



ADRRI JOURNALS ([www.adrri.org](http://www.adrri.org))

E-ISSN: 2026-5360 VOL. 4, No. 3 (4), October, 2021-December, 2021

## Investigating Colleges of Education Students' difficulty in understanding Circle Geometry

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Available Online: 31<sup>st</sup> December, 2021

URL: <https://www.journals.adrri.org/>

### Abstract

Geometry is one of the key branches of mathematics. It has numerous applications in real life, yet students at the Colleges of Education, Ghana find it extremely difficult to learn resulting in their poor performances in examinations. This study intended to investigate the factors responsible for students' difficulty in circle geometry and to suggest ways by which the identified factors can be overcome. The study also examined whether there was any significant difference in the average test scores between male and female students in circle geometry. A sample of 352 level 100 students was selected purposively from a population of 2940 level 100 students for the study. The main research instruments for data collection were questionnaire and teacher-made test. The four points Likert rating scale was used in administering the questionnaire and it was analysed using percentages. The findings showed that, the factors responsible for students' difficulties in circle geometry at the Colleges of Education in Ghana were: Lack of instructional aids, students' psychological fear for circle geometry, poor foundation of students in basic school mathematics, poor preparations on the part of some mathematics teachers and large classes but no significant difference in performance were found with respect to gender. Based on the findings, the study recommended among others that mathematics tutors at the Colleges of Education in Ghana should try as much as possible to relate the teaching of circle geometry to real life situations in order to reduce the perceived abstract nature of circle geometry.

**Keywords:** circle geometry, pre-service teachers

[Cite Article as: Ansong, E. K. and Wiafe, D. A. (2021). Investigating Colleges of Education Students' difficulty in understanding Circle Geometry. ADRRI Journal of Physical and Natural Sciences, Ghana: Vol. 4, No. 3(4). Pp. 1-27, E-ISSN: 2026-5360, 31<sup>st</sup> December, 2021.]

Received: (October 14, 2021)

Accepted: (December 31, 2021)

## INTRODUCTION

Over the years, the performance of students in circle geometry has not been encouraging. Researches have revealed that difficulty in teaching and learning of mathematics, in particular geometry, has led to mass failure in examinations (Adolphus, T. 2011). This mass failure in mathematics is seen at the Colleges of Education, Ghana and the trend of students' (Pre-Service teachers) performance in circle geometry has been on the decline (UCC, Chief Examiner's Report for EBS 143: Geometry and Trigonometry, 2018).

Again, several reports emanating from the West African Examination Council (WAEC) show that students who take WASSCE perform abysmally in circle theorem questions (WAEC, 2011, 2012, 2014, 2015 & 2018). In June 2018, the chief examiner for core Mathematics stated that most candidates who answered question 8 (a) demonstrated that their understanding of geometrical concepts were woefully inadequate. Candidates could not apply the cyclic quadrilateral theory and other geometrical principles to solve the problem. Mostly candidates refuse to answer circle theorem questions when they have other options. On rare occasion, those who answer questions on the topic, most of them demonstrate lack of understanding of the topic (Fletcher & Anderson, 2012) and because the students at the colleges of education are the product of these senior high schools, they come with little or no understanding of the topic. This study therefore sought to investigate the causes of students' difficulty in learning and understanding the concept "circle geometry" and to examine how best this problem could be overcome.

Again, according to the National Education Assessment (NEA) report, the mean of mathematics for P4 and P6 were respectively 41.7% and 43.8% (Ministry of Education, 2016) with Geometry being one of the key topics at that level. The NEA findings indicated that primary school pupils were challenged by mathematics, with only 22% of P4 pupils and 25% of P6 pupils achieving proficiency in mathematics. These findings were no different from the 2013 and 2015 National Early Grade Mathematics Assessment (EGMA). It can be deduced from the EGMA report that primary school pupils have difficulty with mathematics that requires some levels of thinking. It is clear from the EGMA report that Ghanaian pupils do not internalize the mathematics they learn and therefore are unable to apply it beyond the memorable level. The above stated

statistics as revealed by the national large-scale assessment (NEA & EGMA), the national examinations (BECE and WASSCE) and the international assessment (TIMSS), show that the achievement of Ghanaian students in numeracy in general and geometry in specific in the past years is low (Mereku, 2012). These findings indicated that pupils right from the basic school have problems in learning the concept geometry. It was therefore necessary that the root cause of this problem be investigated so as to be able to find a lasting solution to it.

Geometry has been identified as one of the core mathematics concepts often posing a challenge to learners and teachers. This problem came to fore when mathematics tutors of the selected Colleges of Education met fresh Pre-Service level-100 teachers in the 2018/2019 first semester academic year. During their interactions, the Student-Teachers were asked to write one topic that really gave them problem when they were in the senior high school. Surprisingly over 90% of the Pre-Service Teachers indicated they did not understand circle geometry and as such have developed hatred for the topic.

This really challenged the researchers being practitioners in the area to find out what can be done to help improve the understanding of the concept "circle geometry" at the colleges of Education. The study again was motivated by the chief examiners' report of the West African Examinations Council (WAEC, 2011, 2012, 2014, 2015 & 2018) lamenting on the poor performance of students in geometry as compared to other areas of mathematics. This led to the choice of the research topic: Investigating Colleges of Education Students' difficulty in understanding Circle Geometry. The rationale of this study was to investigate the causes of students' difficulty in learning circle geometry and to see how best this problem can be overcome.

