**Original Research Article**

**Exploring Inductive Teaching: Its Effectiveness in Teaching Circle Theorems to High School Students**

**ABSTRACT**

The study examines the effectives of inductive teaching method on High School students’ achievement in circle theorems and whether students’ gender influence their performance in circle theorems. A non-equivalent control group quasi-experimental design was employed. One hundred and sixty-two students from two schools in Keta Municipality participated in the study. The control group consists of 80 respondents and the experimental group consists of 82 respondents. The eighty-two students in the experimental group were taught topics in circle theorems using inductive teaching method while the eighty students in the control group were taught the same topics using conventional approach. Two research questions and two null hypotheses guided the study. At the beginning of the experiment a pre-test was administered to the students in the two groups while at the end of the experiment session that last for two weeks, a test was administered to the students as post-test using achievement test of 20 items. A reliability coefficient of .805 was achieved for multiple choice questions and an estimate of .732 was achieved for the essay using Cronbach’s alpha. Data were analysed using frequencies, percentages, mean, standard deviation, ANCOVA and independent sample t-test. Findings showed that students who were taught circle theorems using inductive teaching method performed better than students who were taught circle theorems conventionally. It further revealed that there was no significant difference in the performance of male and female students taught circle theorems using inductive method of teaching. The implication is that students’ gender has no statistically significant effect on their academic performance in circle theorems. The study recommended that mathematics teachers should vary their classroom teaching practices, including inductive teaching method in mathematics.

*Keywords: Academic performance, circle theorems, inductive teaching method, geometry*

## 1.1 INTRODUCTION

Geometry as an important division of mathematics consists of points, straight lines, plane figures, space, and three-dimensional figures and the relationships between them. Geometry as explained by Alzahrani (2021) is the area of mathematics related to the study of points and figures, and their properties. It is the study of shapes and spatial relationships of objects. Geometry is studied through basic school to the higher level of education in Ghana. The study of shapes and their properties aids us to see Mathematics as a portion of the things we experience and use every day. For example, symmetry which is a central part of geometry, nature and shapes form patterns that help us shape our world conceptually (Tapp, 2021). The right learning of the concepts of shapes particularly solid shapes, and their properties helps place a solid basis for the study of Mathematics topics such as mensuration, vectors, fractions, statistics and mechanics (Jones & Tzekaki, 2016).

According to Hidalgo (2017), teaching inductively naturally is psychological. Teaching inductively develops curiosity within the learners, which is very crucial for nation development. The inductive method of teaching is supported by Pestalozzi and Francis Bacon. This method of teaching is based on the procedure of induction in teaching-learning practices. In the world of mathematics, it is an approach of making a formula with a sufficient number of concretes, actual and real examples. By this approach of teaching mathematics, the students follow the content with serious attention and understanding at various levels. Inductive teaching approach is useful in algebra, geometry, trigonometry and arithmetic. Inductive teaching method proceeds from particular examples to general rules of formulae, concrete illustrations to abstract rules, known to unknown and simple to complex. Inductive teaching method is time consuming if not managed well.

Learning geometry as an area of mathematics in particular is said to be determined by gender differences. A few studies investigated the influence of gender on perceived difficult geometry concepts in mathematics and achievement have been conducted. Mutai (2016), argued that gender of students has effect on the learning of mathematics in favour of males. However, in an effort to examine whether the number of geometry concepts perceived difficult to study vary between male and female senior high school students, Fabiyi (2017) led a study in Nigeria of five hundred senior secondary school students and found out that gender of learners had a significant impact on the learning of geometric concepts in favour of female students.

All aspects of human life at diverse levels are affected by Mathematics as a subject. A way or a pattern of life can only be attained through the philosophy of mathematics. Unluckily, performance of students in mathematics over the decades has not been positive at the basic, secondary and tertiary levels of schooling in Ghana (Enu, Nkum, & Agyeman, 2015). Studies have revealed that students have difficulties in learning circle theorems (Weiss & Herbst, 2015). The Chief examiner’s reports for WASSCE core mathematics from 2013 to 2018 suggest generally that, candidates had difficulties in solving problems involving geometry such as, cyclic quadrilaterals, chord theorem and circle theorem. The Chief examiner further states that the majority of candidates found it difficult solving problems concerning the concepts of exterior and interior angles of polygons and their properties, among other concepts (WAEC & GOG, 2022; WAEC, 2017).

