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Engaging Neural Plasticity in Senior High School Students: The Impact of Guided Discovery Teaching Method on Achievement in Circle Theorems

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Abstract

Purpose: The study's objective was to ascertain how circle theorem achievement in SHS students was affected by the guided discovery teaching method, a student-centered approach associated with improved neural plasticity.

Materials and Methods: Two Form 2 classes from various Wa Municipal schools were chosen for the study using convenient, purposeful, and straightforward random sampling techniques. The study adopted a non-equivalent quasi-experimental design to compare students who are taught with the guided discovery method and the traditional method of teaching circle theorems concepts. The sample size was composed of 164 students. Using a separate t-test and descriptive statistics, the Geometry Achievement test was investigated. A pre-test was given before the experiment (post-test) began. The students who engaged in guided discovery instruction outperformed than those who did not when teaching and learning Circle theorems.

Findings: The findings suggested that student-centered methods like guided discovery can greatly improve students' achievement in the study of circle theorems. One of the implications derived from the study indicated that guided discovery teaching approach offers students the chance to put a method of learning into practice after they have used it. This was done by using illustrations of diagrams on cardboard. This must be considered in the planning of educators and subject-matter experts. For pre-tertiary education, the government must make it mandatory to use cardboard, mathematical instruments, and instructional sheets as teaching aids. Since visual representations of Euclidean Geometry diagrams bring reality to teaching and learning through pictures and diagrams, the importance of visualization and experimentation in learning circle theorems should not be underestimated by teachers or students. This will improve their conceptual understanding.

Implications to Theory, Practice and Policy: One can recommend that in order to enhance the performance of SHS students, it will be most advantageous to introduce guided discovery teaching methods to pre- and in-service teachers, through promotion by Ghana Education Service and/or other stakeholders in the education sector. This introduction may be distributed through workshops and seminars for mathematics teachers' instructional techniques and skills will improve as a result. This study has added a lot to our understanding of the world. The guided discovery teaching method approach to teaching circle theorems has been strengthened and expanded as a result of this research, first and foremost. This thesis thus makes a substantial enhancement of the body of knowledge. The research also explains and backs up the notion that guided discovery methods aid students' academic endeavors. This shows that the teaching process engages students' attention and improves their capacity for memory and recall.

Keywords: *Guided Discovery Method, Constructivism, Circle Theorems, Students' Achievement, Traditional-Based Instruction*

1.0 INTRODUCTION

Mathematics is one of the foundational tools that are more applicable to the field of engineering courses according to studies by (Kashefi, Ismail, Yusof, & Mirzaei, 2013). Not only that, but engineering as a course also depends on mathematical theorems or axioms that will be used for the formulation of engineering tools which will increase productivity studies (Kashefi, Ismail, Yusof, & Mirzaei, 2013). Mathematics significantly contributes positively to every aspect of human development for instance, in areas like banking, and application development according to studies revealed by (Quddsi, 2018). Topics like Euclidean geometry serve as guides for learners to write mathematical proofs and solve mathematical problems (Yixuan, Lei, Peng, & Jinhong, 2016), further increasing their problem-solving abilities. This suggests that the contribution of mathematics instruction is vital for many facets of life.

There is however a challenge with regards to mathematics learning, particularly as it comes to circle theorem. As students' progress through the years of their education, there seems to be a problem with the poor performance of students' knowledge of circle theorems in areas like chord theorem, opposite angles of a cyclic quadrilateral, inscribed angle theorem properties and difficulties associated with exterior and interior angle properties. Studies have been conducted that demonstrated the difficulty in both teaching and learning geometry, which has led to widespread exam failure (Adophus, 2011).

This poor performance may not be ascribed to student motivation, as students are incredibly motivated to learn mathematics depending on the teaching method. One such teaching method is guided discovery. The guided discovery approach is a process in which students are encouraged to reinvent knowledge through their exploration and problem-solving with minimal guidance from the teacher (Casad & Jawaharlal, 2012). Even though there is still teacher guidance throughout the guided discovery learning process, students are equipped to find solutions to a problem on their own (Casad & Jawaharlal, 2012).

Research has shown that there is increased student activity per session of guided discovery as evidenced by Arynda and Susanto (2012). This suggests, then, to improve student performance in Euclidian geometry, one technique that can be applied to the problem is the guided discovery teaching approach. To support this, Hanafiah (2010), states that this approach demands that students put forth their best efforts to seek, examine, and conduct methodical investigations, critically, and logically to discover the manifestation of the change in their knowledge, attitudes, insights, and abilities themselves. Guided discovery assists students in constructing and organizing knowledge because it involves them actively and bases their understanding on what they originally know (Honomich & Chen, 2012).

One reason guided discovery may also be effective is the effect that student-centred approaches in general have on the brain. In response to experience (learning) and injury, the brain can modify itself, functionally and structurally (Von Bernhardi et al., 2017). This principle is called neural plasticity. It suggests then that the greater the challenge and experience as is encouraged when students take charge of their learning, the greater the neural plasticity and the more learning that occurs, as opposed to when students are fed information through traditional teacher-centred approaches. Thus, in the realm of teaching and learning, guided discovery emerges as a highly effective approach for enhancing neural plasticity among students. This pedagogical method exhibits a remarkable capacity for fostering neural plasticity primarily through its integration of problem-solving activities. By actively engaging in problem-solving tasks, students are effectively propelled to challenge their brains to adapt and reconfigure in response to novel encounters (Bryck & Fisher, 2012).

