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Research Article

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Using activity method to address students' problem-solving difficulties in circle geometry

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ABSTRACT

This action research sought to address the problem-solving difficulties of students in circle geometry problems using activity method of teaching and learning. The study in investigated students' difficulties in solving circle geometry problems. It also found out how activity method of teaching and learning helped address the students' difficulties of solving circle geometry problems. Finally, it established the extent to which the activity method of teaching and learning affected the performance of students in circle geometry. The accessible population was all form two students at Zion College in the Volta Region of Ghana. It numbered 499. The sample was general science 2B students. The sample size was 27 students made up of 10 girls and 17 boys. The instruments for data collection were pre- and post-test. The pre-test was conducted to establish the existence of the difficulties of students in solving circle geometry problems. After establishing the problems, activity method of teaching and learning was used as an intervention to remedy the situation. A post-test was administered to measure the improvement. The data was presented using tables and figures. Inferential statistics was also used to analyze the data. From the analysis, activity method help the students solve complex questions, which demand multiple circle theorems to solve. It was recommended that mathematics teachers should always use activity method of teaching and learning in teaching circle geometry.

Keywords: activity method, circle geometry, problem-solving, students' difficulties

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INTRODUCTION

In 1987, there was a major reform in Ghana's education system. One of the objectives of the reform was to produce well balance individuals with requisite knowledge and skills to become useful and productive citizens. However, after the implementation of the reform, it was evidenced that there were some inadequacies in the new system. Consequently, the government constituted a committee of experts to review the education system and make recommendations to address the existing challenges in 2002. The committee suggested that for the education system to produce productive citizens as enshrined in the curriculum, problem-solving should be an integral part of the pre-university curriculum (Anamuah-Mensah, 2002). This recommendation by the Education Reform Review Committee was consistent with the suggestion of National Council of Teachers of Mathematics (2000) proposal that problem-solving should be included in school mathematics curriculum. The council highlighted that mathematics should be taught through problem-solving . This requires that mathematics be taught through the use of problem-solving as a tool. A curriculum is the set of experiences to be provided to students by the schools to make them useful in the society. According to Bishop (1985), curriculum is defined as 'learning experiences to be organized by teachers within and outside the school, to enable the pupils to adopt positive attitudes to learning, to apply knowledge and skills and to develop their taste and a balanced sense of value'. In this perspective, a problem-solving curriculum provides the experiences and activities that would develop the metacognitive domain of the students such that they would be able to address challenging situations of life through critical reasoning, analysis and application of knowledge. The problem-solving curriculum was recommended with the aim of equipping students with skills to solve personal and societal problems. The recommendation by the committee was implemented in 2007 where problem-solving curriculum was integral in the content domain delineated by the mathematics curriculum. This new problem-solving mathematics curriculum was designed to put emphasis on developing students' mathematical knowledge and skills to enable them to solve mathematical and everyday life problems. This would make the students relevant in the society.

The current problem-solving mathematics curriculum requires that the mathematics teacher should use appropriate problems that will demand critical thinking and analysis, not just a recall of theorems and mere use of standard procedures to solve in their teaching and learning process (Ministry of Education, 2007, 2010). The problem used must require the application of content knowledge specified by the curriculum. The curriculum also provides the opportunity for the students to learn in small groups cooperatively. Problem-solving is not a topic in the curriculum but a tactic to teach all topics.

It is very important to use the appropriate teaching strategies in teaching problem-solving in our mathematics classroom. There are two main common method of teaching: the traditional method and activity method. The traditional method is a teacher-centered approach of teaching in which the students have little or no involvement in the teaching and learning process. The students perform very little of the teacher-learner activities. They are passive recipients of knowledge. This strategy of teaching is the commonest in Ghana's schools (Anamuah-Mensah et al., 2008). The activity method, however, is a student-centered approach in which the teacher mainly moderates discussions, investigations, explorations and experimentations during the lessons for the students to discover and understand concepts and theorems better. The teacher does less talk and activities in the activity method than in the traditional method.

Now there has been a campaign for the activity method due to its great impact and convenience to problem-solving in many national mathematics curricula today. The activity method creates the environment for the students to be engaged in problem-solving activities.

