The student factor includes study habits, time management, attitude and interest in mathematics; the environmental factor includes issues such as parents' values and attitudes, classroom settings, and peer group [1]. This study sought to explore one aspect of the teacher factor (teaching aids), namely, the extent to which technology-inspired instructional techniques and strategies impact on student achievement in mathematics.

The major problem that this study sought to solve is poor achievement in circle geometry, that I believe has its origins in an inadequate background in geometry and poor motivation to learn it. The study investigates the effect of the integration of GeoGebra into the teaching of circle geometry on student achievement at the college level. The emphasis is to discover whether the method of instruction (computer assisted instruction using GeoGebra) motivates students, enhances their problem-solving techniques and ultimately improves their achievement in geometry.

Also Geometry is classified central to mathematics and has been called its "formal pillar" [2]. As such, school mathematics curricula around the world afford prominent positions to geometry, especially at the secondary school level.

This research discusses ways of enhancing geometry through the use of *GeoGebra*, a freely-available open-source software package that provides a versatile tool for visualizing mathematical ideas from elementary through to university level. Following a presentation of some examples of teaching ideas using *GeoGebra*for

Colleges of Education students' mathematics, this research raises issues concerning the current emphases and treatment of geometry in the school curriculum and the current and potential impact of technology such as *GeoGebra*. Finally, this research broaches the implications of all this for the pre-service education and in-service professional development of mathematics teachers as technology such as *GeoGebra*becomes more pervasive in mathematics classrooms.

Objective of the study

This study is guided by the following objectives:

1. Students will acquire some skills for teaching geometry (circle theorem) using the GeoGebra.
2. Students will understand and appreciate the social constructivist approach as a method of teaching

Research questions

The following research questions were formulated to guide the study:

1. To what extent will Geometric thinking through Phase-Base instruction using GeoGebra change students' performance in the learning of Circle Theorem?
2. How does Geometric thinking through Phase-Base instruction using GeoGebra relate to students attitude towards learning of Circles?
3. To what extent will the phase-base instruction using GeoGebra help students to improve their abilities of seeing, measuring and reasoning in learning Circles?

Significance of the study

The results of this study would help to sharpen most students' analytical skills in understanding Circle Theorem. It would promote and sustain students' interest to learn geometry as well as motivate slow learners to improve upon their learning.

This will also help address students' needs as prospective teachers and fight the anxiety of their future students and to instill and improve attitude towards geometry in general. The findings will contribute to greater understanding of students' attitude towards geometry and enhance the teaching and learning of mathematics.

It will also add to the existing body of knowledge in teaching and learning of geometry. Other researchers can also use it as reference for further similar studies. The researchers' work will inform, educate and sensitize teacher trainees to develop confidence and greater interest and cultivate positive attitudes towards the teaching and learning of geometry.

II. Material And Methods

Population

The target population for the research is all teacher Trainee Students of Abetifi Presbyterian College of Education. There are three levels namely; level 100, level 200 and level 300 with a total population of about 980 students all pursuing general course, of which mathematics is predominant or the Core subject. Out of these, 350 students are in out segment program (Teaching Practice). Hence the Target students will be levels 100 and 200 students with a total of about 630 students.

The Study Population and Sample

[3] define a population as all elements (individuals, objectives, and events) that meet the sample criteria for inclusion in a study. The population of the study was extracted from the Students' academic register. The study population considered for the study was 980students.

[3]also defines a sample to involve the examination of a carefully selected proportion of the units of a phenomenon in order to help extend knowledge gained from the study of the part to the whole from which the part was selected. Therefore, a sample size of hundred and forty – seven (147) was selected from a population of 980 students. Forty – two (42) students each from the two classes is the sample for the study, making a total of Eighty - four (84) respondents, representing 57.14% of level 100 students and Sixty - three (63) was also given to the level 200 students who were observers. [4] published the formula below for determining the sample size for known population size.

S = $X^2NP(1-P) \div d^2(N-1) + X^2P(1-P)$

S = required sample size

X^2 = the table value of chi-square for 1 degree of freedom at the desired confident level (3.841)

N = the population size

$P=$ the population proportion (assumed to be 0.50 since this would provide the maximum sample size

$d=$ the degree of accuracy expressed as a proportion (0.05)

Furthermore, [5] defines a sample selected with the intension of finding out something about the total population from which they are taken. A convenient sample consists of subjects included in the study because they happen to be in the right place at the right time [6].The sample size of 147 students was the total of respondents who were willing to participate in the research and who met the sampling criteria during the one month period of data collection.

The Sample Criteria

Respondent included in the sample were selected to meet specific criteria. The students of Abetifi College of Education had to meet the following criteria to be included in the sample.