Interestingly, the influence of guided discovery extends beyond its direct impact on neural plasticity. Research findings indicate a notable trend in educational practices: educators tend to gravitate towards more student-centred and constructivist teaching strategies when exposed to insights about neural plasticity (Schwartz et al., 2019). This demonstrates the profound interconnectedness between instructional approaches and cognitive insights, suggesting that a deeper understanding of neural plasticity can empower teachers to embrace pedagogies that further enhance students' learning experiences.

As a result, the researcher found that the majority of students thought the circle theorem was a challenging topic. Those who answered questions on this topic in rare cases exhibited a lack of comprehension of the subject or the issue has been raised in studies proposed by, (Fletcher & Anderson, 2012). Additionally, the Council of Chief Examiners for the West African Examinations has reported that WAEC, 2011, 2012, 2014, 2015, and (2018), are included, and they revealed that many students performed poorly in their understanding of circle theorem concepts when compared to other areas of mathematics.

A lot of Ghanaian Senior Secondary School students could not solve problems of Euclidean circle geometrical construction due to their inadequate grasp of the ideas about fundamental circle theorem knowledge Boson-Amedenu (2017), Hissan & Ntow (2021), (Dogwi, 2014; Lim, 1992). In Ghana's Senior High Secondary institutions, a lot of students struggle to comprehend circle theorem knowledge in areas like chord theorem, opposite angles of a cyclic quadrilateral, inscribed angle theorem properties and difficulties associated with exterior and interior angle properties have not been addressed in previous studies as the researcher interaction with mathematics educators from 2015-2023 within the Wa Municipality. The majority of guided discovery studies conducted in Ghana also did not focus on specific mathematics topics; instead, they primarily targeted young children in lower grades, such as kindergarten or primary students. Despite extensive mathematical research into circle theorems, there are only a limited number of circle theorem research studies using guided discovery-based instruction in Wa Municipality. The researcher is looking into how the guided discovery teaching method affects students' mastery of circle theorems if implemented in order to reduced how poorly students perform mathematically in circle theorems for instance chord theorem, opposite angles of a cyclic quadrilateral, inscribed angle theorem properties and difficulties associated with exterior and interior angle properties and other relevant areas of mathematics at the national and international levels.

Statement of the Problem

At varying degrees, the study of mathematics has an impact on every aspect of daily life. To find a way or a pattern of life, one must first understand the philosophy of mathematics. Unfortunately, student performance in mathematics education in Ghana at the primary, secondary, and tertiary levels has not improved over time (Enu, Nkum, & Agyeman, 2015).

According to studies demonstrated by two researchers, circle theorems are difficult for students to learn, according to research (Weiss & Herbst, 2015; Adegun & Adegun, 2013). Candidates generally struggled with geometry-related problems, such as those involving cyclic quadrilaterals, chord theorems, and circle theorems, from 2013 to 2018, as based on the core mathematics chief examiner's reports for the WASSCE. The Chief Examiner also notes that most candidates had trouble understanding questions that included, among other concepts, angles on the outside and inside of polygons, as well as their characteristics (WAEC, 2017; WAEC & GOG, 2019). The observed weaknesses, in the opinion of the Chief Examiner for Core Mathematics Reports, result from mathematics teachers' inability to effectively teach the subject which is attributed to students' shallow understanding of concepts in circle theorems (WAEC, 2013, 2016).

Teachers' ineffective presentational abilities and the lack of tools for displaying geometrical shapes are believed to be the main causes of students' disinterest in understanding circle theorem concepts in geometry (Johnson-Wilder & Mason, 2005). Scientists, educators, and mathematicians have all shown a strong interest in how geometry is taught and learned (Mesa, Gómez, & Cheah, 2012). Students' capacity for critical thought and problem-solving develops thanks to the knowledge and skills they acquire in geometry (Clements, 2004). To help students comprehend Circle theorems and other geometrical concepts, inventive teaching strategies must be created.

When teaching the concepts of circle theorems in mathematics, the capacity of students to resolve mathematical issues can be strengthened and trained with the proper application of the guided discovery learning model (Kara & Incikabi, 2018). The guided discovery learning model has been effectively applied, and the ability to solve mathematical puzzles with fifth-grade elementary school pupils has improved (Abal & Kaan, 2018). The study's findings, according to Nahdi (2018), showed that the guided discovery learning model had a positive impact on the students' capacity for problem-solving. Allowing students to find their information in the form of a concept, rule, or theorem is part of the teacher-guided discovery method used in the learning process (Mardati, 2018). Findings from a different study indicate that incorporating GeoGebra into guided discovery learning can improve students' comprehension of mathematics and problem-solving skills (Sariyasa, Ardana, & Murni, 2017). The majority of guided discovery studies conducted in Ghana also did not focus on specific mathematics topics; instead, they primarily targeted young children in lower grades, such as kindergarten or primary students. Despite extensive mathematical research into circle theorems, there are only a limited number of circle theorem research studies in Wa Municipality. The gaps found serve as the primary focus of this study. This current study focused on the impact of the guided discovery teaching method on students' achievement in circle theorems among SHS in Wa Municipality.