Also, the researcher’s observation during teaching and WASSCE 2016 through to WASSCE 2019 co-ordination and marking meetings also suggest that students’ knowledge of plane geometry and mensuration is insufficient. For example, candidates have difficulties identifying similarities and differences among shapes, identifying properties of shapes and solving problems relating to concepts of circle theorems. Globally, Ghanaian mathematics students perform below standard of Trends in International Mathematics and Science Study (TIMSS) (Enu *et* *al.,* 2015). Though Ghana could not participate in TIMSS 2015, the recent low performances were justified in the previous TIMSS examinations in 2003, 2007, and 2011 when Ghanaian students held one of the lowest-ranked positions amongst the participating nations in mathematics achievement Mullis, Martin, Foy, & Hooper, 2016).

According to Akaboha and Kwofie (2016), students’ performance in Mathematics at the BECE and WASSCE seems to be low over the years. An analysis to determine students’ achievement in West African Senior School Certificate Examination was employed by Akaboha and Kwofie (2016) using one hundred and four (104) students who finished Suhum Senior High Secondary Technical School in 2013. Statistics of students Basic Education Certificate Examination grades in mathematics and distribution of their corresponding relative achievement in the WASSCE were analysed. It is inferred that the better the BECE grade in Mathematics the better the performance in the WASSCE. The poor performance of secondary school students in the subject in Ghana is confirmed by the 2018 WASSCE results. Yeboah, (2018) reported that in a total of 314,401, candidates, 193,882 candidates representing 62 per cent failed to obtain grades A1 to C6 in core Mathematics in the 2018 WASSCE.

The students’ insufficient knowledge in geometry and their weak performance, if not addressed, have the potential of creating great difficulties in attaining their future goals. It is possible a good teaching approach can help even weak students come up in mathematics by the end of the 3-year programme. This raises the research question bothering the mind of the researcher. A number of studies have been conducted to establish the impact or veracity of using inductive teaching methods in schools (Acharya, 2016; Atta, Ayaz, Nawaz, & Khan, 2015; Rahmah, 2017). But it appears they covered various disciplines except circle theorems. Furthermore, they worked on inductive teaching methods as a pedagogic approach leaving out its effect on the gender. This current study focused on the effect of the use of inductive teaching method on students’ achievement in circle theorems and whether such effects depend on the gender of students.

The research questions that underpinned the study were as follows;

1. What is the effect of inductive teaching method on students' achievement on a circle theorems test?
2. What is the difference in the performance of male and female students taught circle theorems using inductive teaching method?

Based on the research questions of study, the following null hypotheses were formulated for testing;

: There is no significant difference in the mean achievement scores of students taught circle theorems using inductive method and those taught using conventional instructional approach.

: There is no significant difference in the mean achievement scores of male and female students taught circle theorems using the inductive instructional approach.

**2.1 THEORETICAL AND CONCEPTUAL FRAMEWORK**

This research is skewed toward the wide spectrum of constructivism. Constructivism is traced to the works of Piaget, Vygotsky and Bandura. Constructivism could be clarified as an epistemological opinion which perceives the student as an active participant in the teaching and learning process. The building of new knowledge happens at an existing framework, such as culture, religion, social, economic or a geographical setting.

Moreover, the study seems to be prepared on the principle of individuals creating their sense of new information or knowledge offered to them on the basis of their prior knowledge as determined by the learning environment. The new skills are used by the individual to construct new sense out of what is provided. According to Van Der Veer (1986), new knowledge construction is shaped through social interactions with elements in the community. This study therefore, adapted inductive teaching method framework from Shaffer (1989).

**2.1.1 Inductive approach**

According to Hidalgo (2017) teaching inductively naturally is psychological. Teaching inductively develops curiosity within the learners, which is very crucial for nation development. The inductive method of teaching is supported by Pestalozzi and Francis Bacon. This method of teaching is based on the procedure of induction in teaching-learning practices. In the world of mathematics, it is an approach of making a formula with a sufficient number of concrete, actual and real examples. By this approach of teaching mathematics, the students follow the content with serious attention and understanding at various levels. Inductive teaching approach is useful in algebra, geometry, trigonometry and arithmetic. Inductive teaching method proceeds from particular examples to general rules of formulae, concrete illustrations to abstract rules, known to unknown and simple to complex.

