Education Journal
2024, Vol. 13, No. 5, pp. 318-328
https://doi.org/10.11648/j.edu.20241305.19

Research Article

Exploring Effective Strategies: Guided Discovery in Teaching Surface Area of a Cylinder

Christian Kwame Kpotosu*, Nicholas Kofi Cudjoe, Henry Lovejoy Nii Armah

Department of Mathematics and ICT Education, University of Cape Coast, Cape Coast, Ghana

Abstract

The objective of this study was to evaluate the effects of implementing the Guided Discovery approach on students' ability to determine the Surface Area of a Cylinder. The research study employed an explanatory-sequential mixed-methods design to instruct a sample of 80 students from a school situated in the Cape Coast Metropolis. The participants were put into an experimental group with no control group. Data was collected using Mathematics Achievement Test MAT and interviews through focus group discussions. The quantitative data was subjected to analysis using two software programs: the Statistical Package for Service Solutions (SPSS version 26.0) and Microsoft Excel 2019 and the qualitative data was analysed thematically. The data was subjected to analysis using descriptive statistics, specifically frequency counts and percentages, as well as inferential statistics, specifically t-tests. The findings indicate a statistically significant difference in the academic achievement of students who were instructed in the concept of the Surface Area of a Cylinder using the Guided Discovery approach. Furthermore, there was no statistically significant difference observed in the post-test scores between male and female students after their exposure to the Guided Discovery method for teaching the Surface Area of a Cylinder. It was also found that students demonstrated positive experiences (clarity, interest, and lesson presentation) when learning with the Guided Discovery. Hence, it is suggested that mathematics educators should utilise the Guided Discovery approach to instruct students on mathematical concepts, to stimulate students' engagement and enthusiasm towards the subject matter.

Keywords

Cylinder, Experiences, Guided Discovery, Mensuration, Surface Area of a Cylinder, University of Cape Coast

1. Introduction

Mathematics is a compulsory subject that is mandated for all students within our educational system, up until the tertiary level, at which point it becomes an elective [1]. Ojaloye [2] asserts that secondary school students exhibit inadequate preparedness in addressing mathematical problems due to substandard instruction. The performance of students in the West African Examinations Council (WAEC) mathematics examination has consistently been poor, despite the acknowledged significance of mathematics [3]. The calculation of the surface area of figures, specifically within the domain of Mensuration, has been identified as a challenging concept for students to grasp, as highlighted in the WAEC Chief Examiner's Report [4].

Mensuration, a scientific discipline concerned with the quantification of physical dimensions, finds extensive utility across various domains such as land surveying, engineering,

*Corresponding author: christian.kpotosu001@stu.ucc.edu.gh (Christian Kwame Kpotosu)

Received: 27 September 2024; **Accepted:** 15 October 2024; **Published:** 31 October 2024

and mechanics. Additionally, it exhibits strong connections with various branches of mathematics, including arithmetic, geometry, trigonometry, and calculus. The lack of success among students in the subject of Mensuration has been ascribed to various factors, with the instructional methods employed by teachers emerging as a significant contributor. Consequently, the students experienced difficulties in comprehending the concepts. The reduction, if not complete elimination, of students' misconceptions regarding mensuration concepts can be achieved through their active engagement in the lesson, facilitated by the utilisation of tangible and partially tangible instructional materials, while the teacher assumes the role of a facilitator. This statement serves to reinforce the commonly held belief that the process of learning is enhanced through active engagement and experiential involvement.

It succinctly captures the idea that passive reception of information, such as through hearing alone, is less effective in fostering understanding and retention compared to the act of observing or engaging in a task. According to Ensor et al. [5], it is recommended to employ textbooks in conjunction with the inductive teaching approach. The recommendation put forth was to utilise teaching and learning materials as an effective approach for instructing mathematics, particularly among young children. The instruction of Mensuration, specifically the determination of the Surface Area of a Cylinder, should adopt an activity-based approach to enhance students' comprehension.

The Guided Discovery approach is considered an effective method for teaching Mensuration to enhance students' comprehension. In educational contexts, the Guided Discovery method of instruction is commonly employed as a problem-solving approach aimed at fostering self-development and sustainability. The learners can establish a clear plan for achieving their objectives with minimal assistance or guidance from the teacher [6, 7]. The Guided Discovery method of teaching in mathematics education is widely recognised for its potential to enhance the retention of learned materials.

This approach encourages learners to actively organise newly acquired information and integrate it with their existing knowledge base. By doing so, learners can establish meaningful connections between new and prior knowledge, thereby facilitating the retention process. In typical learning situations, learners assume the role of investigators within a stimulating educational setting. In this context, one study [8] noted that learners tend to categorise a newly introduced object based on their prior discoveries or identifications.