Purpose of the Study

The study's goal was to investigate how the guided discovery method of instruction impacts SHS students' achievement in circle theorems. The study was intended to help stakeholders identify remedies required for helping students or learners overcome difficulties in circle geometry.

Research Question

The following was the key research question of the study;

What is the effect of guided discovery teaching method on SHS students' achievements in concepts of circle theorems in Wa Municipality?

Arising from the study, the following hypothesis was formulated during the study at $p<0.05$ (2-tailed) level of significance.

H_{01}: There is no statistically significant difference between the effect of guided discovery teaching method and traditional teaching method on SHS students' achievement in concepts of circle theorems in Wa Municipality?

Theoretical Framework

The study was influenced by Piaget's (1953) idea of cognitive constructivism was created by adapting human knowledge without the ability of learning something about the outside world from our own experiences (Von Glasersfeld, 1995) which itself if embedded in the biological principle of neural plasticity. Neural plasticity is the capacity of the brain to modify itself, functionally and structurally, in response to experience, (which includes learning and discovery) and injury (Von Bernhardi et al., 2017). Guided discovery as a method of teaching and learning is particularly adept increasing neural plasticity because it involves problem-solving, which can promote neural plasticity by challenging the brain to adapt and change in response to new experiences (Bryck & Fisher, 2012). In fact, research has suggested that teachers adopt more student-centred, constructivist approaches when they are confronted with knowledge on neural plasticity (Schwartz et al., 2019).

Effects of Guided Discovery Teaching Method

It has been shown that by implementing the appropriate guided discovery learning strategy in mathematics, teachers can train and improve their students' ability to solve mathematical problems (Incikabi & Kara, 2018). The guided discovery learning model has been effectively applied, and the ability of solving mathematical puzzles with the fifth-grade elementary school pupils has improved (Abal & Kaan, 2018). The guided discovery learning model appeared to have a positive impact on the student's ability to solve problems, according to (Nahdi, 2018). Giving students the freedom to discover their information in the form of a concept, principle, or theorem is part of the teacher-guided discovery method in the learning process (Mardati, 2018).

Results from the second trial demonstrated a significant improvement in students' capacity for solving mathematical problems as well as their sense of self-efficacy (Saragih & Simamora, 2019). According to the results of a different study, GeoGebra can enhance students' mathematical understanding and problem-solving skills when it is incorporated into discovery learning (Sariyasa, Ardana, & Murni, 2017). The guided discovery learning model encourages students to actively engage in their own learning and self-discovery, which can aid in the development of mathematical critical thinking abilities.

The regular teacher guidance, the guided discovery approach will aid students in becoming more engaged in their studies (Sutiarso & Wahyu, 2017). The use of both computer-assisted instruction and a discovery learning strategy can improve students' learning outcomes. An average of students meets or exceeds the minimum completeness criteria as a result of the learning process that uses scaffolding and discovery learning. Exploration-based education statistics on inference learning show that scaffolding performs better than traditional learning according to studies by (Nugroho & Hidayah, 2020).

According to Ramadhani (2017), guided discovery method students are more capable than those who receive traditional instruction. Students who use the guided discovery learning model exhibit higher levels of critical thinking than those who use the guided inquiry learning model or traditional teaching methods, according to (Widayati, Suyono, & Rahayu, 2018). Research on this topic by Prasasti, Koeswanti, and Giarti (2019), found that discovery learning is used widely at all educational levels and has been shown to enhance students' critical thinking skills.

Traditional Based Instruction

Although studies conducted by Fawad (2015), agreed that the traditional-based instruction is required for teaching higher order complex skills and training procedures of complex theories which is more teacher-centred approach of learning. Traditional method which requires the use of teacher-centred approach helps in facilitation of large classes for training mathematics for kids understanding. In another study conducted by Jansen, Middleton, Cullicott, Zhang, Tarr, and Curtis, (2019), agrees that participation is explained of interaction and relationship that exist between students' as well as the subject matter that is being taught by the traditional- based instruction. In the traditional method of teaching students' is not getting the enough interaction of relationship that is existed to help them in their engagement in the classroom activities of the subject matter being taught? Traditional method of teaching also known as the conventional approaches adopted by teaching the concepts of Geometry in the classrooms where the teacher is the only one directing the learning with the students been regarded as listeners with little or no contribution in the learning environment according to studies posited by (Tay & Mensah-Wonkyi, 2018). Students' difficulties in mathematics are associated with this teacher centred approaches towards concepts in mathematics has been cited by some articles of (Tay & Mensah-Wonkyi, 2018).