Some of the activity methods of teaching that could be used to teach problem-solving are discovery method and cooperative learning method. Discovery method, according to Krisnawati (2015), is method of teaching in which the teacher takes the learners through a set of activities with clues along the way to help the students arrive at the solutions. As the name implies, in the discovery method, students are engaged in activities like exploration and experimentation to discover truth (knowledge) for themselves. They are made to come to their own conclusions on concepts and theorems. Discovery learning promotes cooperative learning.

In the cooperative learning method, students are asked to share ideas and solve problems in pairs or small groups. Appiah (2011) defines cooperative learning as a teaching and learning strategy, which brings learners together to share ideas in small groups. Learners are made to apply what is learnt to real life experiences, in a very relaxed atmosphere. When the two strategies are employed in our mathematics classroom our students would not struggle to do mathematics and solve problems. Our students will become critical thinkers and productive citizens. The activity method of teaching is now preferred to the traditional method of teaching mathematics because of its enormous benefits. It improves students' understanding, achievement and problem-solving capability. The deep understanding of the concepts and theorems is a base to good achievement in mathematics and problem-solving .

The syllabus prescribes the contents to be taught, the way to teach them and how to assess students' understanding of them. There are seven key content domains of the senior high school mathematics syllabus. These are numbers and numeration, plane geometry, mensuration, algebra, statistics and probability, trigonometry, vectors and transformation in a plane (Ministry of Education, 2010).

The plane geometry, which is the domain of interest in the study covers angle properties of polygons, Pythagoras theorem, and its application, and circle geometry theorems in the mathematics syllabus. In the mathematics curriculum, geometry is a branch of mathematics that studies planes and solids. There are two divisions of geometry: plane geometry and solid geometry. Solid geometry deals with polyhedrons and spheres while plane geometry deals with angles and flats. Plane geometry, which is one of the key content domains of the syllabus for the senior high schools is useful in the development of the students in various ways. Plane geometry contributes to the development of skills such as visualization, critical and logical reasoning, problem-solving and intuition. It also helps the students to understand other areas of mathematics including arithmetic, algebra and statistics (Drickey, 2001; Jones, 2002). Geometry is applied in many fields such as arts, architecture, engineering, robotics, and survey, astronomy, sculpture, and many more. Students with sound background in geometry can have a career in these fields. The usefulness of geometry for that matter plane geometry cannot be overemphasized.

Due to the relevance of geometry, every year, a lot of test items are constructed to assess students understanding of concepts on plane geometry in core mathematics at the West Africa Senior School Certificate Examination (WASSCE). One aspect of geometry on which test items are often constructed is circle geometry. In the mathematics curriculum, circle geometry has to do with concepts and rules concerning angles subtended by chords or arcs at the circumference or center of a circle. Mastery of concepts and theorems in geometry especially circle geometry contributes to students' ability to solve geometrical problems and enhance their performance in mathematics. However, Anabah (2011) observed that many senior high school students have various challenges in understanding and applying the theorems of circle geometry. This led to the poor performance of students in circle geometry. He said that current literature points to students' difficulties in solving circle geometry problems in Ghana particularly in the Upper East Region. Chief Examiners Report (2000, 2005) had earlier reported that students' poor achievement in geometry is linked to their lack of knowledge in circle geometry. Chief Examiners Report (2012) corroborate this fact by stating that students having been performing poorly in circle geometry questions. Many students avoid circle geometry questions when they have other alternatives questions.

In like manner, the researcher identified the students in Zion College to be having difficulties solving circle geometry problems. In a test to assess their understanding and their ability to apply circle geometry theorems in solving problems, nine students representing 33% of the students could not attempt any of the questions. Only nine students scored 50% and above the total mark. This performance confirms Chief Examiners of West Africa Examination Council (WAEC) assertion that many students avoid questions on circle geometry. This implies that, most students are not grounded in the theorems of circle geometry and so are unable to apply them in solving problems.

These problems point to the need to intervene to give the students a strong conceptual background to enable them solve problems in circle geometry to avert failure in their mathematics examinations.

Statement of the Problem

Circle geometry, which is an aspect of plane geometry is a major content area in the core mathematics curriculum of the senior high school. A good understanding of this topic is an omen of good achievement in geometry and mathematics in the West African senior school certificate examination and beyond.