In addition, several research findings (Ezeh, 2005; Doris, Oneill & Sweetman, 2013) indicated that gender differences exist in mathematics. Forgasiz (2005) insist that gender should be a concern in mathematics education because of its importance. He opined that it is essential to include sex differences as a variable in research studies analysis even if it is not the main focus of the study. This argument motivated the researchers to assess this variable. Hence the

researchers decided to examine whether differences exist in the average test score between the sexes.

Students' (Pre-Service teachers) poor performance in circle theorem at the Colleges of Education in Ghana has been a source of worry to both students and teachers for some time now. Most teachers have done and continue to do everything within their power to ensure that students excel in circle geometry, yet the problem still exists. The annual chief examiner's report for West African Senior School Certificate Examination and that of the University of Cape Coast EBS 143: Geometry and Trigonometry, 2016, 2017, 2018 & 2019) are good testimonies of these facts. The semester by semester results from Institute of Education, UCC always revealed that the pre-service teachers are not performing well in circle geometry as expected. Again, results from the International assessment (TIMSS, 2003 & 2007) at the junior high school (JHS) level (equivalents to grade 8) are evidences of poor mathematics performance in Ghana. In the said assessment, Ghana's JHS students were placed 43<sup>rd</sup> out of 44<sup>th</sup> and 46<sup>th</sup> out of 47 countries that took part in the 2003 and 2007 study respectively (Mullis et al 2004, 2008). Sadly, Geometry was one of the core areas candidates' performance was weak. This trend of the poor performance is disturbing and can have serious implications for geometric teaching especially as students move to higher areas of mathematics such as engineering which require strong geometric reasoning, (Akayuure et al, 2016). It is upon these assertions that this study acknowledged circle geometry as a topic that needs attention in order to curb this disturbing trend in students' performance.

#### *Purpose of the study*

The study aims at:

- 1 Investigating the cause of students' difficulties in solving problems in circle geometry at Colleges of Education in Ghana.
- 2 Examining the approach that could be employed to overcome students' difficulty in learning circle geometry at the Ghanaian Colleges of Education.

#### *Research Objectives*

The research objectives are as follows:

1. Investigate the cause of students' difficulties in solving problems in circle geometry.

2. Examine the approach that could be employed to overcome students' difficulty in circle geometry.
3. Investigate if differences exist in the mean scores between male and female students in circle geometry.

### *Research Questions*

The above objectives were achieved by finding answers to the following:

1. What is the cause of students' difficulties in solving problems in circle geometry?
2. What is the approach that could be employed to help remedy students' difficulty in learning circle geometry?
3. Is there any statistically significant difference in the average test scores between genders in circle geometry?

## **LITERATURE REVIEW**

### *Causes of difficulty in learning circle geometry*

Idris (2006), studied the causes of students' difficulties in geometric learning and came out with the following as the main causes; visualization abilities, geometry language, and ineffective instruction by teachers. Other factors according to her include: absence and/or the use of outmoded teaching learning materials, gender differences, poor reasoning skills, teaching methods and students' knowledge on proofs (Mason, 2002; Uduosoro, 2011 and NERDC, 2012). Johnson–Wilder and Mason (2005) have also attributed students' problem in learning geometry on teachers' poor methods and lack of resources for teaching geometrical shapes to students. According to them, the ordinary primary teacher fear the very word 'geometry' and therefore do not handle its concepts well. Again textbooks for basic schools devote little attention on geometry. Thus, students who enter Colleges of Education have very weak foundations in geometry especially circle geometry.

Adolphus (2011) also studied the challenges of teaching and learning of geometry in secondary schools in Rivers State, Nigeria. The sample for the study comprised 300 students and 30 teachers. The research instrument for the study was questionnaire. The research also adopted the descriptive survey method as the design for the study. The data collected were analysed

using simple means. The following were identified as some of the causes of students' difficulties in learning geometry; teachers' poor knowledge of the subject matter (geometry), students' poor foundations in mathematics in general, poor teaching and learning environment of most schools, poor attitude of students towards learning of geometry, lack of commitment on the part of some teachers due to lack of motivation. As a result of the findings, the study recommended that (a) School authorities should as a matter of necessity allocate enough time for mathematics teaching and learning. (b) Mathematics teachers should be employed mainly on merit and not on political lines.

Adegun and Adegun (2013) also conducted a study to find out the opinions of both teachers and students on difficult topics in the senior secondary school mathematics curriculum. The sample for the study comprised 180 Form III students and 15 mathematics teachers selected from 18 secondary school through simple random sampling techniques. Survey questionnaires were designed and administered by the researchers to elicit information on difficult areas in mathematics from both teachers and students. The analysed data indicated that geometry was one of the topics students perceived as difficult and the reasons assigned were: poor knowledge of the subject matter by teachers, low level of commitment by teachers and poor attitude towards geometric learning by students.

Surendra (2016) also conducted a qualitative research on the topic: "Problems of teaching and learning mathematics in geometry at the grade IX". The purpose of the research was to identify the problems encountered by teachers and students in geometry. The sample for the study was made up of two mathematics teachers, five students, a head-teacher and five parents. The sample was purposively selected from Shree Rajaji Tulihal Jonchhe Janta higher secondary school Siswa-Belhi, Saptari District. The main research tools used to collect data for the study were observation, recorded history and interview. The data collected were descriptively analysed using SPSS. From the study, the researcher identified that the teaching-learning environment of school and home, pre-knowledge of students, learning activities which seems to be exams oriented rather than practical oriented, poor evaluation techniques, students' weak pre-

knowledge about geometry, lack of appropriate teaching methods and materials, complex and voluminous syllabus in secondary level mathematics curriculum, and no-effective management related problems as factors militating against the learning of geometry by students.