2.0 MATERIALS AND METHODS

Research Design

The research was carried out by the using a quasi-experimental non-equivalent design for which the researcher includes a control group as well as an experimental pre- and post-test group. Studies conducted by, Pallant (2001), agreed that they are the best designs when comparing the performances of students' in adopting two intact classes or groups in the field of study. The design is shown below.

Table 1: Table Showing Two Groups by Using a Quasi-Experimental Non-Equivalent Design

Group	Pre-test	Treatment	Post-test
Experimental	T_1	X	R_1
Control	T_2	C	R_2

The experimental group's learners' performance was enhanced by guided discovery learning compared to the students in the control group, who received conventional instruction. The independent variables of the study, that causes or influence the study's outcome was the two learning teaching strategies that utilize the learning of geometry with respective to circle theorems were guided discovery teaching method as compared to the traditional-based instruction. The dependent variable of the study was students' achievement in geometry test. The pre-test (T_1 and T_2) and post-test (R_1 and R_2) were conducted to measure students' mastery level of proficiency in understanding geometry and subsequently followed by the intervention process by the experimental group and control groups.

Sample and Sampling Technique

The study comprises of 164 students as the sample size of which two intact classes within two senior high schools in the municipality, namely school (A) and school (B), whereas school (A) is the experimental group consisting of eighty-nine (89) students and school (B) is the control group totaling seventy-five (75) students. There were sixty-five (65) females and twenty-four (24) males in the experimental group as sites for the intervention group, and fifty (50) females as well as twenty-five (25) males were in the control group. Due to their similar rankings with the Ghana Education Service and the availability of sufficient ICT resources to serve as the site for both the experimental and control groups—where two intact classes were used—two senior high schools, School A and School B, were chosen through the use of purposive sampling.

Data Collection Procedure

During the beginning of the study, the Achievement Test of Geometry (ATG) was administered to students of both control and experimental groups as means of pre-test and post-test. Prior to collecting data, the Institutional Review Board of C.K. Tedam University of Technology and Applied Sciences was consulted.

Research Instruments

The pre-test and post-test items from the achievement test in geometry (ATG) were constructed using the geometry ideas from Plane Geometry II, a subject covered in SHS2 mathematics. According to the Cronbach alpha (α) reliability analysis performed on each test was 0.936 as well as 0.813 for the control groups and the experimental group's post-test results, this research tool measures a good reliability coefficient. The instruments were reviewed by experts on the aspect of validity.

The Teaching of Circle Theorems in the Control Group

During the study, the experimental group was taught using guided discovery-based instruction to aid students' conceptual understanding of circle theorems and with the control group taught using traditional or conventional teaching strategy. In the control group the researcher used a demonstration-and-example approach in the first lecture before switching to a question-and-answer style. When demonstrating the circle theorem, for instance, the instructor first provides definitions, theorems, and algorithms on the various angle properties of the theorem before working through examples of how to calculate those properties while taking into account relevant prior knowledge about plane geometry.

Group Receiving Treatment

In the experimental group, during the opening lesson, the researcher posed the following question to the students about their prior understanding of Euclidean geometry's properties and the relationships that may be inferred from these qualities. The researcher introduced the lesson for about fifteen minutes. With the introduction of the guided discovery method, the researcher divided the students into groups of five and gave them an instruction sheet outlining all the tasks describing the various properties. The researcher gave the students a worksheet with instructions to draw a circle of any radius with a chosen quadrilateral inscribed on it. They were also told to measure the angles on the quadrilateral and record the values in the pairs to which they were assigned, add the opposite side of each angle, and then observe their findings. Many of them were able to say that the opposing angles of a cyclic quadrilateral add up to 180^0, indicating that they are supplementary. They measured the angles throughout the activity, and they independently found the theorem on their own, as stipulated in the diagram below. Normally, subsidiary angles add up to 180^0; for example, a + d and b + c add up to 180^0. By asserting that opposite angles exist, they came up with the conclusion that the theorem by stating that opposite angles of a cyclic quadrilateral are supplementary.

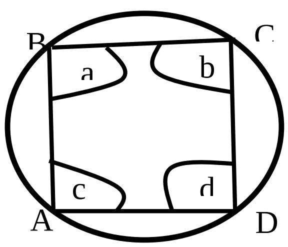

Figure 1. A Cyclic Quadrilateral

In order to minimize biases or any conflicts of interest, the researcher employs two lesson plans to instruct the two groups as a baseline. To make sure the two teaching strategies complied with the specified learning environment, the two instructional lesson plans underwent a review by specialists in the field of mathematics education. The researcher adhered to the lesson plans' stringent guidelines and created them according to the study's number of days. Each day of instruction for both groups was recorded for no more than two hours during the course of the four-week study. According to the instructions on the school schedule, each group met four times. Two unbiased observers with advanced degrees in mathematics education assessed each lesson's instructional duration. Evaluations from independent observers were compared and examined for consistency, and it was clearly evident that there was agreement for each educational lesson time as a gauge of reliability. These tactics were used to assure the validity and reliability of the study's conclusions in order to reduce or entirely eliminate the biases of the researcher during the treatment's implementation phase.