They should:

- Read Geometry as a topic of study.
- Be a level 100 student.
- Be of either sex

Sampling procedure

In this study, a non-Probabilistic sampling procedure was used. Also Convenient and purposive sampling procedure were used since the model used is action research. Convenient sampling was adopted because of logistical financial constraint and easy accessibility of the students bearing in mind of the Colleges of Education's tight programmes.

Instruments/Data Collection

The researcher's criterion of data collection was based on that of University of Education Winneba, and University of Cape Coast grading system. Raw marks of the students were grouped in ranges. Thus the marks range interpretation, grades, number of students and finally the percentage. Tables with students' performance in angles were constructed for both the Pre-Test (Lecture Method (LM))and the Post-Tests (GeoGebra (GM)) in the first phase and the second phase respectively. And can be found in chapter four (4). SPSS version16.0 was also employed for the analysis of the data.

The researcher did a pilot study of both the pre – test and the post - test questions set with five (5) of his colleagues. The essence was to make the language and syntax less complex in order for the questions to be more clear, comprehensible, more reliable and valid. That was to see roughly how long it takes to answer the questions if the questions are clear or need further explanations. [7], [8].The aim of the pilot study was to stimulate the real thing as closely as possible. This was done after the classroom discussion with the use of the Lecture method (LM) and GeoGebra method (LM) tests respectively

Data Analysis

The researcher adopted descriptive statistics method of analyzing the data in a form of marks range in percentages, means, standard Deviation and Grades with interpretation was employed to enhance the discussion. Descriptive statistics was useful because they make it easy to compare and contrast the performance of students easily [7]. Quantitative analysis collects data that is factual and can be measured and considered statistically[8].
The quantitative data were analyzed, using the Statistical Package for Social Science (SPSS) software. This software was chosen for the data analysis because it is reasonably user friendly and does most of the data analysis one as far as quantitative analysis is concerned. SPSS is also by far the most common statistical data analysis software used in educational research [9]. The data entries were done by the researcher in order to check the accuracy of the data. The responses from the interventions (i.e. Pre and Post Tests) were all tabulated to support the discussion of the results.

Validity and Reliability

Content Validity

The quality of a research instrument or a scientific measurement is determined by both validity and its reliability [10]. The procedure by which the content of the test is judged to be representative of some appropriate domain of content is the validity of the content. The instruments designed were therefore developed in consultation with my supervisor and other experts who also provided excellent advice for correction and amendments to ensure that the instruments were valid. Thus, the items were subjected to critical examination to ensure that, they measure the predetermine criteria' objectives or content of the study.

Reliability

Reliability therefore refers to the consistency of data when multiple measurements are gathered [11]. A pilot study conducted on five (5) students from the school, and using the split – half test method, the scores obtained were used to determine the reliability. The Half - test method correlated 0.755 giving rise to Spearmen - Brown coefficient of 0.860. This correlation coefficient of 0.860 estimates the reliability of the full test, an indication that the results of the instruments were sustainable

Intervention

Phase 1 (first two weeks) Pre-Test (Lecture Method)

Having taught angles using the lecture method for both levels 100B and 100F respectively for the first two weeks with a total sample students, population of 90, thus forty - five (45) in each class. The researchers decided to write on a sheet of paper numbers from 1 – 45 for the students to select from. The chosen numbers were used to identify the participants. The researchers chose to use numbers in order to hide the identity of the participants. These numbers were used in both the Pre - test and the Post- test respectively. Pre- test was conducted on angles to assess students' knowledge and abilities. A total of five (5) questions each carrying four marks, were given to students during the extra contact hours to solve individually (see Appendix A). Each student was given a printed question paper and an answer booklets of which he / she is supposed to use.

The duration for both tests was forty five (45) minutes. The answers to the Pre- Test was marked using a prepared marking scheme made by the researcher. The marks were recorded

Meeting one lecture method (week one)

Topic: Circle Theorem

Sub – topic: Proving Circle theorems

R.P.K: students are familiar with circles and its area.

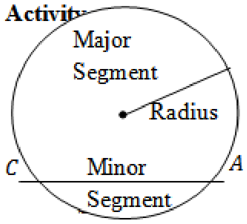
Introduction: Introduce the lesson by reviewing students' idea by asking them to write down the formulae for the area of a circle

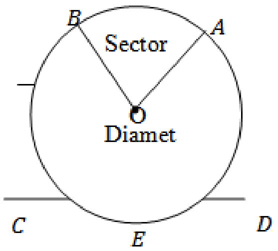
Expected answer: $A = \pi r^2$

Objectives: By the end of the lesson, the students will be able to:

i. identify the various segments, chords and sectors in a circle;
ii. identify that angles standing on the same arc are equal, and
iii. prove that the angle subtended at the circumference by a semi – Circle is a right angle.