Steps in an inductive teaching approach

The use of an inductive teaching method, progresses through the steps that follow;

1. Presentation of examples: the teacher shows examples of the same type, and obtain solutions of all those specific examples with the help of the student.
2. Observation/Reflection: the students detect and observe these examples and try to reach some conclusion.
3. Generalization (Simplification): the educator assists students to solve common rules, laws, formulae or principle by logical mutual discussion.
4. Testing and verification (authentication): the teacher takes students through the test and assists them to prove the law, rule or principle.

These help students to logically achieve the knowledge by an inductive teaching method.

**2.1.2 Conventional Approach**

Conventional approach refers to the traditional way of teaching wherein most of the time lecture method is used. This method of teaching is teacher dominant, and textbook-centred. The emphasis here is mainly in remembering and reproducing facts, principles and theories of learning. Conventional approach generally based on deduction. In deduction, teaching progresses from general to particular and from abstract to concrete. The teacher gives out the rule, principle or law to the learners and the teacher then guides the learners to know rule, principle or law. First of all, the rules are given and then learners are requested to apply rules to answer more problems. Algebra, Geometry, Arithmetic and Trigonometry can be taught deductively. A deductive teaching method is used for teaching mathematics in junior high schools, senior high schools and higher educational institutes. Teaching deductively proceeds from general (rules, laws, principles or formula) to specific (examples), unknown to known, abstract law to concrete example and complex to simple.

Steps in a conventional approach

Teaching deductively follows these steps;

1. Statement of the Problem
2. Generalization
3. Observation/Inference
4. Verification

In conventional teaching, the teacher gives the learner a new concept, explains it, and then asks the learner to practise using the concept (Hidalgo, 2017).

**3. METHODOLOGY**

**3.1 Research Design and sampling**

The quasi-experimental (Pre-test-Post-test) non-equivalent control group design was employed. This design was necessary and suitable for the study since the setting of study prohibit the formation of artificial groups. It is a non-equivalent comparison-group design and is amongst the most regularly used quasi-experimental designs. A quasi-experiment is an empirical study used to evaluate the causative-and-effect treatment activity on the target population without random assignment so as not to disrupt school classes (Achor & Agamber, 2016). There is no randomization of respondents into treatment and control groups (Creswell, 2012). This design is specifically used since it determined the effectiveness of using the inductive teaching method on students’ achievement.

In applying the non-equivalent pre-test-and-post-test design in this study, the dependent variable (geometry achievement) was measured before and after the treatment. This enabled the investigator to find the sequential precedence of the independent variable (inductive teaching method and conventional teaching method) over the dependent variable and measure between group differences before the treatment. The progress of the treatment gave the investigator more self-confidence when making an interpretation to the effect that the independent variable would be accountable or not for changes in the dependent variable and use the pre-test to measure between-groups differences before the introduction of the treatment, which decreased significantly the risk of selection bias by revealing whether the groups changed on the dependent variable prior to the treatment (Creswell, 2018).

The investigator assigned whole groups as the treatment and control. The researcher administers a pre-test to both groups, conducted experimental activities with the treatment group, and then administered a post-test to measure the variation between the two groups. The population for this work was the entire second year students from the seven senior high schools in the Keta Municipal. There were 2750 SHS2 students in Keta Municipal for 2019/2020 academic year. The choice of this population was necessitated by the selected topic—circle theorems, which according to the Ministry of Education, (2020) is learnt in SHS2. Second year students have some previous knowledge of plane geometry—angles at a point, angle properties of parallel lines, relationships between corresponding angles, vertically opposite angles, alternate angles and adjacent angles, supplementary angles, and exterior angle theorem—learned in SHS1.

There are seven public senior high schools in the municipality; one GES category B school, four are GES category C schools and the rest are GES category D schools. All the schools are mixed-sex schools. There are no private senior high school in the municipality. The students are from all the sixteen regions of Ghana, with the majority coming from the Volta region. The mean age of the second-year students was seventeen years all of whom are BECE holders.

The target population was all second-year students from the two schools involved in the study. There were 519 SHS2 students in 2019/2020 academic year. The study employed three sampling techniques at various levels (Alvi, 2016). The researcher randomly selected one hundred and sixty-two (162) senior high school form two students from two schools—as the control school and other as the experimental school for study. This consists of eighty-two (82) students for the experimental group and eighty students for the control group. Fifty-two students were males and one hundred and ten (110) were female students. The schools are about seventeen kilometres apart. This helped to lessen the errors that may occur from collaboration and interchange of ideas amongst students from the two groups.