Data Analysis Procedure and Process

The data had to be analyzed using a variety of methods. Both descriptive and inferential statistics were used in the data analysis. The average test outcomes for the experimental and control groups were calculated using descriptive statistics for both the pre- and post-tests. Scores from the pre- and post-tests are distributed as follows, was examined using further descriptive statistical methods like standard deviation and range. Data from the post-test were examined using inferential statistics following the pre-test. Prior to putting hypothesis 1 to the test, an analysis was done to verify the prerequisites and presumptions for the statistical techniques that would be applied. First, we looked at the presumptions of normality for the experimental and control groups' pre-test outcomes. Homogeneity of variances was all checked as measures of no violation.

3.0 FINDINGS

Respondents Preliminary Analysis of their Socio-Demographic Features

The sample for the study consisted of 164 students, 49 males and 115 females. There were 75 students in the control group and 89 in the experimental group. The pre-test and post-test were both completed by every student. The survey was distributed to every pupil in the experimental group. In Table 2, the gender distribution of the students in the two groups is displayed. Students' demographics in the experimental and control groups was age from 10 to 20 years, and the majority of the students fall within the age ranges given, indicating that they are all of similar ages within the interval given.

Table 2: Gender Distribution of Students in Both Groups

Sex	Control	Experimental	Total
Male	25	24	49
Female	50	65	115
Total	**75**	**89**	**164**

Source: Authors Field Work, 2022

Research Question 1

RQ1 Was 'What Is the Effect of Guided Discovery Teaching Method on SHS Students' Achievements on Concepts of Circle Theorems in Wa Municipality'?

The researcher is focused on comparing two different teaching methods and that is, guided discovery teaching method with the conventional method of teaching in aiding students' conceptual understanding in circle theorems.

Table 3: Descriptive Statistic of the Pre-Test Scores

Statistic	Control	Experimental
N	75	89
Mean	15.95	15.51
Standard Deviation	3.537	3.223
Minimum	9	9
Maximum	24	23
Range	15	14

Source: Authors Field Work, 2022

The pre-test was graded concurrently with the test (View Appendix G). Table 3 displays the results of the pre-test. Both the experimental group's average score (M = 15.51; SD = 3.223) and the control group's average score (M = 15.95; SD = 3.537) were remarkably close. According to the study's findings, one control group student in the pre-test received a perfect score. The results also show that the mean scores were nearly equal and that the range of scores was very close, with the experimental group's range of scores being 14 and the control group's range of scores being 15. An independent sample t-test was performed to see if the pre-test scores differed statistically significantly from one another.

Table 4: T-Test Conducted Independently for Both Groups' Pre-Test Results

Group	N	M	SD	t-value	D f	P-value
Control	75	15.95	3.537	0.835	162	0.809
Experimental	89	15.51	3.223			

Source: Authors Field Work, 2022

An independent sample t-test was performed to see if the pre-test scores differed statistically significantly from one another. According to the studies by Pallant (2005), the experimental group's (M= 15.51; SD = 3.223 ;) performance was not statistically and significantly superior to that of the control group's (M = 15.95; SD = 3.537; t (162) = 0.835; p = 0. 809). Any variations in the students' circle theorem performance following the intervention can be attributed to the intervention because, based on the pre-test results, the geometric proficiency of the students in both groups was equal prior to the intervention.

Table 5: Descriptive Statistic of Post-Test Results

Statistic	Experimental	Control
N	89	75
Mean	58.80	50.33
Standard Deviation	9.847	8.684
Minimum	33	28
Maximum	75	68
Range	42	40
Skewness	-0.464	-0.190

Source: Authors Field Work, 2022

Following the intervention, the experimental group's average score was higher than the control group's (M = 50.33; SD = 8.684) on the post-test (M = 9.847; SD = 58.80). The mean scores of the two groups differ by 8.47. This suggests that on average, students in the experimental group outperformed those in the control group by 8.47 points. The experimental group's score distribution was wider than that of the control group. Students in the experimental group received the highest score of 75, while those in the control group received the highest score of 68. The experimental group's minimum score was 33, while the control group's minimum score was 28, which strongly suggests or confirms that most of the students who used the intervention received more than half of the total marks.

The experimental group had a 42-point difference between the highest and lowest scores as opposed to a 40-point difference for the control group. This demonstrates that the control group's highest and lowest scores ranged over a wider range. The control group's standard deviation 8.684 and mean was 50.33, while the students had a mean of 58.80 and a standard deviation of 9.847 in the experimental group. This demonstrates that the mean score spreads for the experimental and control groups had a marginally different distribution. Prior to testing hypothesis 1, analysis was conducted to confirm the conditions and assumptions related to the techniques to be applied in statistics. Initially, assuming normality for the control and experimental groups' pre-test outcomes were looked at Figure 2 and 3 as displays in the specifics below.