Students at Zion College have difficulties in solving circle geometry problems, which led to low achievement in tests in circle geometry. Most of the student wrongly apply the circle geometry theorems. Most of them also could not solve questions demanding multiple theorems in solving. This implies that they do not have good understanding of the circle geometry concept. The challenge negatively affected the achievement of the students on circle geometry. Chief Examiners' Reports of WAEC have also observed that senior high school students have problem-solving geometry problems. It is therefore very imperative to address them the problem.

It is possible that the students were taught earlier using traditional method of teaching such that most of them could only solve problems that requires only recall and direct use of the circle geometry theorems.

Therefore, the study was designed to use activity method of teaching and learning to address the students' difficulties in solving problems in circle geometry. And find out how this method contributes to the performance of the students in solving circle geometry problems.

Purpose of the Study

The purpose of the study was to use activity method of teaching to address students' difficulties in solving circle geometry problems and examine how the activity method of teaching and learning could help address the difficulties. It was also to explore the extent to which the activity method of teaching and learning could affect students' performance in problems in circle geometry.

Research Questions

The following research questions guided the study:

1. How can the use of the activity method contribute to addressing students' problem-solving difficulty in circle geometry?
2. To what extent activity method of teaching and learning affect students' achievement in solving circle geometry problems?

METHODOLOGY

Research Design

This study is an action research, which is toward addressing students' difficulties in circle geometry using activity method of teaching and learning. According to Kusi (2012), action research is aimed at improving practice rather than promoting knowledge. Action research is selected because is normally associated with 'hands-on', small-scale research projects and is for improving teaching and learning (Awanta, 2011).

Sample and Sampling Technique

The sample for the study was general science 2B students at Zion College, Anloga. The class had 27 students made up of 10 girls and 17 boys. The average age of the class is 17 years. The sampling technique employed was purposive sampling. General science 2B students were selected purposively because they were taught by the researcher, and they were identified with the problem.

Research Instruments

The instrument used in collection of data were tests. The researcher administered pre-test and post-test. The pre-test was administered to assess the difficulties students face in solving circle geometry problems. The pre-test consists of five items. After the intervention, the researcher administered post-test to measure the effect of the intervention on the students. The pre- and post-test items are similar.

Validity and Reliability of Instruments

The extent to which an instrument measures what it is intended for is the validity (Awanta & Asiedu-Addo, 2008). To ensure validity of the research instruments, the research was piloted in general science 2A in the same school since the two classes share the same characteristic. The Head of Mathematics Department of the school was asked to make inputs into the test items to ensure content validity. More so, for the purpose of validity of the test items the researcher chose only West African Senior School Examination questions.

According to Awanta (2011), criterion of reliability is whether the research instruments are neutral in their effect and would measure the same result when used on other occasions. Awanta (2011) suggested that for a reliability to be ensured, explicit account of

(1) the aims of the research and its basic premises,

(2) how the research was undertaken, and

(3) the reasoning behind the key decisions.

Besides, Joppe (2000) defines reliability as: "The extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable" (p. 1). So, to make sure that the reliability of my research is assured, the researcher provided vivid account of the research, which when followed under similar condition and method would provide similar results.

Furthermore, the reliability coefficient of the tests (pre- and post-test) is calculated. Test retest was used. The researcher administered the tests to students in general science 2A in the same school and the scores were used to calculate the correlation. The correlation coefficient was 0.77. Orodho (2005) says that correlation coefficient of 0.75 or above is strong to say that an instrument is reliable.

Pre-Intervention Activity

To confirm the existence of the students' difficulties in solving problems in circle geometry, the researcher administered a pre-test.

Intervention

After using the pre-test to ascertain that students were challenged with problems on circle geometry, the following lessons were taught as intervention.

Lesson one: Review of angle geometry properties and establishment of circle geometry theorems.

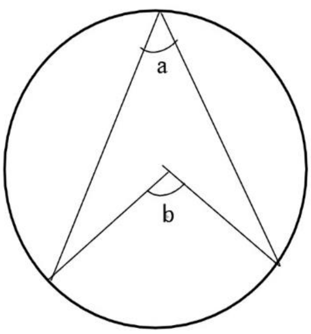
Teaching learning material: Mathematical set, plain sheets.