According to [6, 7, 9], the implementation of the Guided Discovery method has been identified as an effective approach to enhance the level of engagement in teaching. The Guided Discovery method of teaching and learning mathematics promotes active learner engagement in the exploration of procedures, principles, and concepts related to various topics. This approach facilitates the development of problem-solving skills across different mathematical domains.

It was observed from the WAEC Chief Examiners' reports from 2007 to 2019, that candidates exhibited deficiencies in the domain of Geometry, with a particular emphasis on Mensuration. Ali [9] conducted a comprehensive investigation and revealed that a significant proportion, approximately 90%, of students enrolled in Teacher Training Colleges in Ghana exhibited inadequate proficiency in accurately solving problems related to Mensuration. This observation implies the presence of a problem, thus necessitating the implementation of a solution. Based on this rationale, the implementation of Guided Discovery has the potential to effectively support students in addressing their challenges related to determining the Surface Area of a Cylinder.

Chikamai [10] and Otobo [7] have both asserted that among the various strategies employed in mathematics instruction, the Guided Discovery method is particularly effective in capturing students' interest and fostering a conducive learning environment that promotes active engagement for all learners. In a study conducted by [11], the impact of the Guided Discovery method on students with varying levels of mathematics aversion was investigated. The findings revealed that students with low mathematics aversion demonstrated superior performance when instructed using the Guided Discovery method. Conversely, the Expository method exhibited a comparative advantage when employed with students experiencing high mathematics aversion.

The study conducted by [12] investigated the impact of the Guided Discovery learning model on the development of mathematical problem-solving skills of fifth-grade students. It was recommended for educators to incorporate this model into their mathematics instruction. Furthermore, another study, [13] revealed that the implementation of the Guided Discovery teaching method resulted in enhanced student performance in problem-solving tasks. This instructional approach was employed to support students in overcoming their challenges in comprehending and applying the concept of the Surface Area of a Cylinder at Abakrampa Senior High/Technical School.

The Guided Discovery approach offers advantages to students, with a particular focus on girls and racial minorities, as it facilitates learning as a dynamic process rather than reinforcing the notion of inherent capabilities. Nevertheless, it is worth considering whether the implementation of Guided Discovery in mathematics instruction may yield varying outcomes for male and female students. It is worth noting that certain research findings indicate the presence of gender disparities in mathematics performance among students in secondary education.

Odogwu [14] and Armstrong [15] revealed a notable disparity in academic performance between male and female students in the field of mathematics. Conversely, [1] conducted a study on the acquisition of Geometry skills among students and did not find any significant gender differences in their learning outcomes. Is it possible that the discrepancy in academic performance between male and female students in

mathematics could be effectively mitigated through the implementation of the Guided Discovery instructional approach when teaching the concept of the Surface Area of a Cylinder? The researchers were motivated to conduct this study to address the aforementioned issue among Senior High Schools (SHSs) in Ghana.

1.1. Aims

The objective of this study was to utilise the Guided Discovery approach in mathematics instruction, with a specific focus on teaching students how to calculate the Surface Area of a Cylinder, for students in the SHSs in the Cape Coast Metropolis. The. The study aimed to assess the impact of the Guided Discovery method on students' comprehension of the concept of the Surface Area of a Cylinder.

1.2. Objectives

The primary objectives of this study are to:

1. find out the effects of the use of Guided Discovery on senior high school students' performance in Mensuration I (Surface Area of a Cylinder)
2. assess how the use of Guided Discovery affects the performance of male and female students in Mensuration I (Surface Area of a Cylinder) at the SHSs in Cape Coast Metropolis.
3. examine the experiences of students when learning the Surface Area of a Cylinder using the Guided Discovery approach.

The objective of this study is to enhance the understanding of the application of instructional approaches such as Guided Discovery in the pedagogy of mathematics education. This approach facilitates the learner's development of creative and observational skills. Additionally, it enables teachers to effectively plan their teaching methods and techniques. Moreover, it empowers both slow learners and gifted students to confront challenges and be motivated to engage in activities that surpass expectations. Furthermore, it allows both teachers and learners to utilise a diverse range of resources to enhance student performance. Lastly, it empowers teachers and learners to devise and demonstrate concepts and methods that indicate a higher level of learning achievement.

2. Materials and Methods

2.1. Research Design

This research used an explanatory-sequential mixed-methods design. The explanatory-sequential mixed methods design entails gathering quantitative data first and then qualitative data to explain or expand upon the quantitative findings [16]. A common structure for this type of research is to start with quantitative methods, and then switch to qualitative methods to better understand and explain the results. In the quantitative phase, the research design employed in this study was a true experimental approach.