Activity





Chord:
A chord is formed when a straight line touches both ends of the circumference of a circle.

Segments:
They are formed from chords. From the diagram, line *CA* is the chord.

Radius:
A radius is formed when a straight line extends from the circumference of the circle to the centre of a circle.

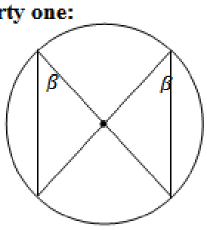
Sectors:
They are formed when two radii meets at the centre of a circle

Diameter:
A diameter is formed when a chord divides acircle into two equal parts

Tangent of a Circle:
It is formed when a straight line touches the circumference of a circle.

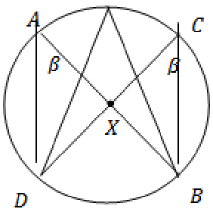
Activity two

Property one:



When a chord or arc Subtend at the Circumference in the same Segment of a Circle, the angles formed are said to be equal

Angles standing on the same arc are equal



Prove $\angle AXD = \angle CXB$

a. $\angle AXD = \angle CXB$ (vertically opposite)

b. $\angle XAD = \angle XCB$ (Angle standing on the same arc)

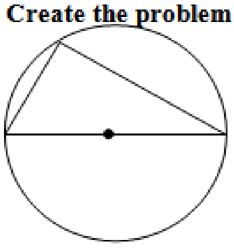
c. $\angle XDA = \angle XBC$ (Angle sum of triangle)

Corresponding angles of similar triangles are equal. Hence $\angle DAB = \angle DCB$

Activity three:

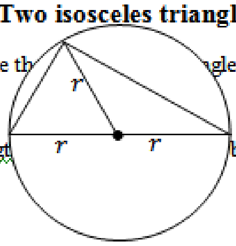
Property two: Angle in a semicircle (The angle a diameter of a circle subtend at the circumference is equal to 90^0)

Step 1: Create the problem



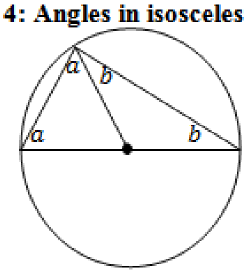
Draw a circle, mark its centre and draw a diameter through the centre. Use the diameter to form one side of a triangle. The other two sides should meet at a vertex somewhere on the circumference.

Step 3: Two isosceles triangles



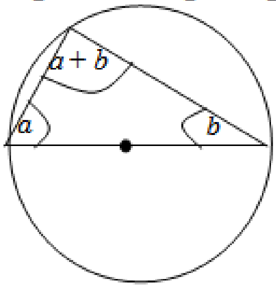
Recognize th gle has two sides that are radii.
All radii are the same in a particular circle.
This means that each small triangle has two sides having the same lengt both be isosceles triangles.

Step 4: Angles in isosceles triangles



Because each small triangle is an isosceles triangle, they must each have two equal angles.

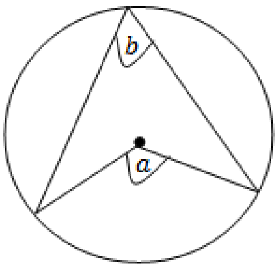
Step 5: Angles in the big triangle add up to 180°



The sum of internal angles in any triangle is 180°. By comparison with the diagram in step 4, we notice that the three angles in the big triangle are a, b and $a + b$. We can set up an equation:

$2a + 2b = 180$ $\qquad a + b = 90$

$a + b$ is therefore a right angle – proven as required.

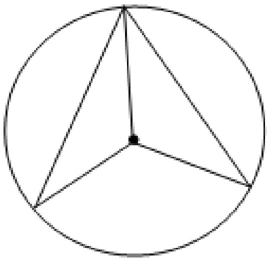


Step 1: Create the problem

Draw a circle and mark its centre. Choose two points on the circumference below the centre and one point on the circumference above the centre.

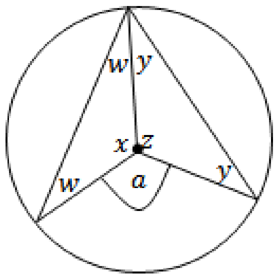
Draw a line connecting each point below the centre to the centre itself and to the point on the circumference above the centre. Label the angle at the centre as a and the angle at the circumference as b.

In symbols, we want to prove that $a = 2b$.