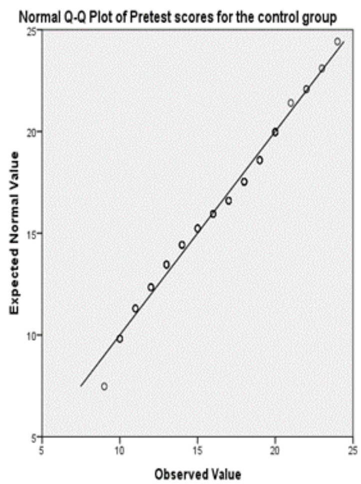

Figure 2: Pre-Test Normal Q-Q Plots CONT

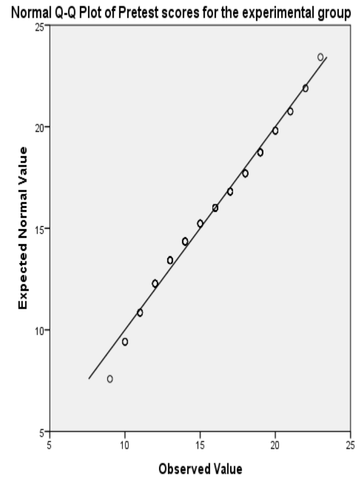

Figure 3: Pre-Test Normal Q-Q Plots EXP

Source: Authors Field Work, 2022

As can be seen in Figures 3 and 4 all of the plots could be roughly fitted onto the straight line in every circumstance, indicating that the pre-test data had a normally distributed distribution. A hypothesis was tested using parametric statistical procedures after the homogeneity of variance assumptions and conditions associated with those procedures had been satisfied, and the normality of the distribution for the pre-test data had been established (Adam, 2015). Furthermore, post-test normality hypotheses were investigated; the details are shown in Figure 4 and 5

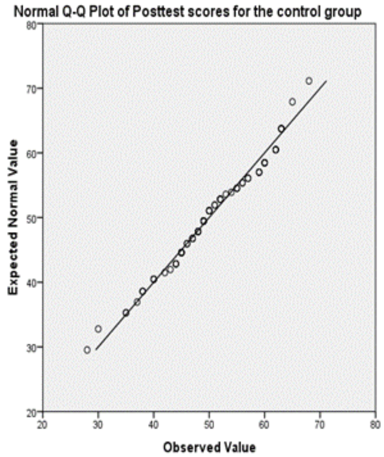

Figure 4: Posttest Normal Q-Q Plots for CONT

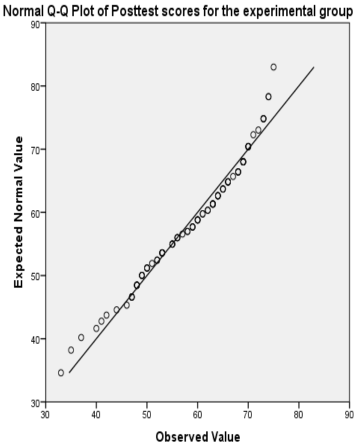

Figure 5: Posttest Normal Q-Q Plots for EXP

Source: Authors Field Work, 2022

Due to the fact that all of the plots were roughly fitted onto the straight line, the post-test data, as shown in Figure 4 and 5, was normally distributed. The study's post-test addresses the hypothesis formulated at 95% confidence interval as discussed in Table 6.

Table 6: Comparing the Post-Test Results of the Experimental Group Using Independent T-Test Statistics

Group	N	M	SD	t-value	D f	P-value
Experimental	89	58.7978	9.84676	5.786	162	0.000
Control	75	50.3333	8.68415			

Source: Authors Field Work, 2022

According to Table 5, the experimental group's post-test performance was statistically significantly better than that of the students in the control group (M = 50.3333; SD = 8.68415 ;) post-test results (M = 58.7978; SD = 9.84676; t (162) = 5.786; P = 0.000). With differences that are present have significant impacts on the magnitude of the effect (differences from the mean = 8.46442, 95% CI: 5.57538 to 11.35346). The eta squared statistics was very high (0.1712613744).

According to the t-test results, studies demonstrated by Adam (2015), since the p- value is less than 0.05 which showed a significant difference between students who learned circle theorem concepts through guided discovery teaching method and those who received traditional instruction to learn circle theorems in Euclidean geometry, the null hypothesis was rejected. When compared to students who were not taught using the guided discovery teaching method, these students' average performance was found to be significantly higher according to the results of the t-test. According to the results, the experimental group's mean mark percentage value was 58.1%, higher than the control groups' average mark percentage value of 41.9%. The results of the post-test scores' percentage comparison are shown in Table 7.