The selection of this design was based on its adherence to the principles outlined by [17]. Specifically, this experimental design was chosen due to its ability to effectively mitigate the influence of extraneous variables without necessitating the fulfilment of all requisite conditions. The utilisation of this design is employed in situations where the implementation of a quasi-experimental design is not deemed feasible. Furthermore, the qualitative phase was a case study designed to examine the experiences of the students while learning the Surface Area of Cylinder using the intervention.

2.2. Population and Sampling

The study's population encompassed all students attending public senior high schools within the Cape Coast Metropolis. The study focused on the target population of second-year Senior High School (SHS 2) students during the 2020/2021 academic year in Cape Coast. The population under study comprised second-year students enrolled at School A (a dummy name for the actual school), located in the Cape Coast Metropolis within the Central Region of Ghana. The selection of second-year classes was based on the inclusion of Mensuration I, specifically the topic of calculating the Surface Area of a Cylinder. Furthermore, the study employed a simple random sampling technique to select the participants, specifically targeting Form Two General Arts students.

The study utilised a sample size of 80 students (all of whom are used for the experiment. Thus, no control group). The pre-and post-tests were administered to the entire sample that was selected for the study. Therefore, the study consisted solely of an experimental group, lacking a control group. The purpose of this study was to evaluate the effects of the intervention on the entire student population involved in the research. Furthermore, as the primary objective of the study did not involve a comparison of student performances between those taught with Guided Discovery and those taught with the traditional method, the categorization of students into control and experimental groups was deemed unnecessary.

However, five students, who were willing to take part in an interview, were conveniently selected for the qualitative phase of the study. The five students for the interview are adequate to generalise over the entire population since [18] recommended that researchers can observe from 5 to 25 individuals who have all experienced the phenomenon.

2.3. Data Collection Instruments

The study employed several instruments, including the Mathematics Achievement Test (MAT) for both the pre-test and post-test assessments, the Lesson Plan, and an interview protocol.

2.3.1. Mathematics Achievement Test (MAT) (Pre- and Post-test)

The Mathematics Achievement Test (MAT) was used to collect quantitative data for this study. Tests encompass a collection of inquiries, exercises, or practical undertakings designed to evaluate an individual's proficiency, aptitude, and comprehension. The questions included in the MAT were taken from the WAEC set of questions over the years. The students were required to provide detailed solutions to the questions to enable the researchers to understand how well the students understood the concepts taught to them using the Guided Discovery approach. The five questions used for testing the students' performance are:

1. A cylinder has a radius of 6cm and a height of 13cm. Find the total surface area of the cylinder. [Take π = 3.142].
2. Given that the radius of a can in the shape of a cylinder is 7cm and its height 9cm, find the total surface area of the can. [Take π = 3.142].
3. A cylinder closed at both ends has a diameter of 25m and a total surface area of 1760m^2. How long is the cylinder? [Take π = 3.142].
4. A cylinder opened at both ends has a diameter of 15cm and a height of 12cm. Calculate the total surface area of the cylinder. [Take π = 3.142].
5. The radius of a hollow cylinder is $2\frac{1}{6}$ cm and the height is 8.3cm. Find the total surface area of the cylinder. [Take π = 3.142].

The tests were administered in two stages, namely the pre-test and post-test. The research employed the pre-test and post-test methods, which entailed administering a consistent set of questions on the topic of Surface Area of a Cylinder. The primary purpose of their design was to facilitate the efficient collection, interpretation, analysis, and organisation of the gathered data. The pre-test and post-test tasks were utilised as the foundation for the evaluation and assessment of the students. The pre-test was administered to assess the students' initial proficiency in the concept of Surface Area of a Cylinder, while the post-test was conducted to evaluate the impact of intervention activities on their subsequent performance improvement.

The examination consisted of a set of five questions, each graded on a scale of 20. The assessments were administered during a regular instructional session in a classroom setting. In both tests, students were instructed to independently solve the questions without seeking assistance from peers or consulting any reference materials, such as textbooks. The pre- and post-tests were administered to the identical group of students who received the intervention. Hence, the study comprises a single experimental group, devoid of any control group.

2.3.2. Lesson Plan

A lesson plan is a comprehensive outline of an instructional session that a teacher intends to deliver during a specific class period. The lesson plan was formulated utilising the Guided Discovery pedagogical approach. The duration of one lesson spanned a period of forty-five (45) minutes. In total two weeks were used to carry out the lesson.

2.3.3. Interview Protocol

The interview protocol was used to collect qualitative data after the post-test was administered to the students. The interview included questions that elicited responses from the students regarding their experiences while learning in the Guided Discovery classroom setting. Questions were targeted towards the clarity of the lesson, the students' interests in the lesson, and how the lesson was presented.