Egwu, Asuque and Ofori (2018) investigated the topic: Geometry viewed as a difficult mathematics. The study considered a sample of 450 SS 2 students, comprising 230 females and 220 males. The accessible population was selected from 30 senior secondary schools within the three senatorial District in Cross River State, Nigeria. The difficult mathematics concepts as perceived by the students were studied using the 20-item research questionnaire. Data collected from the test were analysed and presented by using frequency counts and percentages. From the analysis, the following concepts were perceived as difficult by the students: bearing and distance, longitude and latitude, surface area of solid figures, coordinate geometry, circle theorem, construction and locus, congruent triangles and volume of solid figures and the reasons assigned for perceiving geometry concepts as difficult were lack of opportunity for practice, lack of teaching and learning resources and teachers' method of teaching. Based on the study, the researchers recommended appropriate teaching methods and effective instructional material if teachers want students to have better understanding on geometric concepts.

Fabiyi (2017), studied geometry concepts that senior secondary Form two (SS2) students perceived to be difficult to learn in Ekiti State, Nigeria. A total sample of 500 students responded to a 23-item questionnaire on geometry concept perceived to be difficult to study by students. The sample was selected from thirty (30) co-educational schools in Ekiti State, Nigeria. The proportionate and random sampling methods were utilized in selecting the sample for the study. The data obtained from the study were analysed descriptively using percentages and frequency counts while the hypothesis was tested using chi-square statistics. The research findings indicated that students have difficulties in the following geometry concepts: Construction and locus, congruent triangles, similar triangles, latitude and longitude, volume of solid figures, surface areas of solid figures, Coordinate geometry, circle theorem and theorems

of triangles and the reasons given for the difficulty includes: lack of instructional resources, teachers' method of teaching and attitudes of students towards geometric learning.

Identification and remediation of challenges students face in learning geometry was the subject of investigation by Ejiofor-Chima and Accra (2019). A total of 314 students were selected from sixteen public school in Port Harcourt Local Government schools through the purposive sampling method. The design of the study was a quasi-experimental. The instrument used in the study was test, i.e. Learning Difficulties Identification Test on Geometry (LDITOG) and Remediation Test on Geometry (REMTOG). The reliability coefficient of the instruments were determined using test re-test. Before treatment, the two groups were given pre-test on the identification of presence and types of learning difficulties experienced. A post-test was given after treatment to find out the effect of remediation. The test before remediation were analysed descriptively in order to address the research questions. Chi-Square and Analysis of Covariance (ANCOVA) were again employed to analyse students' remediation scores. The results of the study indicated that secondary school students have problems with mathematical reasoning. Procedural formulation, strategic competence and conceptual understanding learning difficulties were among the problems that the study revealed. However, there was an improvement in students' performance and mathematics ability levels after remediation.

Ntshengedzeni (2015) did a study on the topic "Enhancement of learners' performance in geometry at secondary schools in the Vhembe District of Limpopo Province. The aim of the research was to improve students' performance in Euclidian Geometry. The participants for the study were chosen through two different sample techniques. Purposive sampling were employed to select the sample for the study while cluster and simple random sampling were used to group schools into low, average and high performing schools. A total of nine schools were selected for the study with each cluster having three schools. In all, 405 students, 6 principals, 6 heads of departments and 6 teachers took part in the study. The study adopted the mixed method design. The study employed questionnaire and interview as the research instruments for the collection of data. Both teachers and students were asked to response to the

causes of difficulties in teaching and learning geometry as well as how these causes can be overcome. The data collected from the instruments were analysed using SPSS Version 22. The data analyzed revealed the following as the causes of students' difficulties in geometry: poor learning environment, large class size, lack of resources for teaching geometry, poor students' attitude towards geometry. On the other hand, the following were identified as strategies that could enhance learners' performance in geometry: provision of adequate instructional materials to teach geometry, applications of geometry in real life situations, frequent monitoring by supervisors, frequent helpful feedback to students, allowing students enough time to practice geometry, practicalizing the teaching of geometry, parents buying textbooks and other reading materials for students and willingness of learners to learn on their own.

Shankar (2016), carried-out a research titled "Problems faced by secondary level mathematics teachers and students in geometry. The participants of the study consisted of ten secondary level mathematics teachers, ten guardians and two hundred secondary level students. In all 220 candidates were taken as the sample for the study. These sample were obtained through the simple random sampling from a population of all secondary schools, mathematics teachers and students of grade 10 (also guardians) of Tokha. The main data collection instruments for the study were observation, interview and achievement test. The data collected from the study were analysed by survey design. Responses obtained from class observation and achievement test were analysed by three Likert scale with the help of mean weightage, content of text books. The study identified school administration, parents, teachers, publications, students and academic policy of the nation as responsible for students' difficulties in learning geometry.