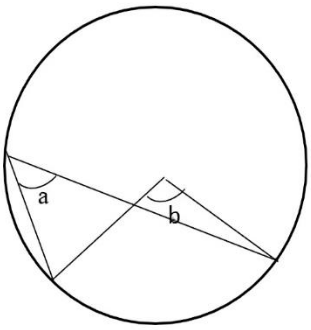
Relevant previous knowledge: Angle geometry properties.

Objective: By the end of the lesson, the student should be able to establish the circle theorems.

Teacher-learner activities

1. The teacher briefly reviewed the angle geometry properties with the students.
2. The teacher put the students in group of four to draw two circles and subtend angles from a chord/an arc to the center and circumference.



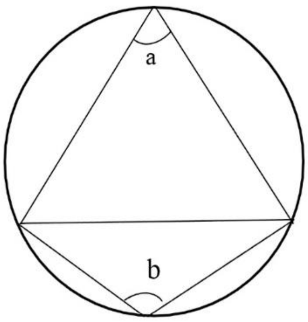


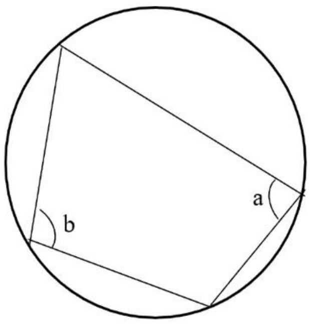
3. Let the students measure and state the relationship between the angle at the center and circumference.

Students' observation: a=b, that's the angle at center is twice the angle at the circumference.

Theorem 1: Angle subtended by a chord or arc at the center is twice the angle it subtend at the circumference.

4. Let the students in groups draw two circles and subtend angles from a chord in the opposite segment.



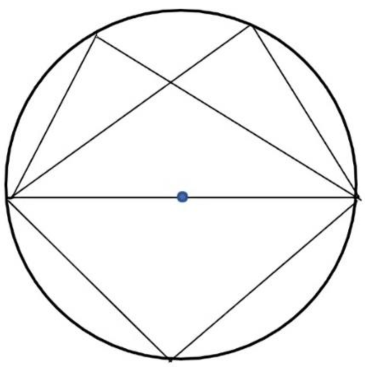


5. Let the student measure and establish the relationship between the angles.

Students' observation: a+b=180, that's angles subtended by a chord/an arch in the opposite segment are supplementary.

Theorem 2: The angle subtended by a chord or an arch in the opposite segment are supplementary.

6. Let the students in group draw two circles and subtend angles from a diameter to the circumference.

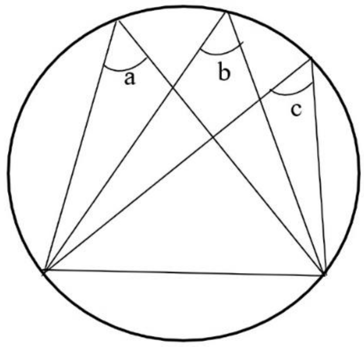


7. Let the students measure the angles and state the relationship between them.

Students' observation: All the angles are 90^0.

Theorem 3: The angles subtended by a diameter at the circumference is 90^0.

8. Let students in group draw a circle and subtend angles at the circumference from a chord/arc.

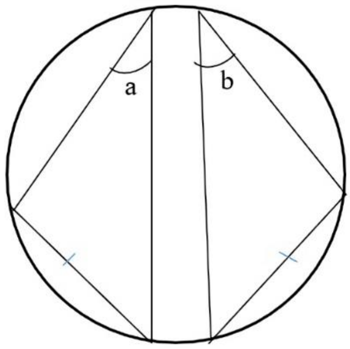


9. Let the students measure and state the relationship between the angles.

Students' observation: a=b=c, that's angles subtended by the same chord or arc at the circumference are equal.

Theorem 4: Angles subtended at the circumference by the same chord are equal.

10. Let the students in group draw a circle and subtend an angle form equal chords/arcs at the circumference.

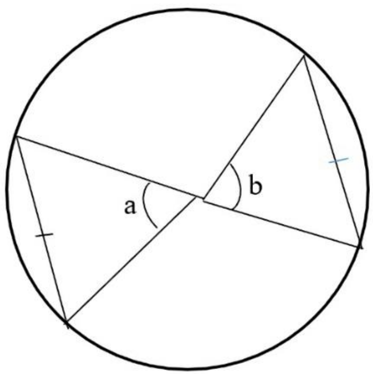


11. Let the students measure and state the relationship between the angles.

Students' observation: a=b, the angles subtended by equal chords or arcs are equal.