## 3.2 Research approach and data collection instrument

The paper is part of a broader study conducted by the first author in partial fulfilment for the award of Master of Philosophy Degree in Mathematics Education. As result, the main thesis has been hosted in the University repository.

To determine the influence of the independent variables (inductive teaching method) on the dependent variable (achievement tests), data was obtained through the use of pre-test, and post-test. WASSCE Core Mathematics past questions on circle theorem were adapted with little changes to the names and sizes of the angles by the researcher in designing the achievement tests. A test blueprint was developed using the test items on circle theorem topics in the Teaching Syllabus for Core Mathematics for Senior High Schools (Ministry of Education, 2020). Specifically, topics covered include Circle Theorems, Tangent and Radius of a Circle, and Angle between Tangent and a Chord.

The tests consist of ten multiple-choice questions (with a key and three distractors) each and two constructed response type questions. The pre-test was administered to the two groups, four days prior to the start of the intervention activity in order to determine whether students have equivalent knowledge in plane geometry before the intervention activities and a parallel test, post-test was administered to students, a day after the end of the treatment as post-intervention test to determine the success of the treatment. The tests lasted for a maximum of one hour and scored out of twenty marks. Each student was given a printed question paper. Answers of students to the pre-test and post-test questions were marked using a marking scheme prepared by the researcher. Answers to the ten multiple choice test items for each test were scored '1' for correct responses and '0' for incorrect responses. The two constructed response type questions were each scored out of five making a total of 10 marks for each test.

Inputs made by two qualified mathematics educators who were WAEC Core Mathematics assistant examiners before the instruments were sent to a senior lecturer (research principal supervisor) in the Department of Mathematics and ICT Education, to review the content, construct validity and standard of the items with respect to the learners’ level. The opinions about instruments’ strength of measuring the trait to be measured and suggestions were adhered to. The Teaching Syllabus for Senior High Schools Core Mathematics also aided the determination of curricular validity by examining the content of the test and judging the degree to which it is a true measure of the specific objectives of the study. Also, lesson plans were written and vetted by the research supervisor and the necessary amendments were made.

The reliability of the test was checked by KR-20 and Cronbach’s alpha estimates. These procedures were used to regulate the internal consistency of the items on the test. A reliability coefficient of .805 was achieved for multiple choice questions and an estimate of .732 was achieved for the essay using Cronbach’s alpha. McNeish (2017) suggested that, a test is a good measure if its reliability coefficient surpasses 0.60. The value indicated a good degree of reliability of the instrument. The result also suggests that the test items, to some extent, were free from errors.

## 3.3 Data Collection Procedure

Preceding the start of the data gathering, the researcher went to the selected schools to explain the reasons for the study. In addition, the researcher had a conversation with mathematics teachers of the sampled classes and sought for their consent and assistance towards administration and invigilation of the students in the tests. Students were assigned participant numbers, which were used for all the tests. Four days prior to teaching, the researcher conducted pre – test for students in the two groups in order to determine whether students have equivalent previous knowledge in plane geometry.

The treatment took a period of two weeks. There were three lessons—two lessons in the first week and one lesson in the second week. A lesson lasted for two hours. The researcher taught the experimental and the control group. To check students’ attendance regularly the researcher prepared attendance register for each group. The treatment activity was done from 12th—22nd October, 2020. The experimental group was taught geometry using inductive method whereas the control was taught geometry using conventional teaching approach. However, all other conditions remain the same for the two groups—topics to be taught were the same for the two groups. The teaching process was followed by a post-test for the experimental and control groups.

## 3.4 Data Processing and Analysis

The data were analysed with the aid of Statistical Package for the Social Sciences (SPSS) version 23. Before the analyses of the data were done, the researcher did preliminary data screening. This involved checking for missing values, checking for assumptions of outliers and normality. The data entries were done by the researcher in order to check the accuracy of the data. Data cleaning was done and this helped to get rid of errors that could result from coding, recording, missing information, influential cases or outliers.