2.4. Data Collection Procedures

After obtaining permission from the school, an introductory letter was received from the Department of Math and ICT Education and sent to the school informing them of the intention to conduct the study. A letter was written to the Head of Department seeking permission to conduct the research and the purpose of the study and treatment implementation were explained to the teachers as well. The respondents were told that the exercise was for academic purposes only and that confidentiality was assured to encourage them to give their responses without suspicion. Students were ensured of their anonymity and confidentiality. All Covid-19 protocols were also adhered to limit the spread of the coronavirus pandemic.

2.4.1. Pre-test

The students were given the pre-test to respond to within 30 minutes after which the intervention was introduced.

2.4.2. Intervention

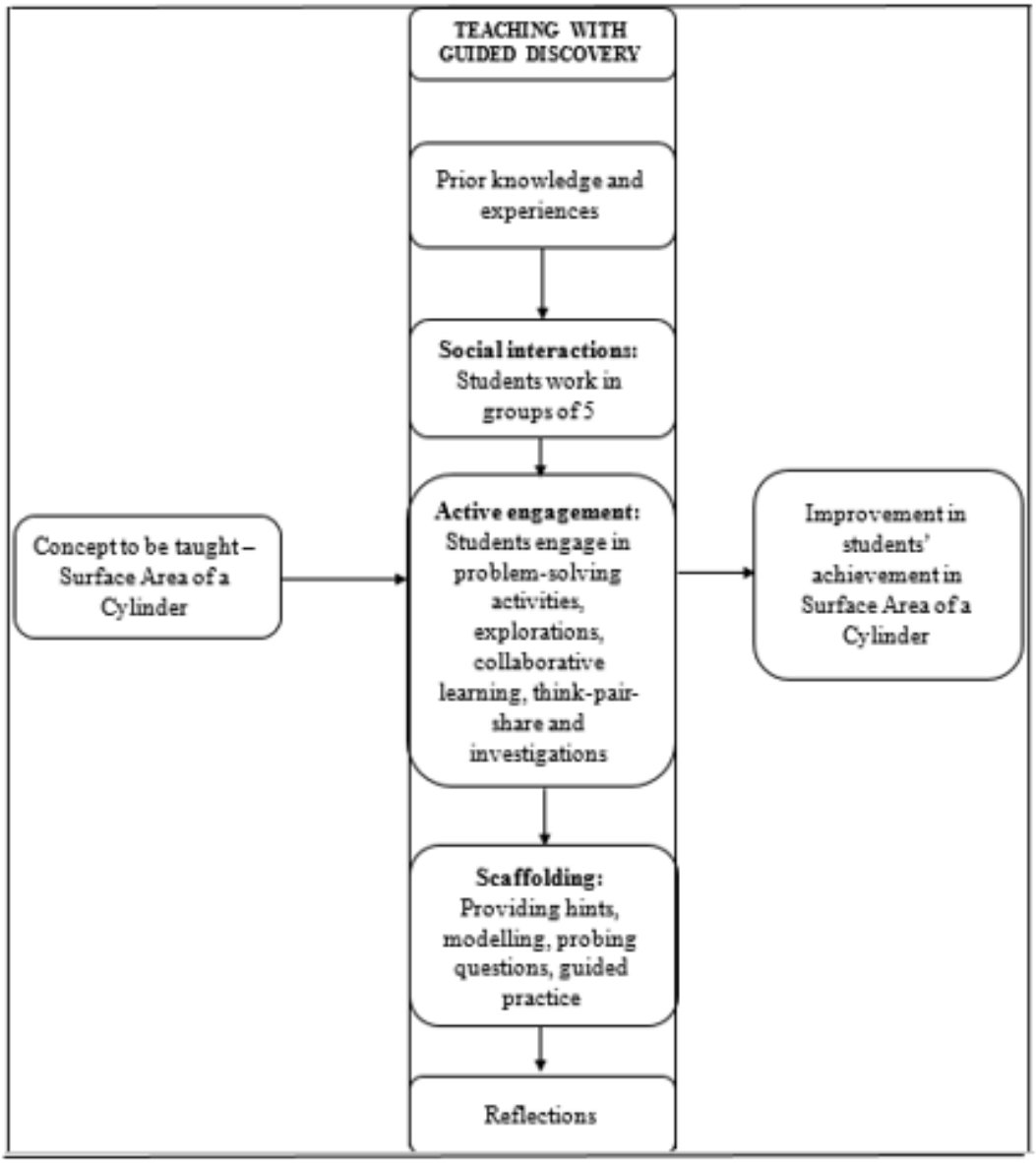

Figure 1. *Intervention process.*

The students were taught Mensuration I (Surface Area of a Cylinder) using a Guided Discovery lesson plan. The lesson took place over two weeks.