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Table 7: Comparison of the Percentage Scores of the Post-Test

Group	Mean Mark	Percentage
Experimental	58.7978	58.1
Control	50.3333	41.9

Source: Authors Field Work, 2022

Students do not learn the concepts better when there are fewer diagrams available for each theorem. Due to their inability to recognize or visualize the concept or theorem presented in the question, students in the control group did not significantly outperform those in the experimental group on the post-test. For instance, the majority of the students in the control group couldn't provide a complete response to Question 1. The circle at S in the diagram is intersected by TS. If O is the circle's center, < TSP = 21^0 and < RQP = 100^0, find (I) < SPR, (ii) < QSR

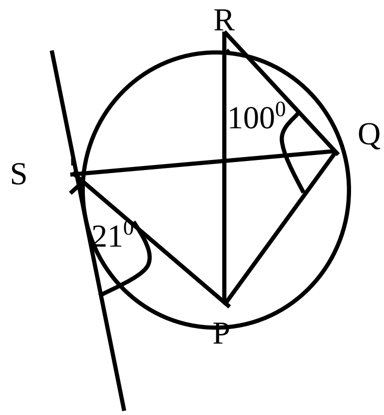

Figure 6: Post-Test Question Not Solved

The expectation for the students was that angle SPR in triangle PSR requires both angle R and angle S. They were expected to assume that alternate segment angles are equal. They were to visualize that the cyclic quadrilateral's opposing angles add up to 21^0 degrees, which implies that angle R = angle TSP = 180^0. <S + 100^0 = 180^0. <S =180^0- 100^0 = 80^0. The triangle PSR has 180^0 total angles. < SPR + <R + <S =180^0. It implies that <SPR + 21^0 + 80^0 = 180^0, < SPR + 101^0 = 180^0, <SPR = 180^0 – 101^0 = 79^0. The answer to the <SPR = 79^0. The students were to infer from the theorem that ends of the diameter at the circumference are 90^0, as deduced by the students. Angles within a single segment of chord SP are equal, so <SQP = <SRP = 21^0, <RQS = 100^0 – 21^0 = 79^0, summation of angles in triangle QSR is 180^0, <QSR = 180^0 – 90^0 – 79^0 = 11^0. This means that <QSR = 11^0. From these results 52 out of 75 students could not answer the question fully based on their shallow understanding of concepts in circle theorems representing 69% that angle SQP is 79^0 and angle QSR is 11^0. This Question 6 particularly was able to be solved by students in the experimental group. The circle ABCD in the diagram has a diameter of AB. Parallel to AB is DC. And < BAC = 25^0. Calculate < ADC

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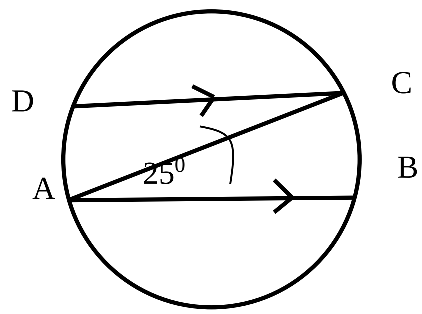

Figure 7: Post-Test Question Solved

Students had to show that the ends of diameter AB angle at the circumference are 90^0 in response to question 6 of the post-test. Triangle ABC has 180^0 angles total. In the experimental group, 68 out of 89 individuals could do this at this point. In the end, they were able to connect these geometric ideas to arrive at the solution. The researcher also observed how students responded to the questions by drawing on their understanding of the circle theorems. In the experimental group, 68 out of 89 individuals could do this at this point. In the end, they were able to connect these geometric ideas to arrive at the solution. For instance, 68 of the students who took part in guided discovery learning with card board were able to identify and recall the fact that an AB angle has a diameter of 90^0 at its circumference. The answer to question 6 demonstrates that the triangle ABC's total number of angles is 180^0.

Discussions

The findings from the independent t-test of Table 6 in the post-test of the experimental group allow for the conclusion that students who learned circle theorem concepts through the guided discovery method outperformed their peers who did not. According to the study's findings, students taught using guided discovery instruction performed better in concepts of circle theorems or geometry during the post-test. The findings' outcomes showed consistency of studies demonstrating that pupils who were instructed during the intervention or treatment could distinguish between different types of diagrams and draw valid conclusions based on the theorems one can use to solve a problem. Huang and Leung (2017) agreed that the learner-centered method of teaching is able to differentiate standard-oriented diagrams (SO), which are drawn in the upright position of their familiar shape, from non-standard-oriented diagrams (NSO), which show a non-prototype diagram drawn from an unfamiliar shape.

There are differences between a basic diagram that does not include reconfiguration as a form of task at hand, for instance, a cyclic quadrilateral in diagrams of circles, whereas a complex diagram requires overlapping, and a configuration that includes a quadrilateral should be isolated from another one if a cyclic quadrilateral is intended to be the emphasis. Studies' comparing the results of this is supported by statistical analysis of inference learning, discovery learning with scaffolding, and traditional learning, according to Nugroho & Hidayah (2020).

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The observation on figure 7 supports the findings of research by Hattie, Fisher, Frey, and Briars (2017) that students learn best in mathematics classes because it gives them a chance to sharpen their minds by reviewing their prior knowledge prior to presenting a topic for discussion, which leads them through guided discovery learning to independently discover concepts and strategies. In order to explore and come up with what they have, students or learners must be ready to base their knowledge more on the discussions and consultations of other learners in guided discovery teaching. Link, T., Huber, S., Fischer, U., and Nuerk, H. C. Moeller (2013) found that these types of activities improve students' estimation performance more significantly than the control group in the study mentioned above, which examined the effectiveness of guided discovery instruction on educational math activities related to embodied training and recall of numerical concepts. The research results supported studies that demonstrated how guided discovery learning can improve and train students' problem-solving skills in mathematics (Incikabi & Kara, 2018).