Results were presented in tables indicating descriptive statistics such as means, standard deviations and percentages. The pre-test score of the two groups were analysed by computing the mean scores and standard deviation. The descriptive statistics were compared to check if the scores differ markedly. To establish whether the observed difference was statistically significant, the independent sample t-test was run on the raw scores of students. This revealed a significant difference in the performance of students before the intervention or the treatment. In view of that, there was the need to control for the ‘effect’ of the pre-test scores since it can give misleading results (Adam, 2015). Therefore, Analysis of Covariance (ANCOVA) was used to test the hypothesis one, of effect of treatment on achievement. This was to adjust the post-test scores based on their initial difference on the pre-test scores and control the ‘effect’ of the pre-test scores on the post-test. However, there was no statistically significant difference in the performance of male and female students in experimental group before the treatment hence, the research hypothesis two was tested using independent sample t-test.

Anonymity and confidentiality were upheld throughout data collection process for the study. Data gathered were stored safely and treated confidentially at all phases of the research process. To ensure a high response rate of the items on the instrument administered as well as confidentiality, the identity of respondents who partook in the research were not recorded on the instrument. In this research, the ethical moralities were followed to consider the likely significances of gathering and disseminating various types of data and protect against likely misinterpretations.

## 4. RESULTS AND DISCUSSION

The result is presented in two sections; background information of the participants, and the main results. There are two groups of participants—control (students taught circle theorems using conventional instructional approach) and experimental (students taught circle theorems using inductive method) groups. There are two research hypotheses. Table 1 presents the distribution of participants based on group and gender.

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| --- | --- | --- | --- | --- | --- | --- |
| ***Table 1: Distribution of participants by group and gender*** | | | | | | |
|  | Control | | Experimental | | Total | |
| Gender | *F* | *%* | *F* | *%* | *N* | *%* |
| Male | 32 | 40.0 | 20 | 24.4 | 52 | 32.1 |
| Female | 48 | 60.0 | 62 | 75.6 | 110 | 67.9 |
| Total | 80 | 100.0 | 82 | 100.0 | 162 | 100.0 |
| Source: Fieldwork (2020) | | | | | | |

From Table 1, there were more female (67.9%) than male (32.1%) participants in the study. There were 48 females and 62 females in the control and the experimental groups respectively. The males were 32 for control group and 20 for experimental group.

## 4.1.1 Research hypothesis one

*: There is no significant difference in the mean achievement scores of students taught circle theorems* *using inductive method and those taught using conventional instructional approach*.

The research hypothesis sought to find out if there are differences in the the mean achievement scores of students taught circle theorems using inductive method and those taught using conventional instructional approach. The post-test scores for respondents in the experimental (students taught circle theorems using inductive method) and control (students taught circle theorems using conventional instructional approach) groups were compared. To control the influence of the pre-test scores the one-way ANCOVA was used to do the analysis. Having normality of the distribution for pre-test data established, parametric statistical procedures were triggered for testing of the hypotheses upon satisfying homogeneity of variance assumptions and conditions relative to those procedures (Adam, 2015). The pre-test scores of the two groups were also compared using independent samples t-test. Having assumed normality, the homogeneity of variance assumption was checked using Levene’s test, and the result showed no violation of the assumption (*p* = .175). Table 2 presents the comparison of pre-test scores for the groups using independent samples t-test.

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| --- |
| Table 2: The t-test statistics for comparing pre-test scores of control group and experimental groups |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Group | *N* | *M* | *SD* | *t* | df | *p* |
| Control | 80 | 5.338 | 2.783 | 2.933 | 160 | .004\* |
| Experimental | 82 | 4.122 | 2.486 |  |  |  |
| *Source: Fieldwork (2020)* \**Significant, p < .05* | | | | | | |

The results of the independent samples t-test in Table 2 showed a statistically significant difference between the pre-test scores for participants in the control group (*M* = 5.34, *SD* = 2.78) and those in the experimental group (*M* = 4.12, SD = 2.49), *t*(160) = 2.933, *p* = .004. The implication of this result is that the groups were not the same in terms of students’ achievement in basic geometric concepts before the treatment.