Mifetu, Kpotosu, Bessah and Amegbor (2019) researched on geometry concepts senior high school students perceived as difficult to learn in mathematics in the Cape Coast Metropolis in Ghana. Using the descriptive survey design, the researchers collected data from 300 senior high school Form two students comprising 200 males and 100 females using simple random sampling technique. Questionnaire and teacher-made achievement test were the two main research instruments employed in the study. Participants were asked some of the geometry

topics they perceive as difficult to learn. In addition, 30-items multiple choice achievement test on geometry were designed for the study. Data collected from both the survey questions and the teacher-made achievement test revealed that, four of the geometry concepts senior high school students perceived as difficult to learn are: circle theorem, perpendicularity of tangent to the radius of a circle, angle between tangent and chord and tangent from an external point. The main reasons outlined by students for perceiving those geometry concepts as difficult include: lack of teaching aids to make the teaching of geometry real and lack of understanding of geometrical concepts by teachers. However, the study found that one's gender does not affect his/her learning of geometry.

Ahmed, Amin and Anwar (2017) also did a research on challenges students face when learning mathematics at the second cycle level. A sample of 360 participants consisting of 60 mathematics teachers and 300 students were randomly selected through the simple random sampling approach for the study. The findings of the study shown that students find it difficult in learning geometry concepts.

#### *The role of gender in learning geometry*

Anas (2018) investigated the effect of gender on geometric reasoning stages and achievements among preservice teachers of E. P. College of Education, Bimbilla, Ghana. Data collected from the research were analysed using descriptive and inferential statistics. The results indicated that male and female students do not differ in their geometric achievements, however the mean of the male preservice teachers was slightly higher than that of the female. Again the independent sample t-test conducted did not show the existence of significant difference in Van Hiele's Geometric Test levels between the genders, although the average male performances were higher than that of the females except in level 4 which favoured the female preservice teachers.

Arhim and Offoe (2015) also investigated gender differences and mathematics achievement of senior high school students of Ghana National College, Cape Coast, Ghana. A sample of two intact classes totaling eighty-two students were chosen by simple random sampling technique for the study. The sample were again classify into experimental (42 students) and control (40

students) groups. The aim of the study was to find out if differences exist between male and female students in mathematics (including circle geometry). Two equivalent performance-based assessment test were designed and used as the instruments for the study. The results of the study shown existence of significant difference in the post-test score in favour of the female students.

Alex and Mammen (2014) did a quantitative study on gender differences to find out the thinking levels of South African senior secondary school learners on geometry. The study involved a total of 359 students comprising 163 males and 196 females selected purposively from Eastern Cape Province, Umtata District. The research instrument for the study was test. The test results were analysed and the results indicated no statistically significant difference in geometric thinking levels between male and female students.

Achor, Imoko and Ajal (2010) investigated the effect of games and simulations on senior secondary school (SSS) male and female students in mathematics (geometry). A total of 287 (SSS 1) students consisting of 158 boys and 129 girls were selected from 46 secondary schools in Gwer-West LGA of Benue State, Nigeria for the study. Findings of the analysed data indicated that games and simulation have similar effects on students' interest and geometric achievements.

Abbas and Habu (2014), conducted a study entitled "effect of gender-related differences in academic achievement and retention of senior secondary school students in geometry. A total of 70 SS3 students were sampled via stratified random sampling techniques as participants of the study. The design for the study was the pretest-posttest control group design. Both genders were taught geometry through the problem solving approach. Research instruments employed to gather information for the research was test. Data collected from the study was analysed using t-test statistic. Findings from the study indicated that male students performed better than female students in Geometry Retention-Test. Gender differences in geometry and mathematics achievement and self-efficacy beliefs in geometry was the subject of investigation by Erdogan, Baloglu and Kesici (2011). A total of 199 high school students from an Anatolian

(Konya) were used as the sample for the study. 100 out of the 199 students representing 50.3% were men while 99 students representing 49.7% were women. Students' mathematics and geometry GPA were obtained. The data obtained from students' GPA were analysed and the results shown a positive correlation between students' mathematics, geometry and self-efficacy beliefs. The results again indicated no significant differences in geometric performance of males and females even though the mean score of the females were a bit higher than that of the males. This means that when boys and girls are given the needed assistance and encouragement, they can perform well in mathematics.

Udousoro (2011) studied the perceived and actual learning difficulties of students in secondary school level. The rationale of the research was to find out the misconceptions college students have on geometry. A total of 120 students made up of 60 males and 60 females constituted the study sample. This sample was selected from four co-educational secondary school in Akwa Ibom State of Nigeria. The study adapted the descriptive survey technique as a means for data collection. The instruments for the study were questionnaire and teacher-made achievement test. Data collected from the study were analysed using descriptive and inferential statistics. The results of the analysis indicated that as students' misconceptions increase, the actual learning performance decreases and vice versa.

Geometry strategic competence of junior high school students based on sex differences was the topic investigated by Zahra, Budiyo, and Isnander (2017). The aim of the study was to examine whether junior high school students (male and female) had different geometry strategic competences. The design employed in the research was the mix method one consisting of quantitative and qualitative stages. 60 students made up of 34 girls and 26 boys were selected via cluster random sampling for the study. The instruments used for collecting data were test and interview. Students in each sex bracket were asked to perform 14 geometry tasks, the scores obtained were analysed quantitatively using the independent sample t-test. The quantitative analysed data shown that boys and girls exhibit different competences when answering geometry questions.

The review of the related literature indicates that students (male and female) have difficulties in learning geometry and must further be interrogated.