Theorem 5: Angles subtended by equal chords or arcs are equal.

12. Let the students in groups draws a circle and subtend an angle from two equal chords/arcs at the center.

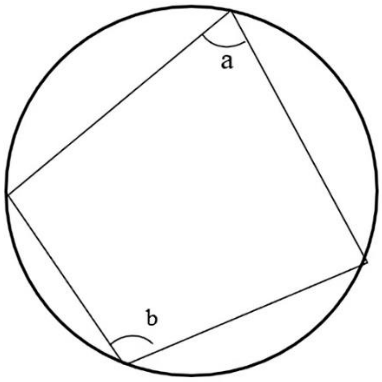


13. Let the students measure and state the relationship between the angles.

Students' observation: a=b, angles subtended at the centre by equal chords or arcs are equal.

Theorem 6: Angle subtended by equal chord at the centre are equal.

14. Let the students in groups draw cyclic quadrilateral.

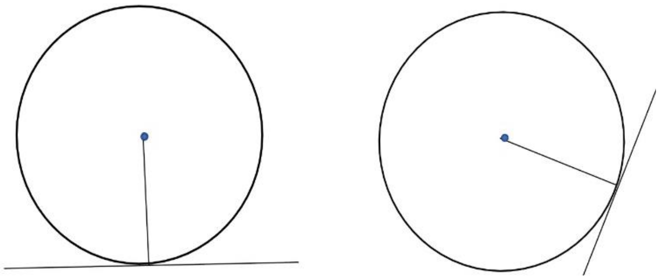


15. Let the students measure and establish the relationship between the opposite angles.

Students' observation: $a+b=180^0$, that's opposite angles of cyclic quadrilateral are supplementary.

Theorem 7: Opposite angle of a cyclic quadrilateral are supplementary.

16. Let the students in groups draw two circles with a radius and a tangent at the radius.

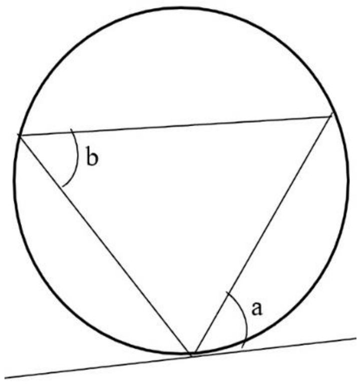


17. Let the students measure the angles between the tangents and the radius and establish the angle between a radius and a tangent.

Students' observation: The angle between the radius and the tangent is right angle.

Theorem 8: The angel between a radius and a tangent is right angle.

18. Let the students in group in draw a circle with cyclic triangle with a tangent at the edge of the triangle.



19. Let the students measure the angle between the tangent and the chord and the angle in the other segment.
20. Let the students state the relationship between the angle between a tangent and a chord and the angle in another segment.

Students' observation: a=b.

Theorem 9: The angle between a chord and a tangent is equal to the angle in the other segment.

Lesson two: The circle geometry theorems.

Relevant previous knowledge: Students established the circle geometry theorems.

Objectives: By the end of the lesson the student should be able to state all the circle theorems.

Teacher-learner activities

1. The teacher revised the circle theorems with the students.
2. The teacher let students to state the theorems of the geometry of circles on the board individually at a time.
3. Students wrote class test in which they were required to write all the circle geometry theorems.

Lesson three: The strategies of solving circle geometry problems.

Relevant previous knowledge: Students can establish and state the circle theorems.

Objective: The student should be able to solve simple questions involving circle theorems using the strategies of solving circle geometry problems.

Teacher-learner activities

1. The teacher teaches the students the strategies of solving circle theorems problems. The strategies are, as follows:
   a. Master all the circle geometry theorems.
   b. Draw helpful imaginary lines to get the pattern of the circle geometry theorem(s) in the circle.
   c. Look for and find all angles that will help you find the required angle.
   d. Split angle you are finding to parts and find the value of the split-angles and the sum will give you the main angle.
2. Let the students solve simple questions involving circles theorems.

Lesson four: Problem-solving in circle geometry theorems.