In view of that, there was the need to control for the ‘effect’ of the pre-test scores since it can give misleading results (Adam, 2015). Hence, Analysis of Covariance (ANCOVA) was used to test hypothesis one, since this will adjust the post-test scores based on their initial difference on the pre-test scores. The Analysis of Covariance (ANCOVA) test was then carried out. The independent variable had two levels: control and experimental groups. The dependent variable was the post-test scores (the homogeneity of variance assumption was checked using Levene’s test, and the result showed no violation of the assumption, p = .651). The pre-test score was used as the covariate in the model. Table 3 shows the summary statistics of the ANCOVA test.

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| --- | --- | --- | --- | --- | --- |
| Table 3: **ANCOVA test for differences in post-test scores** | | | | | |
| *Source* | *df* | *MS* | *F* | *p* | *Eta2* |
| Corrected Model | 2 | 486.274 | 46.846 | <.001 | .371 |
| Intercept | 1 | 4862.552 | 468.447 | <.001 | .747 |
| Pre-test | 1 | 670.981 | 64.641 | <.001 | .289 |
| Group | 1 | 518.395 | 49.941 | <.001\* | .239 |
| Error | 159 | 10.380 |  |  |  |
| Total | 162 |  |  |  |  |
| Corrected Total | 161 |  |  |  |  |
| Source: Fieldwork (2020) \**Significant, p < .05* | | | | | |

The results in Table 3 show that, while controlling for effects of the pre-test, there was a statistically significant difference in the post-test scores of the control group (students taught circle theorems using conventional instructional approach) and experimental group (students taught circle theorems using inductive method), *F* (1, 159) = 49.94, *p* < .001, partial eta squared = .239. From the results, it can be said that, practically, the groups accounted for 23.9% of the variations in students’ achievement scores in circle theorems. This effect was considered large. Testing for the differences was done using the adjusted post-test means for the groups from ANCOVA results, while controlling for the influence of the pre-test scores. Table 4 shows the adjusted post-test mean scores for the groups

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Table 4**: Adjusted and unadjusted group means**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | *Unadjusted* | | *Adjusted* | |
| Group | *N* | *M* | *SD* | *M* | *SE* |
| Control | 80 | 13.613 | 3.893 | 13.135 | .365 |
| Experimental | 82 | 16.342 | 3.726 | 16.808 | .360 |
| Source : Fieldwork (2020) | | | | | |

From Table 4, the adjusted post-test mean score for the experimental group (*M* = 16.81, *SE* = .36) was higher than that of the control group (*M* = 13.14, *SE* = .37). Therefore, there is a statistically significant difference between the control and experimental groups. Comparatively, it can also be said that the students taught circle theorems using inductive method (experimental group) had performed better than the students taught circle theorems using conventional instructional approach (control group) in circle theorems after the treatment. This therefore implies that the inductive method was effective in enhancing students’ performance in circle theorems.

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## 4.1.2 Research hypothesis two

: *There is no significant difference in the mean achievement scores of male and female students taught circle theorems using the inductive instructional approach.*

The research hypothesis two examined whether the inductive method discriminates between male and female students in terms of their performance in circle theorems. This hypothesis sought to find out if there are differences in the mean achievement scores of male and female students taught geometry using inductive method. Having assumed normality for the post test scores, the homogeneity of variance assumption was checked using Levene’s test, and the result showed no violation of assumption (*p* = .131). Using independent sample t-test (Table 5), the independent variable was gender, which had two levels: male and female. The dependent variable was the post-test scores of the experimental group.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Table 5: **The t-test statistics for comparing post test scores of experimental group** | | | | | |
| *Group* | *M* | *SD* | *t* | *df* | *p* |
| Male | 17.750 | 3.226 | 1.979 | 80 | .051 |
| Female | 15.887 | 3.786 |  |  |  |
| Source : Fieldwork (2020) | | | | | |

From Table 5, there was marginally no significant difference between the post-test scores for both male participants (*M* = 17.75, *SD* = 3.226) and female participants (*M* = 15.89, *SD* = 3.79), [*t*(80) = 1.979, *p* = .051] in the experimental group (students taught circle theorems using inductive method). The implication is that achievement of male and female in circle theorems after the treatment was the same. It can be concluded that there was no statistically significant difference in the performance of male and female students taught circle theorems using inductive method of teaching.