Students were asked to come along with objects such as tins of milo, milk, tomato etc. The researchers guided the students to cut out the tins into cylindrical shapes using scissors and knives. The students were instructed by the teacher to discern the facial features of the cylinder to identify three distinct faces or surfaces: a circular base, a circular top, and a rectangular curved surface. These components are visually represented in the accompanying diagram:

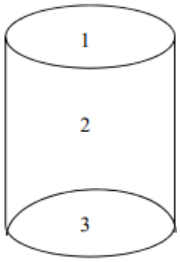

Figure 2. *Solid cylinder.*

The researchers guided the students to separate the faces

with the help of a pair of scissors.

Students found out that, the three surfaces of a cylinder are the two circular ends and the curved surface. The curved surface was flattened to form a rectangle, and the net of the cylinder looked like what is shown below:

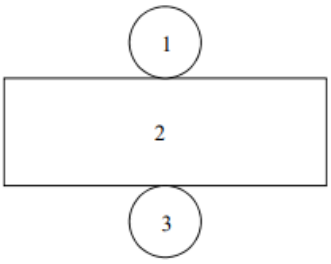

Figure 3. *Cross-section of a cylinder (a).*

The Surface Area of a Cylinder

Students were made to observe the cylinder to come out with the surface area of the cylinder. The student concluded that it is the total area of the nets of the figure. The following figure was sketched to explain more about cylinders.

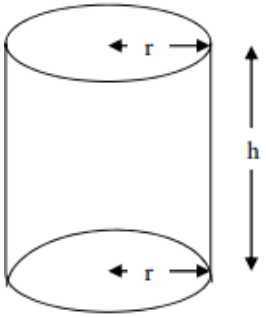

Figure 4. *Cylinder with dimensions.*

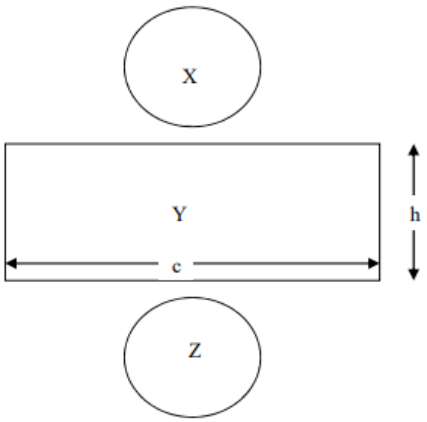

Figure 5. *Net of a cylinder.*

$$\text{Area of net X} = \pi r^2 \quad (1)$$

$$\text{Area of net Z} = \pi r^2 \quad (2)$$

Area of net Y = ch, but $c = 2\pi r$ (Circumference of a circle) $= 2\pi rh$ (3)

Total surface area = (1) + (2) + (3) = $\pi r^2 + \pi r^2 + 2\pi rh = 2\pi r (r + h)$

After the students had understood the whole concept of the Surface Area of a Cylinder, the researchers guided the students to solve a series of problems on it.

2.4.3. Post-test

Following the instructional period, the students were administered the identical achievement test. The post-test was completed by the students within a time frame of 30 minutes.

2.4.4. Interview

After the post-test was conducted, the students who were willing to be interviewed were sent to an empty class where the interviews were conducted face-to-face in a focus group discussion form. This enabled the students to share ideas on the lesson and express their views on the whole lesson.

2.5. Data Analysis Procedure

Sharp et al. [19] argued that the conversion of raw data obtained from field research into meaningful and pertinent information is essential for effective decision-making. The process involves the organisation and arrangement of data acquired through research in order to generate knowledge. The interpretation of raw field data poses challenges due to its inherent complexity, necessitating the need for comprehensive analysis in order to derive meaningful insights. The primary data for the study were derived from the scores obtained in the MAT. Following the completion of the examinations, a cumulative sum of four points was assigned to each individual question. Since the questions five, a total score of 20 marks was used. Hence, the minimum passing score required for the assessment was 50% (10 out of 20). The data were compiled and analysed utilising statistical measures such as the mean, standard deviation, and t-tests.

Furthermore, the demographic data of the students was analysed using descriptive statistics, specifically frequency counts and percentages. These statistics were presented in tables to provide a comprehensive overview. Additionally, inferential statistics, specifically t-tests, were utilised to analyse the first two research objectives. The analyses were conducted utilising the Statistical Package for Service Solutions (SPSS version 26.0) and Microsoft Excel 2019. The qualitative data that was gathered underwent thematic analysis, with themes being classified as students' interests, clarity of the lesson, and lesson presentation. This categorisation of themes was adapted from the work of [20].