*Contribution of this study to literature*

- The literature review of this paper is divided into two sections: Causes of difficulties in learning circle geometry and the role of gender in geometric learning.
- In the previous studies, researchers attempted to examine the causes of students' difficulties in learning circle geometry but no solutions were suggested, this study will investigate further the causes and suggest ways to address them.
- The study will also determine if there exist any significant differences between male and female students' geometric performances and to suggest to stakeholders how to address the gap.
- This research is again intended to address the challenges students in the Colleges of Education face in learning geometry so that they will be able to teach it well when they are finally posted as teachers.

## **METHODOLOGY**

The study utilized the descriptive survey method. The targeted population for the study was all the 2940 level 100 students drawn from six (6) mixed ability Colleges of Education in Ghana using simple random sampling. This number was made up of 1400 females and 1540 males. The study also involved twenty-four (24) mathematics tutors at the selected Colleges in Ghana. Out of this number, 352 students made up of 186 males and 166 females participated in the study as well as all the twenty-four (24) mathematics tutors of the selected colleges of Education in Ghana. Miller and Brewer's (2003) formula was used in determining the 352 students for the study. The main research instruments used in collecting data for the study were questionnaire and teacher made test. Tutors' and students' opinions on the causes of difficulty in learning circle geometry were solicited through the questionnaire as well as how the problem can be

addressed. Data collected from the questionnaire were analysed using percentages. The test item had a reliability of 0.66 and this was done using the test-retest method.

## FINDINGS

The findings of the study are discussed based on the research questions and hypothesis.

### *Research Question 1*

*What is the cause of students' difficulties in solving problems in circle theorem?*

The research question 1 was answered using the first ten items in both teachers' and students' questionnaire. The four point Likert scale were coded as Strongly Agree = 4, Agree = 3, Disagree = 2 and Strongly Disagree = 1. The responses on agree and strongly agree were put together as agree and those on disagree and strongly disagree were put together as disagree. The responses are presented in table 4.1 and 4.2 below.

**Table 4.1:** Teachers' opinion on the causes of students' difficulties in teaching and learning circle theorem at Colleges of Education in Ghana.

| S/N | Item  | Extent of agreement |            |            |             | Total   |
|-----|---|---------------------|------------|------------|-------------|---------|
|     |   | SA<br>F(%)          | A<br>F (%) | D<br>F (%) | SD<br>F (%) |         |
| 1.  | Students' attitudes towards the teaching and learning of circle theorem                           | 16(66.6)            | 4(16.7)    | -          | 4(16.7)     | 24(100) |
| 2.  | Students psychological fear for circle theorem poses a problem in teaching and learning the topic | 8(33.3)             | 12(50)     | 4(16.7)    | -           | 24(100) |
| 3.  | Inadequate professional mathematics teachers.   | -                   | -          | 12(50)     | 12(50)      | 24(100) |
| 4.  | Large classes make it difficult for both teachers and students to practicalise circle theorem.    | 12(50)              | 12(50)     | -          | -           | 24(100) |
| 5.  | Lack of teaching and learning resources makes circle theorem difficult.                           | 16(66.7)            | 8(33.3)    | -          | -           | 24(100) |

|     |  |          |         |         |         |         |
|-----|--|----------|---------|---------|---------|---------|
| 6.  | Mathematics teachers do not handle circle theorem well because they themselves have weak foundations in circle geometry. | -        | 8(33.3) | 8(33.3) | 8(33.3) | 24(100) |
| 7.  | The weak mathematical bases of students at the basic school level makes the teaching of circle theorem difficult.        | 16(66.6) | 4(16.7) | 4(16.7) | -       | 24(100) |
| 8.  | Parents do not buy textbooks for their wards to practice circle theorem at home.   | 8(33.3)  | 4(16.7) | 8(33.3) | 4(16.7) | 24(100) |
| 9.  | Poor preparation on the part of some mathematics teachers in teaching circle theorem.                                    | 8(33.3)  | 8(33.3) | -       | 8(33.3) | 24(100) |
| 10. | There are no motivations to encourage mathematics teachers to put up their best.   | 12(50)   | 8(33.3) | 4(16.7) | -       | 24(100) |

From table 4.1, it could be observed that 20(83.3%) out of the 24 teachers who responded to the questionnaire indicated that the causes of students' difficulty in learning circle theorem was due to poor students' attitude towards the teaching and learning of circle theorem while 4 teachers representing 16.7% disagree with the assertion.

Similarly, 20 teachers representing 83.3% of the teachers were of the view that students' problem in circle theorem was due to students psychological fear for the topic, probably because of the way and manner they were taught circle theorem at the senior high school level, while four teachers representing 16.7% disagree.

Again, all the twenty-four (24) teachers representing 100% disagreed with the statement that inadequate professional mathematics teachers is responsible for students' difficulty in solving circle geometry related questions.

It can also be inferred from table 4.1.1 that all the twenty-four teachers who responded to the questionnaire agreed to the statement that; large classes make it difficult for both teachers and

students to practicalise the teaching and learning of circle theorem. They added that to make the teaching and learning of mathematics in general and circle theorem in particular more effective, class size should not exceed 30.

Again, the twenty-four (24) teachers who took part in the study agreed unanimously to the statement that lack of teaching and learning resources makes circle geometry generally difficult. Eight teachers, representing 33.3% of the participated teachers agreed that the causes of students' difficulty in learning circle theorem can be traced to weak foundation of most mathematics teachers who handle the topic, while 16 teachers (66.6%) disagreed with the statement.