The guided discovery learning model has been successfully implemented, and the fifth-grade primary school students' aptitude for solving mathematical problems has increased (Abal & Kaan, 2018). Purwatiningsi (2013) asserts that studies on the guided discovery approach can improve students' learning outcomes for the topic of surface area and volume of blocks in the class of VIII SMP 12, Palu. Additionally, it was demonstrated by Karim and Maulida (2014) that guided discovery models improve student conceptual understanding more than traditional learning methods. The outcomes additionally demonstrated that guided discovery method students had higher aptitude levels than those who received conventional instruction (Ramadhani, 2017). The findings' outcomes from table 7 showed consistency of studies demonstrating that pupils who learn using the guided inquiry learning model and conventional teaching techniques, comparatively to those students who use the guided discovery learning model, demonstrate higher levels of critical thinking in topics related to mathematics (Widayati, Suyono, & Rahayu, W. 2018).

Findings from Table 7 show that students who receive guided discovery teaching perform better than their peers who do not receive this type of instruction. This finding is consistent with findings by Riley, Luban, Holmes, Gore, and Morgan's (2017) research, which also supports the idea that innovative teaching techniques can aid students in their mathematical learning and help them understand geometry and improve mathematics education. Findings also show that students who receive guided discovery teaching perform better than their peers who do not receive this type of instruction. The study's results concur with those of Ozomadu's (2016) study, which discovered that guided discovery strategies were superior to traditional teaching and learning approaches for improving students' knowledge acquisition. The idea of combining guided discovery teaching and inquiry methods of teaching will enhance a positive impact on students' performances, so teachers must create an environment that will enable students to learn easily.

Major Findings

The study's major findings are discussed according to the research question that guided the study as well as the research hypothesis formulated during the study in this section.

RQ1 was 'What is the effect of guided discovery teaching method on SHS students' achievements in concepts of circle theorems in Wa Municipality'?

Findings from the study reveal that there was no statistically significant difference between the two groups at the pre-test stages. Any variations in the students' circle theorem performance following the intervention can be attributed to the intervention because, based on the pre-test results, the geometric proficiency of the students in both groups was equal prior to the intervention. Students who received instruction using the guided discovery teaching method performed on average superior to those who received instruction in the conventional manner. There was a noticeable achievement gap the treatment group outperformed the control group in the comparison between the two groups.

At a significance level of $p<0.05$ (2-tailed), the study's findings led to the formulation of the following hypothesis. $H0_1$: There is no statistically significant difference between the effects of guided discovery teaching method and traditional teaching method on SHS students' achievement in concepts of circle theorems among Senior High Schools in Wa Municipality?

According to the t-test results of the studies demonstrated by Adam (2015), since the p-value is less than 0.05, which showed a significant difference between students who learned circle theorem concepts through guided discovery teaching methods and those who received traditional instruction to learn circle theorems in Euclidean geometry, the null hypothesis was rejected. When compared to students who were not taught using the guided discovery teaching method, these students' average performance was found to be significantly higher, according to the results of the t-test.

4.0 CONCLUSION AND RECOMMENDATION

Conclusion

According to the second claim, using a guided discovery teaching approach for teaching and learning improves academic achievement in circle theorems. This suggests that math instruction in SHS must be incorporated using the guided discovery teaching method rather than traditional methods of instruction, which results in students performing worse. Accordingly, it appears that students' capacity to make connections between mathematical ideas and theorems is responsible for the significant improvement in student performance. Secondly, using guided discovery method examples to teach and learn circle theorems under the discovery method encourages students to learn mathematics in general. This indicates that incorporating guided discovery learning into blended instruction to teach geometry increases student enthusiasm for the topic.

Recommendations

To enhance the performance of SHS students, it will be most advantageous to introduce guided discovery teaching methods to pre- and in-service teachers through promotion by the Ghana Education Service and/or other stakeholders in the education sector. This introduction may be distributed through workshops and seminars. Math teachers' instructional techniques and skills will improve as a result.

Implications of the Study

i. Since visual representations of circle theorem diagrams bring reality to teaching and learning through pictures and diagrams, the importance of visualization and experimentation in learning circle theorems should not be underestimated by teachers or students. This will improve their conceptual understanding.

ii. Using illustrations of diagrams on cardboard, instructional sheets, and mathematical instruments, and paring students in groups of five for guided discovery learning increases student motivation and interest, which helps them perform better academically when studying circle theorems.

Contributions Made to Theory, Practice and Policy

This study has added a lot to our understanding of the world. The guided discovery teaching method approach to teaching circle theorems has been strengthened and expanded as a result of this research, first and foremost. This thesis thus makes a substantial enhancement of the body of knowledge. The research also explains and backs up the notion that guided discovery methods aid students' academic endeavors. This shows that the teaching process engages students' attention and improves their capacity for memory and recall. The guided discovery teaching approach offers students the chance to put a method of learning into practice after they have used it. This is done by using illustrations of diagrams on cardboard. This must be considered in the planning of educators and subject-matter experts.

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