3. Results

3.1. Demographic Characteristics of Participants

Table 1. Demographic Characteristics of Respondents.

Variable	Frequency	Percentage
Sex		
Male	38	47.5
Female	42	52.5
Age		
10-13 years	38	46.3
14-17 years	35	43.8
More than 17 years	8	10.0

The demographic data of the respondents presented in Table 1 revealed that a little over half 42(52.5%) of the respondents for the study are females and the rest 38(47.5%) are males. Hence more females than males took part in this study. Furthermore, the results revealed that the respondents are diverse in their age categories. A little below half 38(46.3%) of the respondents are between the ages of 10-13 years followed by 35(43.8%) who fell within the 14-17 years age category. The least age category of the students is those who are more than 17 years 8(10.0%) representing a small proportion of the total sample for the study.

3.2. Descriptive Statistics

This section presents the descriptive statistics pertaining to the pre-test and post-test utilised in the study. The descriptive statistics provided for each test encompass the maximum and minimum values, mean, standard deviation, skewness, and kurtosis. The average (pass) mark for the students is set at 10. The data is displayed in Table 2.

Table 2. Descriptive Statistics of Variables.

Variables	Min	Max	Mean	Std	Skewness	Kurtosis
Pre-test	5	16	10.5	2.6	0.19	-0.35
Post-test	10	19	14.6	2.5	-0.003	-0.90

The findings presented in Table 2 indicate that the lowest score achieved by the students on the pre-test was 5 marks, while on the post-test, it increased to 10 marks. The maximum score achievable on the pre-test is 16 marks, while on the post-test, the maximum score attainable is 19 marks. The level of performance is indicated by the mean performance, which represents the average performance of the students on the post-test (M = 14.6, SD = 2.5). This mean performance is 4.1 points higher than their performance on the pre-test (M = 10.5, SD = 2.6). The pre-test performance of the students exhibits a positive skewness of 0.19 and a kurtosis of -0.35. However, the post-test performance demonstrates a different pattern, characterised by a skewness of -0.003 and a kurtosis of -0.90.

3.3. Pre-test and Post-test Performance of SHS Students Taught 'Surface Area of a Cylinder' with Guided Discovery

This research hypothesis sought to determine if the use of Guided Discovery caused any improvement in SHS students' scores in the MAT on the Surface Area of a Cylinder. Data were analysed by coding both the pre-test and the post-test scores of the students. The scores were categorised into four (4) groups (1-5 marks, 6-10 marks, 11-15 marks, and 16-20 marks). The component bar chart was used to compare the students' marks. This was done to ascertain whether the discovery method had any effect on the students' performance. Firstly, Figure 6 presents the results of the pre-test matched against the post-test scores.

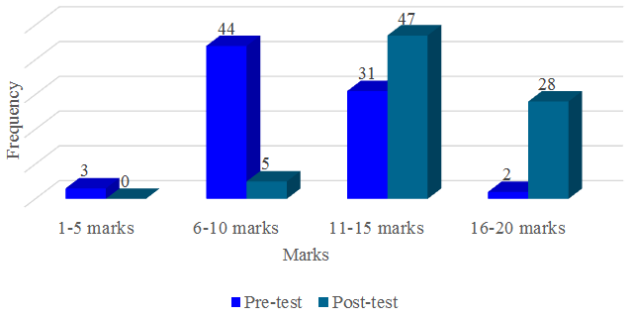

Figure 6. Pre-test and Post-test Performance of Students.

The results in Figure 6 showed that students performed higher on the post-test with more than two-thirds (75) of them scoring marks between 10 and 20 whereas less than half (33) of them scored marks between 10-20. The results again showed that while no student scored 1-5 marks on the post-test, a small proportion (3) of them scored 1-5 marks on the pre-test. Comparing the highest scores (16-20 marks), just two (2) students scored 16-20 marks on the pre-test with a mouth staggering 28 of them scoring 16-20 marks.

Furthermore, the researchers utilised the paired sample t-test to ascertain whether a statistically significant disparity existed in the average performances of the students, with a significance level set at 0.05. The paired sample t-test was employed to assess the statistical significance of the differ-

ences in student performance prior to and following the implementation of the Guided Discovery approach.

Table 3. Results of Paired-Sample T-test.