Furthermore, 50% representing 12 teachers blamed the causes of students' difficulty in learning circle theorem on parents' inability to buy textbooks and other reading materials for their wards to practice circle theorem at home while one-half of the respondents representing 50% disagreed with the statement.

Poor preparation on the part of some mathematics teachers when teaching circle theorem was also one of the factors that contribute to poor performance of students in learning the concept "circle theorem" as 16(66%) out of the 24(100%) respondents alluded to that statement while 8(33.3%) of the respondents think otherwise. They further stated that there are no motivations to encourage mathematics teachers to put up there best.

**Table 4.2:** *Opinions express by students on the causes of difficulty in learning circle theorem*

| S/N | Item  | Extent of agreement |           |           |            | Total    |
|-----|---|---------------------|-----------|-----------|------------|----------|
|     |   | SA<br>F(%)          | A<br>F(%) | D<br>F(%) | SD<br>F(%) |          |
| 1.  | Lack of teaching and learning aids by teachers makes it difficult to grasp the concept of circle theorem. | 181(51.3)           | 108(30.8) | 45(12.8)  | 18(5.1)    | 352(100) |
| 2.  | Lack of motivation in learning circle geometry.   | 92(26.2)            | 140(39.7) | 79(22.6)  | 41(11.5)   | 352(100) |
| 3.  | There are inadequate professional mathematics   | 101(28.7)           | 149(42.3) | 60(16.9)  | 42(12.1)   | 352(100) |

|     |  |           |           |           |           |          |
|-----|--|-----------|-----------|-----------|-----------|----------|
|     | teachers.  |           |           |           |           |          |
| 4.  | Students do not solve circle theorem questions in addition to what is given in school.   | 107(30.3) | 138(39.2) | 60(17.2)  | 47(13.3)  | 352(100) |
| 5.  | Students have a psychological fear for circle.   | 141(40)   | 127(36.2) | 48(13.6)  | 36(10.2)  | 352(100) |
| 6.  | Parents cannot afford to buy textbooks and other learning materials for students   | 65(18.5)  | 90(25.6)  | 127(35.9) | 70(20)    | 352(100) |
| 7.  | Circle theorem is not important to learn because it has no applications in real life.  | 42(12.1)  | 121(34.3) | 82(23.3)  | 107(30.3) | 352(100) |
| 8.  | The weak foundations of students in geometry at the basic level makes it difficult to learn circle theorem at the college level. | 135(38.5) | 101(28.7) | 63(17.7)  | 53(15.1)  | 352(100) |
| 9.  | Poor teaching methods use in teaching circle geometry.   | 119(33.9) | 84(23.8)  | 99(28.2)  | 50(14.1)  | 352(100) |
| 10. | Inability to practicalise circle theorem concepts by teachers.   | 86(24.4)  | 108(30.8) | 84(23.8)  | 74(21)    | 352(100) |

Table 4.2 shows the opinion of students about the causes of difficulty in learning circle theorem at the Colleges of Education, Ghana. From the table, it is evident that 82.1% representing 289 out of the 352 respondents agreed that lack of teaching and learning aids for teaching circle theorem makes the concept difficult to grasp while 63 respondents representing 17.9% think otherwise.

Again, the respondents claimed generally that lack of motivation for learning circle theorem was the cause of circle theorem difficulty by students, 232(65.9%) out of the total respondents agreed to this assertion while 120(34.1%) thought otherwise.

Similarly, 250 respondents representing 71% were of the view that inadequate professional mathematics teachers is the cause of students' difficulty in circle theorem while 102(29%) disagreed.

Again it can be observed from the above table that 245(69.5%) out of the 352 respondents agreed to the statement that students do not solve circle theorem questions in addition to what is given in school while 107(30.5%) of the respondents disagreed. According to the majority of the respondents, to be good in mathematics (circle theorem) one has to solve extra questions to supplement what is given in school.

Furthermore, 268 respondents representing 76.2% attributed the causes of students' difficulty in circle theorem to students' psychological fear for circle geometry in general while 84(23.8%) disagreed.

On the issue of whether parents cannot afford to buy textbooks and other learning materials for their wards, 155 respondents representing 44% answered in the affirmative while 197 respondents representing 56% disagreed. The result indicates that though textbooks and other reading materials are important in students' geometric performance, which alone is not enough.

Again, 163 respondents representing 46.3% believed that circle theorem is not important to learn because it has no application in real life while 189 respondents which in percentage terms represent 53.7% thought otherwise.

Additionally, 236(67.0%) out of the 352 respondents attributed poor students' performance in circle theorem to students' poor foundations in geometry at the basic school level while 116 respondents representing 33.0% presented a contrary opinion.

Again, 203 respondents representing 57.7% believed poor teaching methods use in teaching circle theorem is the cause of students' poor performance in circle theorem while 149 respondents representing 42.3% disagreed.

Last but not least, 194(55.1%) out of the 352(100%) respondents thought students poor performance in circle theorem was due to inability of some mathematics teachers to practicalise the teaching and learning of circle theorem concept while 158 (44.9%) respondents disagreed.

Tables 4.1 and 4.2 above reveal that the causes except inadequate professional mathematics teachers, weak foundations of most mathematics teachers in circle geometry, parents unable to buy textbooks and other learning materials for students and circle theorem lack applications in real life are factors accountable for students’ difficulty in solving circle theorem questions at Colleges of Education in Ghana.