Step 2: Add a radius to form two isosceles triangles

Draw a line from the centre to the point on the Circumference above the centre. This is a radius, as are the other two lines from centre to circumference.
Because all radii in the same circle are equal, two isosceles triangles have been formed – the fact that these triangles have two sides the same length is enough to make them isosceles.



Step 3: Angles in isosceles triangles
Because each small triangle is an isosceles triangle, they must each have two equal angles – the two angles not at the centre.
The sum of angles inside any triangle is 180°.
Therefore, $2w + x = 180°$ and $2y + z = 180°$.
Thus, $x = 180° - 2w$ and $z = 180° - 2y$.
Angles round a point add up to, so $a + x + z = 360°$.
Therefore $(180° - 2w) + (180° - 2y) + a = 360°$.
Consequently $360° - 2w - 2y + a = 360°$.
So $z - 2w - 2y = 0$.
As a result, $a = 2w + 2y$, therefore $a = 2(w + y)$.
Using the fact that $w + y = b$, we conclude that $a = 2b$.
Q.E.D.

The Intervention activity using GeoGebra Method (with Computer) using Phase Base
Here the researcher introduced the usage of GeoGebra through the use of the Phase-Base presentation. Thus to help students progress from one level to the next, Van Hieles proposed a sequence of five phases of learning, or “phase-based instruction” [12]; [13] and [14]:

- *Phase 1: Information.* The teacher engages the students in conversation about the topic of study, evaluates their responses, learns how they interpret the words used and gives them some awareness of why they are studying the topic, so as to set the stage for further study.
- *Phase 2: Guided orientation.* Next, students actively explore the topic of study by doing short (often one-step) tasks designed to elicit specific responses. These steps help students acquaint themselves with the objects from which geometric ideas are abstracted.
- *Phase 3: Explicitation.* In this phase, students learn to express their opinions about the structures observed during class discussions. The teacher leads students’ discussion of the objects of study in their own words, so that students become explicitly aware of the objects of study. Then, the teacher introduces the relevant vocabulary.
- *Phase 4: Free orientation.* Next, the teacher challenges students with more complex tasks that can be completed in different ways. The teacher encourages students to solve and elaborate on these problems and their solution strategies.
- *Phase 5: Integration.* In this final phase, students summarize what they have learned about the objects of study with the goal of creating an overview of the topic. The teacher guides students through this process using standard vocabulary, but does not present any new ideas. At the completion of this phase, the students should have attained a new level of thinking about the topic of study (lines and angles).

Meeting one GeoGebra intervention method
Topic: Circle Theorem (using GeoGebra)
Sub-topic : Exploring the GeoGebra user interface
R.P.K.
Students are familiar with the GeoGebra user interface
Introduction: Student’s idea wasreviewed by focusing on the option at the top of the screen:

Activity one

The students were guided through the usage of the GeoGebra user interface. Thus

i. How to open the GeoGebra window

ii. ii. How to explore the GeoGebra windows and the usage of the tools

iii. They were again taken through how to operate or open some functions from the GeoGebra window

iv. Some of the students were giving the chance to draw some lines and angles using the various tools from the GeoGebra window

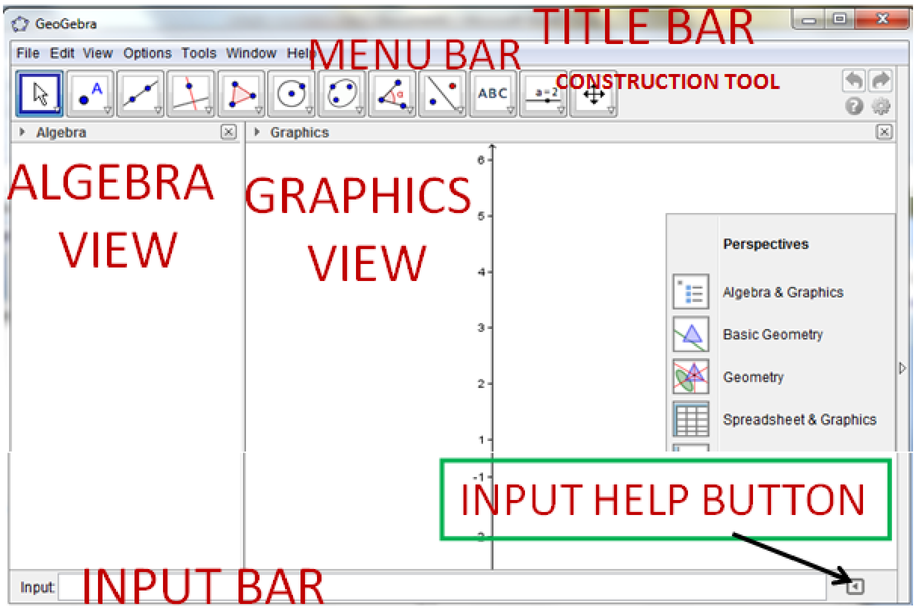


Figure 1 shows all the GeoGebra windows

Meeting two Duration: 2hours

GeoGebra intervention method / Approach

Topic: Circle Theorem (using GeoGebra)