	N	Mean	SD	t	df	Sig. (2-tailed)	95% C. I of the Difference	
							Lower	Upper
Pre-test	80	10.46	2.58	-10.7	79	0.000	-4.96	-3.40
Post-test	80	14.64	2.54					

According to the findings presented in Table 3, a notable and statistically significant improvement in test scores was observed between the pre-test (M = 10.46, SD = 2.58) and the post-test (M = 14.64, SD = 2.54), $t(79) = -10.7$, $p < .05$ (two-tailed). The average increase in test scores was found to be 4.18, as determined by statistical analysis. This result is accompanied by a 95% confidence interval, which indicates that the true mean increase in test scores lies within the range of -4.96 to -3.40. The eta squared statistic of 0.59 suggests a substantial effect size. Therefore, a statistically significant difference existed in the academic achievement of students who were instructed in the concept of Surface Area of a Cylinder through the utilisation of Guided Discovery methodology.

3.4. Mean Achievement Scores of Male and Female SHS Students Taught 'Surface Area of a Cylinder' Using Guided Discovery

To assess the presence of a statistically significant difference in academic performance between male and female students who have undergone instruction using the Guided Discovery approach, the independent sample t-test was employed. The mean of the male and female students was computed, and a two-tailed t-test for equality of means was conducted, using a significance level of 0.05. The decision was made based on the predetermined significance level of 0.05 for the t-statistic. The findings are displayed in Tables 4 and 5.

Table 4. Descriptive Statistics of Gender and Post-Test Scores.

Sex of teacher	N	Mean	Std. Deviation	Std. Error Mean
Male	38	14.47	2.69	0.44
Female	42	14.79	2.43	0.37

Table 5. T-test statistics of Post Test Scores and Students' Gender.

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Post-test	-0.55	78	0.59	-0.312	-1.45	0.83

The post-test scores of male and female students were compared using an independent-sample t-test, as shown in Table 4 and Table 5. The descriptive results indicate that there is a comparable level of performance observed among male students (N = 38, M = 14.47, SD = 2.69) and female students (N = 42, M = 14.79, SD = 2.43). The mean difference between the two groups was found to be 0.32, with a 95% confidence interval ranging from -1.45 to 0.83. This indicates that the observed difference in means is relatively small. Additionally, the effect size, as measured by eta squared, was calculated to

be 0.004. The findings pertaining to the disparity in post-test performance between male and female students indicate that there is no statistically significant distinction ($t(80) = -0.55$, $df = 78$, $p = 0.59$, two-tailed) in the post-test scores between male and female students.

3.5. Experiences of Students

According to the findings from the focus group interviews, the students expressed their belief that the implementation of the Guided Discovery approach facilitated their ability to recognise patterns and formulate generalisations. According to the students, the teacher devoted ample time to thoroughly explain the subject matter, a quality that was absent in their prior instructional experiences. The following statements were cited from a group of students:

Jane: *I didn't know what the teacher was going to do after we cut the tins and removed the lids. However, I was surprised when the teacher used it to derive the formula for the Surface Area*.

Henry: *The lesson was fantastic, and I enjoyed how the teacher used us to do everything without him just giving us formulas to work with*.

This observation indicates that the students perceived the lesson as engaging, as they recounted the teacher's approach to the topic. This claim is substantiated by [7] assertion that, among the numerous strategies utilised in mathematics instruction, the Guided Discovery method stands out as highly effective in captivating students' interests and cultivating a favourable learning atmosphere that encourages active participation among all learners.

Furthermore, the students reported that the Guided Discovery approach provided numerous additional clarifications in the process of calculating the Surface Area of a Cylinder. This indicates that the lesson was presented in a manner that encouraged active engagement from the students, allowing them to take ownership of the material and apply their existing knowledge to solve the given questions. According to the students' recollection:

Jimmy: *I think I don't have to be memorising the formula before I solve the questions. The questions have become cheap, and I solved them with ease without spending much time on it.*

Gloria: *If the teachers will always use this approach to teach us, I think I will pass all my mathematics exams.*

The lesson utilised a collaborative learning approach, wherein students were paired and engaged in group activities. This approach potentially influenced their learning experiences to focus more on the practical aspects of understanding the Surface Area of Cylinder, particularly using tangible materials. According to the students, the instructional sessions were designed to prioritise the needs and preferences of the learners, with the goal of promoting advanced cognitive skills and their practical utilisation in real-life situations. A significant proportion of the participants demonstrated an improved understanding of the fundamental principles underlying the calculation of the Surface Area of a Cylinder.

4. Discussion and Conclusion

The objective of this study was to examine the effects of employing the Guided Discovery approach on the process of determining the Surface Area of a Cylinder. The experimental group consisted of a cohort of students who were subjected to an intervention involving the implementation of a Guided Discovery lesson plan. This intervention aimed to facilitate their acquisition of the knowledge and skills necessary to calculate the Surface Area of a Cylinder. The pre-test was administered to assess the participants' initial proficiency in calculating the surface area of a cylinder.