Relevant previous knowledge: the student know the strategies to solving problems involving circle theorems.

Objective: The student should be able to solve problems involving circle geometry theorems.

1. Let students solve challenging problems involving circle geometry theorems.

Post-intervention activity

The researcher after the intervention administered the post-test to see if there was an improvement in students' achievements.

RESULTS

Research Question One

How can the use of the activity method address students' problem-solving difficulties in circle geometry?

This question sought to find out how the activity method can address the students' problem-solving difficulty in circle geometry. To answer this question, the researcher analyzed the results of the pre- and post-test. More so, the researcher critically examined the solutions in both the pre- and post-test to evaluate the changes and the possibilities for the changes.

Table 1. Pre- and post-test results of students on each item

Question number	Completely correct [n (%)]		Partially correct [n (%)]		Completely wrong [n (%)]	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
1	18 (67)	25 (93)	4 (15)	2 (7)	5 (18)	0 (0)
2	0 (0)	18 (56)	20 (74)	7 (26)	7 (26)	2 (7)
3	4 (15)	8 (30)	10 (37)	15 (55)	13 (48)	4 (15)
4	4 (15)	8 (30)	15 (55)	15 (55)	8 (30)	4 (15)
5	11 (41)	15 (55)	14 (51)	11 (41)	2 (8)	1 (4)

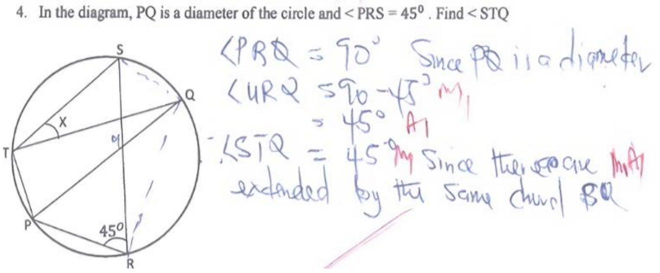


Figure 1. A student's solution to question 4 of post-test (Source: Author)

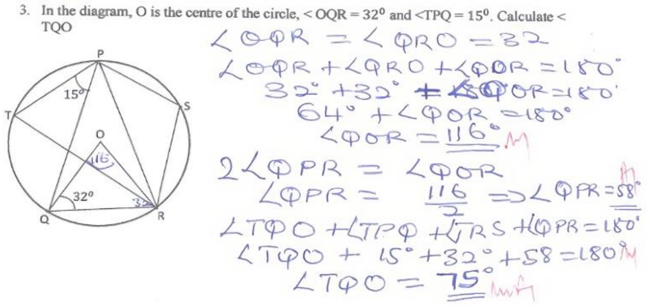


Figure 2. A student's solution to question 3 of post-test (Source: Author)

Table 1 summarizes the pre- and post-test results on each item. There were five similar test items for both tests. The responses of students who provided the right solutions and earned all the marked were described completely correct while those who got part of the solution correct and part of the total mark were described partially correct. But those who did not earn any mark were described completely wrong.

Table 1 compares the results of the students in the pre- and post-test. The results revealed improvement in students' performance.

Figure 1 presents the solution of one student on question 4 in the post-test. This is similar to the solutions of the other seven who had this question completely correct.

Question 4 required that students to draw a straight line from Q to join R and apply the theorem 3, which says that angles subtended by diameter at the circumference is 90 to find angle SRQ and theorem 7, which says angles subtended at the circumference by the same chord are equal to get the required angle STQ. The 23 of the 27 students who had partially or completely wrong could not do this in the pre-test. However, it was evidenced in students' post-test solutions that 15 of the 27 students drew the straight line to join Q and R and apply circle geometry theorem 3 and 7 in solving the problem had everything correct.

The use of activity method of teaching and learning circle geometry has helped students to draw lines that will help them solve problems and also apply circle geometry theorems to the problems since the method of teaching is student centered and inquiring based.

In solving question 3, the students had to take five steps to find the required angle TQO (**Figure 2**). The first is to find the angle at center by the use of isosceles triangle interior angle properties. Second, apply theorem 1 to find angle RPQ. Third, use theorem 4 to find angle RTQ. Four, find angle TRQ by the use of theorem 4 again and finally find the required angle TQO by adding all the interior angles of triangle TQR.