Sub-topic : Exploring angle property one (i.e. when a chord or arc subtend at the circumference in the same segment of a circle, the angles formed are equal) using GeoGebra

Activity one: In pairs teacher guides students to construct circles using the Grid view as shown below.

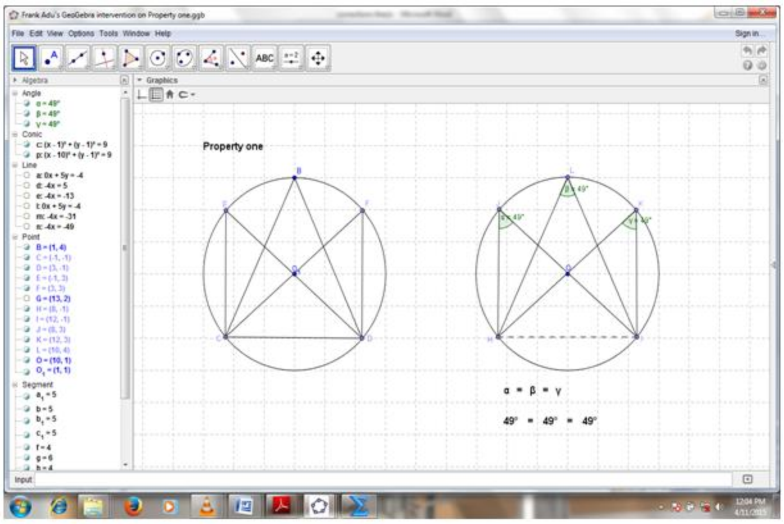


Figure 2 shows the GeoGebra Intervention for property one

Phases / Steps

- Let pupil click on the circle with centre through point and draw a circle.
- Let pupil click on line and the segment to draw various chords to touch the circumference of the circle.
- Let them click on the angle icon on the tool bar and draw the various angles on the circumference of the circle.
- Let them compare the various angles drawn themselves.

Property 2:

Students exploration of the angle a Diameter subtend to the circumference of a circle.
With the knowledge in the angles subtended to the circumference by a chord:

- Draw a circle with diameter GH, and label all the angles correctly. Thus $\angle DAC$ and $\angle DEC$ with centre O
- Let them draw the angle $\angle CAD$ and $\angle CED$
- Students discovered that angle $\angle CAD$ and $\angle CED$ equals 90^0