## 4.2 Discussion of Results

The main objective of the study was to examine the use of inductive instructional method and its effect on students’ achievement in circle theorems and to determine whether such effects were influenced by gender of students in Senior High Schools. The study established that, learners in both groups exhibited an improvement in the understanding of circle theorems in the post test as compared to the pre-test. Nevertheless, students taught circle theorems through inductive based teaching approach achieved better results compared to those taught with the conventional teaching approach. Statistically there was a significant difference in the post-test scores of the control and experimental groups in favour of the experimental group. This therefore implies that, the inductive method is effective in enhancing students’ performance in circle theorems. This finding was consistent with Atta *et al*. (2015) who examined the achievements of basic school pupils in mathematics and established that, pupils who were taught mathematics inductively performed better than the group of pupils who were taught mathematics deductively. The study also affirmed the findings of Acharya (2016) on exploration of efficiency of inductive analysis and transmitter of knowledge models on senior high school students’ academic performance on circle theorem and trigonometry that inductive technique of teaching geometry had superior achievement than that of the deductive method of teaching. However, the finding contradicts Rahmah (2017), who conducted an experimental quantitative study that emphasized on improving mathematical concept and problem-solving for Junior High School (JHS) pupils by inductive teaching. The result has shown that, learning mathematics by using inductive method could not increase pupils’ mathematical problem-solving ability significantly compared to traditional teaching.

The computation of the mean and standard deviation values revealed that male students had a higher post-test mean score than female students. However, a further test to see whether male students performed significantly different from their female counterparts after receiving instruction in circle theorems through the use of the inductive teaching method revealed no significant different in the post-test scores of participants. Males had performed same as females after being taught circle theorems using inductive method of teaching. This confirms the findings of previous studies that gender has no specific effect on the learning of mathematics (Tetteh-Korkor *et al.,* 2018; Arhin & Offoe 2015; Yarkwah *et. al.*, 2020). The findings also supports the claim by Mullis *et. al.* (2016) in an international assessment aimed at helping countries to make decisions about how to improve instruction in science and mathematics education conducted by TIMSS in 2015 for eight grade students’ mathematics achievement of 39 participating nations revealed that there was no difference in performance of boys and girls in 26 participating countries. Furthermore, the study was consistent with the findings of Majumder and Hanspal (2024) on the impact of gender on students’ perceived levels of difficulty of mathematics topics in the secondary school mathematics curriculum that there was no difference in the performance of boys and girls in geometry. In contrast with the finding was Mutai (2016) who argued that gender has effect on learning of mathematics in favour of males. This was as a result of the stronger affinity and interest male students have towards the learning of mathematics. Mutai re-emphasized that learning geometry is believed to be determined by gender differences. This work is novel because it focused specifically on inductive method of teaching to elicit students’ understanding of circle theorems whereas the majority of studies have centred on the use of the inductive method teaching in eliciting students’ understanding of the broader concept of geometry.

## 5. CONCLUSION

The inductive method of teaching has the potential to assist students to overcome the fear that interferes with their performance in circle theorems. Teaching circle theorems using inductive approach enhances students’ performance since the inductive method was seen to be effective in enhancing students’ performance in circle theorems. Findings show that gender had an insignificant effect on senior high school students’ achievement in circle theorems based on the result that male and female were capable of competing and collaborating in classroom mathematics activities. The study recommends that mathematics teachers should vary their classroom teaching practices, and intensify the use of inductive teaching method in mathematics to engender students understanding and performance in geometry, specifically circle theorems. Mathematics teachers are enjoined to use inductive teaching method as an instructional approach to foster greater healthy rivalry teaching and learning circle theorems amongst male and female students.

**Ethical standards**

The procedures performed in this study follow the standards of the Review Board of the University.

**Data availability**

Readers who wish to examine the data may contact the corresponding author.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

# REFERENCES

Acharya, U. P. (2016). *Effectiveness of inductive method in teaching geometry at secondary level*. Tribhuvan University, Kirtipur.

Achor, E., & Agamber, S. (2016). Effect of frequent practical work on secondary school students’ achievement in biology. *Journal of Science, Technology, Mathematics and Entrepreneurial Education*, *1*(1), 14–24.

Akaboha, A. A., & Kwofie, S. (2016). Students’ performance in Ghana : A discriminant Analysis. *International Journal of Business and Social Research*, *06*(09), 8–20. https://doi.org/2164-2559

Alzahrani, A. A. (2021). *Exploring Differences in Mathematical Creative Potential and Problem-Posing in Gifted and Non-Gifted Middle School Students* [University of Arkansas, Fayetteville]. https://scholarworks.uark.edu/etd/4162

Arhin, A. K., & Offoe, A. K. (2015). Gender differences and mathematics achievement of senior high school students : a case of ghana national college. *Journal of Education and Practice*, *6*(33), 67–74.