In the pre-test, four of the 27 students could take these five steps in solving the problem correctly. However, in the post-test, the number has increase to eight. The activity method has help students to apply several theorems in solving complex problem involving so many steps.

Research Question 2

To what extent activity method of teaching and learning affect students' achievement in solving circle geometry problems?

Paired samples t-test inferential analysis was used to find the extent to which the achievement of student was affected by the used of the activity method of teaching and learning in problem-solving in circle geometry at Zion College. The results of the paired samples t-test on the participants' scores in both the pre- and post-test are presented in.

Table 2 shows the comparison of the results in the pre- and post-test. The mean (M) score of the pre-test was 10.74 out 25 with corresponding standard deviation (SD) of 6.920, while that of post-test was 17.17 with corresponding SD of 1.288. the result showed that the was 6.45 increase in the mean scores of the pre- and post-test. This indicated the students performed better in the post-test than in the pre-test. To determine whether or not the difference observed in the mean is statistically significant, a paired sample t test was conducted to compare the pre- and post-test scores.

The paired sampled t-test was examined to compare the students' scores in the pre- and post-test. The result as indicated in **Table 3** revealed that the mean score difference between the pre- and post-test was -6.444 with corresponding SD of 3.105. The paired sampled test was examined to find out if the M=-6.444, SD=3.105 between the pre- and the post-test was statistically significant. The result from the table indicated that was statistically significant increase in students' performance in solving circle geometry problems from the pre-test to the post-test since t(27)=-10.785, p=.000<0.05.

Table 2. Paired samples statistics

		Mean	n	Standard deviation	Standard error mean
Pair 1	Pre-test	10.74	27	6.920	1.332
	Post-test	17.19	27	6.691	1.288

Table 3. Paired samples test

	Paired differences					t	df	Sig. (2-tailed)
	Mean	Standard deviation	Standard error mean	95% confidence interval of difference				
				Lower	Upper			
Pair 1 Pre-/post-test	-6.444	3.105	.598	-7.673	-5.216	-10.785	26	.000

DISCUSSION OF THE RESULTS

The researcher's aim in this study was to address students' difficulties in solving circle geometry problems. Therefore, the focus using circle geometry to solve students' problem-solving difficulties and examine how the activity method of teaching and learning would contribute to addressing the difficulties and the extent to which it affects students' achievement in circle geometry.

At the pre-intervention stage, the students were given a pre-test of five items to ascertain the existence of their difficulties before addressing them.

To address these difficulties, the researcher used discovery method of teaching and cooperative learning strategy all of activity method of teaching and learning to teach the students circle geometry. The discovery method was used to guide the students to discover the circle geometry theorems by themselves.

In the process, the students manipulated teaching-learning materials to aid their understanding. Besides, the cooperative method was used to develop or enhance their skill to apply the theorems learnt by cooperatively solving circle geometry problems. After the intervention, the following were identified as how the students' difficulties of solving circle geometry problems were address.

It was noticed from the students' solution of the post-test that they could now draw lines to help them solve circle geometry problems after the activity method teaching and learning was used to teach them. It therefore showed that the activity method of teaching and learning has equipped or enhanced the students with the skill to draw necessary diagrams and lines to aid them solve problems. This confirms Adu-Gyamfi's (2021) finding that using activity method could be used to address students' difficulty of drawing geometry diagrams.

The activity method of teaching and learning has also helped the students to understand and apply the circle geometry theorems in solving problems demanding many theorems to solve. Churchill (2003) believed that activity method assists the students to create their own mental picture of circle geometry theorems which help them to perform well in solving circle geometry problems. Many geometry problems demand more than one theorem to solve.

The results from the paired sample t test showed that there was a significant difference in the performance in solving circle geometry problems. This showed that activity method of teaching and learning circle theorems has help to improve students' performance immensely. This result is in consonance with Magno et al. (2005) who concluded that students who received instruction through activity method had significantly higher performance in tests than those who receive instruction through the traditional method.

CONCLUSION AND RECOMMENDATIONS

Based on the findings of the study the researcher concluded that the activity method has helped students to identify invisible line and apply circle theorems to solve problems. In question 4 of the post-test, students were able to identify and create line QR and also use two theorems to solve the problem. In addition, the activity method has helped the students to solve complex problems involving so many steps and theorems. In question 3 of the post-test, 15 out of the 27 students were able to correctly apply angle properties and many theorems in five steps to solve the problem.