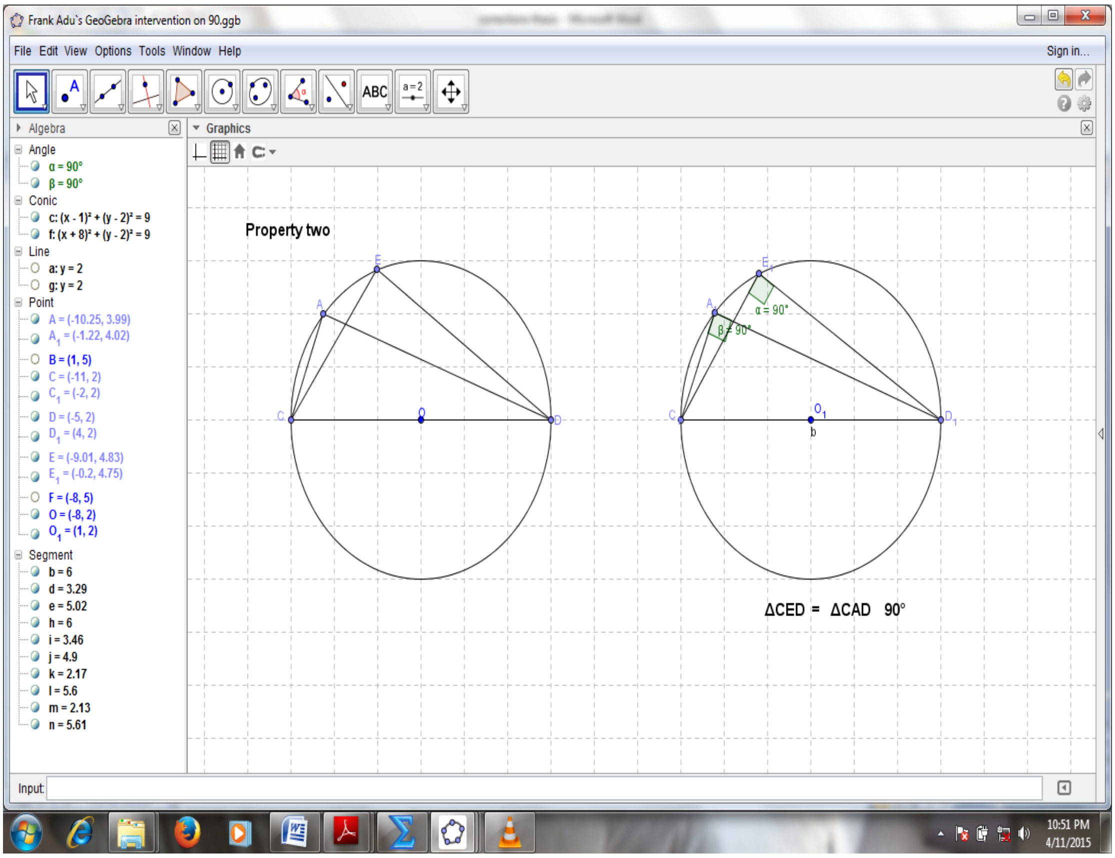


Figure 3 shows the GeoGebra Intervention for propertytwo

Meeting three Duration: 2huors

GeoGebra intervention method / Approach

Topic: Circle Theorem (using GeoGebra)

Sub-topic : Exploring angle **property three** (the angle an arc or a chord subtend at the centre of is twice the angle it subtends at the circumference) using GeoGebra

Activity one: In groups of five, teacher guides students to construct circles using the Grid view as shown below.

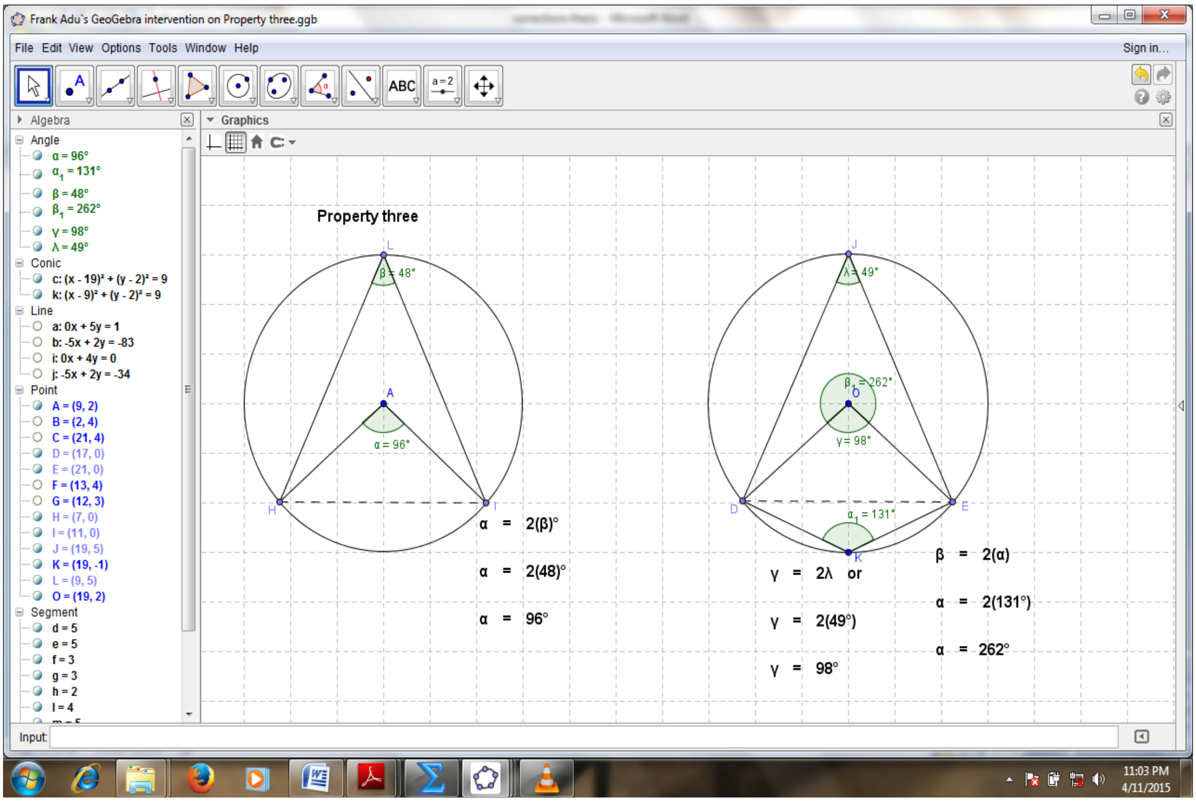


Figure 4 shows the GeoGebra Intervention for propertythree

Phases / Steps:

- Let students click on the circle with centre through point and draw a circle.
- Let then click on line and the segment to draw various chords to touch the circumference of the circle.
- Let them again draw a line from the chord to the centre of the circle. Thus $\angle HOI$
- Let them draw another line from the chord to the circumference of the circle thus $\angle HLI$.
- Let them compare the various angles drawn themselves.

Findings

The findings of the study were discussed based on the objectives stated. The analysis of the post –test achievement scores were conducted using Statistical Package for Social Science (SPSS)

Procedure

Table 1 Analysis of Pre – Intervention Mathematics and Science Classes

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre-Test Math F Pre-TestSciB	.02381	3.13507	.48375	-.95315	1.00077	.049	41	.961

*** Paired samples statistics is significant at the .05 level (2 -tailed)

Looking at table 4.16, the independent sample t-test conducted forMaths F class students had a $M = 4.57, SD = 1.81$ and the Science students score of $M = 4.52, SD = 2.01504$, Thus with condition$t(41) = 0.049,\ 0.96 > 0.05$we then retain the H_0 and reject the H_a .

Hence there was statistically no significant difference between the Lecture method of both Mathematics and Science classes respectively.

Table 2 Analysis of Pre Intervention and Post intervention of Science B class

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	Upper			
Pair 1 Pre-test Science B - Post-test Science B	1.71429	.77415	.11945	1.47304	1.95553	14.351	41	.000

*** Paired samples statistics is significant at the $.05$ level (2 -tailed)

From table 4.17, the Post-Test method for Science B Class recorded $M = 2.86, SD = 1.93$. This is far better than the Lecture Method of the same Science B class which recorded
$M = \ 4.57, SD = 1.81.$ with the condition $t(41) = 14.35,\ 0.00 \le .05$. We therefore reject the H_0.
and accept the H_a which is statistically similar.This attest to the fact that the Post-Test Method is more authentic and preferable than the Pre-Test method.

Table 3 Analysis of Post Intervention and Pre Intervention of Math F class

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	Upper			
Pair 1 Pre Test Maths Class F Post Test Maths Class F	1.14286	.71811	.11081	.91908	1.36664	10.314	41	.000

*** Paired samples statistics is significant at the $.05$ level (2 -tailed)

From the table above, the pre intervention method for mathematics student`srecorded
$M = 4.52, SD = 2.02$and the Post-Test method recorded $M = 3.38, SD = 2.07$.Conditions $t(41) = 10.31,\ 0.00 \le .05$, we therefore reject the H_0.
This gives a clear indication that there exists a statistically significant difference in the usage of GeoGebra method (Post-Test) compared to the lecture method (Pre-Test). Thus the GeoGebra method is more preferable and understandable than the lecture method.

Table 4Analysis of Post Intervention of both Science B class and Math F class

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	Upper			
Pair 1 Post-Test Science Class B Post-Test Maths Class F	-.52381	.50549	.07800	-.68133	-.36629	-6.716	41	.000

*** Paired samples statistics is significant at the $.05$ level (2 -tailed)

With the analysis of the Post-Test method for both Mathematics F Class and Science B Class respectively, it was realized that $M = 2.86, SD = 1.93$, the Maths F Class recorded $M = 3.38, SD = 2.07$. Condition; $t(41) = -6.72,\ 0.00 \le .05$, we therefore reject the null Hypothesis (H_0) and retain the alternate Hypothesis (H_a)

With this analysis, there exist a statistically significant difference between both classes with the Science Class performing even far better than the Mathematics Class in the Post-Test (GeoGebra) method.