It is worth noting that most teachers and students strongly agree to the fact that the weak mathematical bases of students at the basic level, lack of instructional aids, students’ psychological fear, large classes, poor preparation on the part of some mathematics teachers, lack of motivations to encourage mathematics teachers and students’ attitudes towards circle geometry are the main problems facing the teaching and learning of circle theorem as shown in the tables above, the major one being lack of instructional aid in teaching the topic.

*Research Question 2*

*What is the approach that could be employed to help remedy students’ difficulty in learning circle geometry?*

Research question 2 was answered using responses to items 11 – 20 on both the teachers’ and students’ questionnaires. The collected data was again analysed using percentages. The responses are showed in tables 4.3 and 4.4.

**Table 4.3:** *Tutors’ opinion on the strategies that could be employed to help students overcome their circle geometry difficulty.*

| S/N | Item   | Extent of agreement |            |            |             | Total   |
|-----|--|---------------------|------------|------------|-------------|---------|
|     |  | SA<br>F(%)          | A<br>F (%) | D<br>F (%) | SD<br>F (%) |         |
| 11. | There should be adequate instructional aids for teaching circle geometry | 24(100)             | -          | -          | -           | 24(100) |

|     |  |          |          |   |   |         |
|-----|--|----------|----------|---|---|---------|
| 12. | Teacher should use both intrinsic and extrinsic motivation to arouse students' interest in geometry lessons. | 20(83.3) | 4(16.7)  | - | - | 24(100) |
| 13. | There should be in-service training and workshops to update teachers' content knowledge.                     | 12(50)   | 12(50)   | - | - | 24(100) |
| 14. | Class sizes should be reduced to a maximum of 30 students to enable teachers have enough time for students.  | 24(100)  | -        | - | - | 24(100) |
| 15. | Parents should endeavor to provide textbooks and other learning materials for their wards.                   | 16(66.7) | 8(33.3)  | - | - | 24(100) |
| 16. | Geometry lessons should be linked to everyday life situations.   | 20(83.3) | 4(16.7)  | - | - | 24(100) |
| 17. | The classroom settings should be enabling for learning to thrive.  | 20(83.3) | 4(16.7)  | - | - | 24(100) |
| 18. | Mathematics teachers should use varieties of methods when teaching circle theorem.                           | 24(100)  | -        | - | - | 24(100) |
| 19. | There is a need for geometry teachers to individualized learning.  | 8(33.3)  | 16(66.7) | - | - | 24(100) |
| 20. | There should be motivations to encourage mathematics teachers to put up their best.                          | 12(50)   | 12(50)   | - | - | 24(100) |

From table 4.3, it could be seen that all the 24 mathematics tutors representing 100% agreed unanimously to the fact that, all the factors listed above are responsible for ensuring effective teaching of circle theorem at the Colleges of Education, Ghana.

**Table 4.4:** *Opinion of students on the approaches that could be employed to help overcome their circle geometry difficulty.*

| S/N | Item   | Extent of agreement |           |           |            | Total    |
|-----|--|---------------------|-----------|-----------|------------|----------|
|     |  | SA<br>F(%)          | A<br>F(%) | D<br>F(%) | SD<br>F(%) |          |
| 11. | There should be adequate instructional aids for teaching circle geometry.                                    | 266(75.6)           | 86(24.4)  | -         | -          | 352(100) |
| 12. | Teacher should use both intrinsic and extrinsic motivation to arouse students' interest in geometry lessons. | 352(100)            | -         | -         | -          | 352(100) |
| 13. | There should be adequate professional mathematics teachers for teaching circle theorem.                      | 311(88.4)           | 41(11.6)  | -         | -          | 352(100) |
| 14. | There should be in-service training and workshops to update teachers' content knowledge.                     | 350(99.4)           | 2(0.6)    | -         | -          | 352(100) |
| 15. | The teaching of circle geometry should be made practical.  | 352(100)            | -         | -         | -          | 352(100) |
| 16. | Parents should buy textbooks and other learning materials for students.                                      | 320(91)             | 32(9)     | -         | -          | 352(100) |
| 17. | The teaching of circle geometry should be linked to everyday life situations.                                | 352(100)            | -         | -         | -          | 352(100) |
| 18. | Students should be given enough exercise to practice at home.  | 226(64.2)           | 85(24.2)  | 41(11.6)  | -          | 352(100) |
| 19. | Teachers should individualize the teaching and learning of circle geometry.                                  | 298(84.7)           | 54(15.3)  | -         | -          | 352(100) |

|     |  |           |        |   |   |          |
|-----|--|-----------|--------|---|---|----------|
| 20. | Parents should keep track of their wards mathematical performance. | 347(98.6) | 5(1.4) | - | - | 352(100) |
|-----|--|-----------|--------|---|---|----------|

The result in table 4.4 shows that all the ten strategies listed above will promote better understanding of circle geometry at Colleges of Education in Ghana when adopted.

*Research Question 3*

*Is there any statistically significant difference in the average test scores between genders in circle theorem?*

**Table 4.5:** Descriptive Statistics Geometric Score for male and female

| Gender | N   | Mean    | Std. Deviation | Std. Error Mean |
|--------|-----|---------|----------------|-----------------|
| Male   | 186 | 38.4785 | 5.25995        | .38568          |
| Female | 166 | 38.5422 | 3.71826        | .28859          |

The descriptive statistics table 4.5 shows that the males had a mean score of 38.48 while the females had a mean score of 38.54. The mean score difference between the male and the female was 0.06. The standard deviation for the male and the female were respectively 5.26 and 3.72. To determine whether the geometric mean score of males differed from that of the females, an independent sample t-test was conducted. Table 4.6 highlights the details of the results obtained.