Atta, M. A., Ayaz, M., Nawaz, Q., & Khan, D. I. (2015). Comparative study of inductive & deductive methods of teaching mathematics at elementary. *Gomal University Journal of Research*, *31*(1), 1019–8180.

Creswell, J. W. (2017). *Educational research: Planning, conducting, and evaluating quantitative and qualitative qesearch* (4th ed.). Boylston Street, Boston, MA: Pearson Education,.

Enu, J., Nkum, D., & Agyeman, O. K. (2015). Factors influencing students ’ mathematics performance in some selected Colleges of Education in Ghana. *International Journal of Education Learning and Development*, *3*(3), 68–74.

Ghana Statistical Services. (2021). Ghana: Administrative division (Regions and Districts)-2021 housing and population census. Retrieved August 16, 2021, from https://www.citypopulation.de/en/ghana/admin

Hidalgo, F. S. J. (2017). *Tips on how To teach effectively (A Description of 60 teaching methods)*. Paranaque City. Retrieved from https://www.sunstar.com.ph/article/1500934/Davao/Opinion/Hidalgo-1st-National-ICT-Summit-of-DepEd

Jones, K., & Tzekaki, M. (2016). Research on the teaching and learning of geometry. In Gutiérrez A., Leder G., & Boero P. (Eds.), The Second Handbook of Research on the Psychology of Mathematics Education. In *Gutiérrez A., Leder G., & Boero P. (Eds.), The Second Handbook of Research on the Psychology of Mathematics Education* (pp. 109–149). Rotterdam.

Majumder, R., & Hanspal, P. (2024). Factors Affecting the Middle School Students Academic Performance of Raigarh, Chhattisgarh (India) Depending on Socioeconomic Status of their Parent. *Asian Journal of Education and Social Studies*, *50*(3), 215–218. https://doi.org/10.9734/ajess/2024/v50i31297

McNeish, D. (2017). Psychological methods: Thanks coefficient Alpha, we’ll take it from here. *Psychological Methods*, *May*(29), 1–22.

Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2016). TIMSS 2015 International Results in Mathematics. *International Association for the Evaluation of Educational Achievement*, *TIMSS2015*. https://doi.org/timss2015.org/download-center/

Mutai, C. C. (2016). *Gender differences in mathematics performance among Secondary school students in Bureti Sub-County, Kericho County Kenya*. Kenyatta University.

Rahmah, M. A. (2017). Inductive-deductive approach to improve mathematical problem solving for Junior High School. *Journal of Physics: Conference Series*, *8*(12). https://doi.org/10.1088/1742-6596/755/1/011001

Segbefia, C. R. (2020). Effect of inductive teaching method on senior high school achievement in circle theorem. Master's thesis, DMICT, University of

Shaffer, C. (1989). A Comparison of inductive deductive approaches to teaching foreign languages. *Modern Language Journal*, *73*(4), 395–403.

Tapp, K. (2021). *Symmetry: A Mathematical Exploration* (2nd ed.). Springer Cham. https://doi.org/10.1007/978-3-030-51669-7

Van Der Veer, R. (1986). Vygotsky’s developmental psychology. *Psychological Reports*, *59*(2), 527–536. https://doi.org/10.2466/pr0.1986.59.2.527

WAEC. (2017). *The chief examiners’ reports for the west african senior school certificate examination for school candidates, 2017*. Accra. https://doi.org/www.waecgh.org

WAEC, & GOG. (2022). *West african senior school certificate examination 2013 - 2021 past questions and chief examiners’ reports for core subjects*. Accra: WAEC & KBSL.

Weiss, M., & Herbst, P. (2015). The role of theory building in the teaching of secondary geometry. *International Journal of Education, Learning and Development*, *89*(2), 205–229.

Yarkwah, C., Arthur, E., & Donkor, M. (2020). Senior high school students’ readiness to pursue advanced mathematics at the university level. *International Journal of Education, Learning and Development*, *8*(3), 28–51.

Yeboah, P. (2018, July 14). WASSCE 2018 Provisional results. *Graphic Online*, p. 2. https://doi.org/www.graghiconline.com