The following recommendations have been made based on the research findings. Findings have shown that activity method of teaching and learning helped tremendously in improving students' achievements in circle geometry. Due to that, first, mathematics teachers should always use activity method of teaching and learning in teaching circle geometry. Second, universities and colleges of education should equip their mathematics teacher trainees with adequate skills in using activity method in teaching and learning. Third, in-service training should be organized by the Ghana Education Service and Schools to refresh mathematics teachers on various ways of teaching circle geometry using activity method.

Limitation of the Study

There was limited time for the study and students also did not have enough time to participate in the study. This made it impossible to let students solve more questions, which could improve the result the more. Nonetheless the intervention set-ups were reliable. Therefore, future study should consider making time for students to solve more questions circle geometry problems in their study.

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Data availability: Data generated or analyzed during this study are available from the author on request.

REFERENCES

Adu-Gyamfi, R. (2021). *Effect of inquiry-based teaching approach on students achievement in circle theorems* [Unpublished M.Phil Thesis, University of Education, Winneba].

Anabah, S. A. (2011). *Enhancing students' achievement in circle theorem through problem-solving approaching* [Unpublished MEd thesis]. University of Education, Winneba.

Anamuah-Mensah, J. (2002). Ghana Educational Reform Committee report: Meeting the challenges of education in the 21^{st} century. *Ministry of Education, Ghana.*

Anamuah-Mensah, J., Mereku, D. K., Ghartey, J., & Ampiah (2008). TIMMS *(2007) Ghana report.* MOE. Accra, Ghana

Appiah, J. (2011). *Advanced instructional strategies in mathematics.* Institute for Educational Development and Extension (IEDE), University of Education, Winneba.

Awanta, E. K. (2011). *Research methods in mathematics education.* IEDE University of Education, Winneba.

Awanta, E. K., & Asiedu-Addo, S. K. (2008). *Essential statistical techniques in research: For universities, colleges and research institutes.* Salt 'N' Light Publishers.

Bishop, G. (1985). *Curriculum development: A textbook for students.* Macmillan Publishery.

Chief Examiners Report. (2000). *The West African Examination Council, Senior High School Certicate Examination (SSSCE)-school candidates.* WAEC.

Chief Examiners Report. (2005). *The West African Examination Council, Senior High School Certicate Examination (SSSCE)-school candidates.* WAEC.

Chief Examiners Report. (2012). *The West African Examination Council, West Africa Senior School Certicate Examination (WASSCE)- school candidates.* WAEC.

Churchill, D. (2003). *Effective design principles for activity-based learning: The crucial role of 'learning objects' in science and engineering education.* http://www.learnerstogether.net/PDF/Effective-Design-Principles.pdf

Drickey, N. A. (2001). *A comparison of virtual and physcial manipulatives in teaching visualization and spatial reasoning to middle school mathematics students* [PhD thesis, Utah State University].

Jones, K. (2002). Issues in the teaching and learning of geometry. In L. Haggarty (Ed.), *Aspects of teaching secondary mathematics: Perspectives on practice* (pp. 121-139). Routledge. https://doi.org/10.1002/tl.62

Joppe, M. (2000). *The research process.* http://www.ryerson.ca/~mjoppe/rp.htm

Krisnawati, E. (2015). *The implementation of teaching writing using discovering learning to the eighth grade students at SMPN 1 grogol in academic year 2014/2015* [Unpublished PhD thesis]. University of Nusantara PGRI Kediri.

Kusi, H. (2012). *Doing qualitative research: A guide for researchers.* Accra: Emmpong Press.

Magno, C., Lajom, J. A., & Regodon, J. R. (2005). Developing a deep approach and attitude to lhrough project-based learning. *Learning edge.*

Ministry of Education. (2007). *Teaching syllabus for core mathematics (senior high school 13).* Accra.

Ministry of Education. (2010). *Teaching syllabus for core mathematics (senior high school 13).* Accra.

National Council of Teachers of Mathematics. (2000*). Principles and standard for school's mathematics.* National Council of Teachers of Mathematics.

Orodho, A. J. (2005). *Elements of education and some science research methods.* Masola Publisher.