Table 5 Comparing the analysis of the Pre – intervention Method with the Post intervention method for both Classes

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre-Test Math F Pre-Test Sci B	.02381	3.13507	.48375	-.95315	1.00077	.049	41	.961

*** Paired samples statistics is significant at the .05 level (2 -tailed)

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Post-test Science Post-test Mathematics	1.85714	2.25855	.34850	1.15333	2.56096	5.329	41	.000

*** Paired samples statistics is significant at the .05 level (2 -tailed)

In comparing the means of the Post Test (GeoGebra method) of both classes with respect to the Pre-Test (Lecture method) of both classes respectively, analytically, the Post-Test (GeoGebra method) of Science B class recorded $M = 2.86, SD = 1.93$. The Maths F class also recorded $M = 3.38, SD = 2.07$ with condition;$t(41) = -6.72, 0.00 < 0.05$. The Pre– intervention of Science B class recorded $M = 4.52, SD = 2.02$ and the Maths F class also recorded $M = 4.57, SD = 1.81$with condition $t(41) = 0.63, 0.53 > 0.05$. The mean distributions of both tests (Pre – intervention and Post- Intervention) of both Science B and Maths F classes give a clear indication that there is statistically significant difference between the GeoGebra method and the Lecture method. Hence the GeoGebra method is more preferred than the Lecture method.

III. Discussion of Results of the Research Questions

1: To what extent will Geometric thinking through Phase-Base instruction using GeoGebra change students' performance in the learning of Circles Theorem?

The pre –test results of Maths students and Science students indicated that, the Maths students reached a mean score of $(M = 4.57)$ whilst the Science students also recorded a mean score of$(M = 4.52)$. Their differences in mean were0.05. The paired sample test was used to investigate whether the differences were significant or not. The t – test gave a significant value (2- tailed) of 0.53 which is far higher than 0.05. Hence there was statistically no difference between the means of the two classes.

On the other hand, the Post tests of the two classes were further analyzed to determine whether Post – Test in both classes yielded a remarkable improvement, in their performances. Here the record was$(M = 2.86, SD = 1.93)$, also the mathematics classes recorded $M = 3.38, SD = 2.07$. The t – test gave a significant value (2 – tailed) of $0.00 < 0.05$. With this it was realized that there was statistically, a significant difference between the GeoGebra method and the lecture method in the teaching of Circle Theorem. Thus the GeoGebra method is much preferred rather than the lecture method.

The analysis goes further to support similar research by [15]. The social constructivist approach also helped the students in their intervention because they collaborated and constructed knowledge together rather than being transmitted to.

2: How does Geometric thinking through Phase-Base instruction using GeoGebra relate to students attitude towards learning of Circles?

In the course of the lesson presentation, students engaged in activities in which they investigated, interacted, discovered and cooperated with their peers. It was based on this that the students characterized the lesson as enjoyable and motivating. There was greater collaboration and task - related interaction when students worked with the software [16].

In addition to this, students demonstrated collaborative behavior and had the opportunity to develop their skills of negotiation, observation and interpretation as well as social skills such as sharing ideas. The environment promoted richer and deeper interpretation than are commonly seen in the lecture method, thus enriching and facilitating interaction between all the participants [17]. The use of computers software like GeoGebra eliminates passive learning hence encouraging students centered learning.

The study promoted students autonomy because students were more confident to assert control of their own learning without the constant need of the teacher. They became familiar with the software hence they were somehow autonomous; researchers showed that ICT integration promotes students interaction, collaboration and discussion ([18].

3: To what extent will the phase-base instructions using GeoGebra help students to improve their abilities of seeing, measuring and reasoning in learning Circles?

After the intervention, the students themselves indicated that, they do a lot of critical thinking when trying to use GeoGebra tools to draw diagrams and to explain concepts during lessons. From the findings again, students have appreciated the skill of seeing angles properly through dragging of points which supports the literature on visualization. The students also did mental reasoning which is in line with [19]. Measuring angles clockwise and anticlockwise is a skill they have learnt. But some of them at certain stages of the intervention were finding it difficult in measuring angles. Because, instead of measuring clockwise for acute angles, some students measured anti – clockwise for reflex angles, and vice versa.

IV. Conclusion

The quantitative findings showed significant differences between the GeoGebra method and the Lecture Method in conceptual knowledge of functions. Students usage of GeoGebra method had higher conceptual knowledge at post-test compared to the lecture method

The findings of this study indicated that teaching using GeoGebra could improve conceptual knowledge of students. The use of graphical representation may make it easier for students to learn about the topics of Geometry. Consistent with research conducted by [20], the conceptual approach to teaching Colleges of Education students at Abetifi indicated that the usage of GeoGebra showed significantly higher growth of conceptual understanding of the topic of Geometry compared to the Lecture method.

The study provided evidence that the use of technology can influence students' ability to solve problems [21]. The findings also revealed that students using GeoGebra had higher procedural knowledge compared to the lecture method. This suggests that GeoGebra can also enhance procedural knowledge. Such technology helps in understanding the relationship between conceptual and procedural knowledge. In sum, using GeoGebra in the teaching and learning of mathematics could increase conceptual as well as procedural knowledge of students in the teaching of Circle theorem.

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