**Table 4.6:** Independent Sample t-Test for gender

| t-test for Equality of Means |     |                 |                 |                       |   |        |
|------------------------------|-----|-----------------|-----------------|-----------------------|---|--------|
| T                            | Df  | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |        |
|                              |     |                 |                 |                       | Lower                                     | Upper  |
| -.130                        | 350 | .897            | .06367          | .49094                | -1.02924                                  | .90190 |

The results from Table 4.6 indicated that male (M = 38.48, SD = 5.26) and female (M = 38.54, SD = 3.72);  $t(350) = -.130$ ;  $p = .897$  students do not differ in term of their performance in circle geometry).

## DISCUSSION

The focus of this study was to find out the causes of students' difficulties in answering circle theorem questions. The major causes identified in the study were: (1) poor foundations of students at the basic school level. This finding is supported by (Adolphus, 2011; Bosson-Amedenu, 2017; Surendra, 2016), (2) lack of instructional aids for teaching circle theorem. This result is in agreement with the studies of Johnson-Wilder and Mason (2005); Egwu, Asuque and Ofori (2018); Fabiyi (2017); Ntshengedzeni (2015); Mifetu, Kpotosu, and Amegbor (2019); (3) students' psychological fear for circle theorem. This result confirms the findings of Ejiofor-Chima and Accra (2019); (4) lack of motivations to encourage mathematics teachers to put up their best. This finding is consistent with that of Mifetu, Kpotosu, Bessah and Amegbor (2019); and (5) students' poor attitude towards the teaching and learning of circle theorem. This result is in line with the findings of Adegun and Adegun (2013); Adolphus (2011); Fabiyi (2017) and Ntshengedzini (2015) who all concluded poor attitude of students towards learning geometry as the main problem students face as far the teaching and learning of circle theorem is concern. The study however disagreed with the finding of Johnson-Wilder and Mason (2005) who attributed the causes of students' difficulty in geometry to teachers' poor foundation in geometry.

The study also aimed at finding strategies that could be adopted to help students at the Colleges of Education to overcome their difficulties in learning circle geometry. From the analyses of the students' and teachers' questionnaire, the following strategies were found appropriate: (1) usage of relevant teaching aids. This finding is supported by (Adolphus, 2011; Mason, 2005; Ntshengedzeni (2015); Mifetu, Kpotosu, and Amegbor (2019)); (2) motivation. This finding is consistent with that of Adegun and Adegun (2013); (3) Appropriate teaching methods. This finding agrees with the studies of Surendra, 2016; Fabiyi, 2017); (4) Application of circle geometry to real life situations. This finding is in agreement with the studies of Ntshengedzeni (2015), and (5) having positive attitude towards geometry. The result is supported by the studies of (Adegun and Adegun, 2013; Surendra, 2016; Fabiyi, 2017).

The study again investigated whether male and female differ in terms of their geometric performance. From the result, it was evident that male ( $M = 38.48$ ;  $SD = 5.26$ ) and female ( $M = 38.54$ ;  $SD = 3.72$ ) students do not differ in term of their geometric performance. This result confirms the findings of Arhim and Offoe, (2015) and Anas (2018), who has all found no statistical differences in their researches on gender differences in mathematics. The result however differs from that of Abbas and Habu (2014) whose study shown that male students perform better in Geometry Retention-Test than female students. From the researchers' point of view, this study does not provide enough evidence to suggest that any of the sexes performed better than the other.

### Summary

From the data analyses and theoretical point of view, the following findings were made:

- 1 The students have poor attitudes towards the teaching and learning of circle geometry.
- 2 Students have psychological fear for circle geometry which affects the way they learn the concept.
- 3 Large classes make it difficult for both teachers and students to practicalise circle geometry.
- 4 Lack of teaching and learning resources makes circle theorem difficult
- 5 Students have weak foundations in geometry from the basic school.
- 6 Some mathematics teachers do not handle circle theorem well because they themselves have weak foundations in circle geometry.
- 7 Some mathematics teachers do not put up their best due to lack of motivation in teaching circle geometry.
- 8 Male students do not differ from that of the female students in their geometric learning.

### RECOMMENDATIONS

The following recommendations have been made as a result of the findings of the study:

- Teaching aids should be made an integral part in the teaching of mathematics especially geometry.
- Individual differences exist among learners and therefore geometry teachers should cater for the diverse needs of learners.
- Teacher should use both intrinsic and extrinsic motivation to arouse students' interest in geometry lessons.

- Ghana Tertiary Education Commission (GTEC), Ghana Education Service (GES), Mathematics Teachers' Association of Ghana (MAG) should as a matter of urgency organize professional development workshop for all teachers to update their knowledge in geometry.
- Class sizes should be reduced to a maximum of 30 students to allow teachers enough time to attend to students' needs.
- Geometry lessons should be linked to everyday life situations to reduce the perceived difficulty in geometry concepts.
- Mathematics teachers should employ pedagogically appropriate strategies in teaching circle geometry.
- College mathematics tutors should as much as possible employ gender responsive pedagogy in teaching circle geometry for the benefits of both male and female students.

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