The findings regarding the presence of a statistically significant difference in students' performance between the pre-test and post-test indicate that most students exhibited improved performance on the post-test in comparison to their pre-test scores. The influence of the Guided Discovery method on students' comprehension of the process of determining the Surface Area of a Cylinder can account for this phenomenon. Furthermore, the results of the paired sample t-test indicate that there was a significant improvement in students' performance on the post-test in comparison to their pre-test performance. The findings indicate that the implementation of Guided Discovery had a significant impact on the students' comprehension. According to [21], Guided Discovery is identified as one of the effective teaching practises. The authors further assert that a comprehensive understanding of effective teaching necessitates an examination of various teaching practises. Additionally, they posited that effective teaching strategies necessitate a systematic instructional approach, wherein the subject matter is presented and reinforced until it is fully comprehended and internalised.

This increase in the performance of the students is likely to be attributed to several factors which might include the students being aware of the formulas since they were not pre-informed on the pre-test on what concept they would be assessed on. However, for this study, their performance was likely due to the introduction of the Guided Discovery to teach them how to find the surface area of the cylinder. This could be seen from their works when most students were able to correctly explain the terms in the formula and write the formula better than what they had presented in their pre-test responses.

According to [22], the utilisation of concrete manipulatives by students at the early elementary level over an extended period leads to higher levels of mathematical achievement compared to students who do not use such manipulatives. This study also demonstrates that the use of concrete materials, specifically Guided Discovery, can yield notable short-term effects on students. This study hence agrees with the findings of previous studies [11-13] which found that Guided Discovery had improved students' performance in solving problems involving the Surface Area of a Cylinder.

Concerning the difference in the performance of male and female students, after they had been taught with the Guided Discovery approach, the results showed that female students performed better than males with a slim margin (0.32) which was seen as a very small effect. This could be because more female students were involved in the study than male students. Even though this could be seen as a bias, the probability sampling used for the study made sure every student had an equal chance of being selected for the study, thus this was beyond the control of the researchers. Furthermore, the statistical results showed that there is statistically no significant difference in the performance of male students and female students after they have been taught using the Guided Discovery to find the Surface Area of a Cylinder.

Thus, both sexes performed equally on the post-test results showing that the Guided Discovery was appropriately rolled out hence both sexes demonstrated the same level of understanding that had translated into their performances.

Additionally, the use of Guided Discovery to teach the Surface Area of a Cylinder enhanced the clarity and interest of students in learning Mensuration. Finally, the use of concrete material made the presentation of the concept to students appealing. These findings confirmed the findings of [20].

Based on the findings of the study, it can be inferred that the implementation of the Guided Discovery approach had a discernible impact on the academic achievement of students in the context of determining the Surface Area of a Cylinder. The observed influence was deemed positive due to the notable increase in students' performance on the post-test in comparison to their performance on the pre-test. Moreover, it can be inferred that the implementation of the Guided Discovery method for teaching the concept of Surface Area of a Cylinder was effectively executed, as there was no notable difference observed in the performance of male and female students. This suggests that the instructional approach employed was impartial towards the sex of the students.

Based on the results of the study, it is advisable that mathematics educators utilise the Guided Discovery approach when instructing students in mathematical concepts to stimulate their engagement with the subject matter and to achieve favourable experiences of students in the mathematics classroom. In addition, it is imperative for teachers employing the Guided Discovery approach to allocate equal attention to all students, irrespective of their sex.

Abbreviations

MAT	Mathematics Achievement Test
SHS	Senior High School
SPSS	Statistical Package for Service Solutions
WAEC	West African Examinations Council

Author Contributions

Christian Kwame Kpotosu: Conceptualization, Formal Analysis, Methodology, Writing – original draft, Writing – review & editing

Nicholas Kofi Cudjoe: Data curation, Writing – review & editing

Henry Lovejoy Nii Armah: Conceptualization, Data curation, Writing – review & editing

Funding

No funding was received for conducting this research.

Data Availability Statement

Data for this study is available and will be submitted open request.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Kpotosu, K. C., Amegbor, S., Mifetu, B., Ezah, R. B. K. (2019). *Senior High School Students' difficulties with Geometry Topics.* Preprint: https://doi.org/10.20944/preprints202405.0126.v1

[2] Ojaleye, O. O. (2005). *Promoting the utilization of information technology education in mathematics classes among pre-service teachers*. Marvellous Mike Ventures LTD. No. 7 Abeokuta Street, off Ogbomoso Street, Area Garki Abuja F. C. T.

[3] National Mathematical Centre (2009). *Mathematics improvement programme*. Retrieved from https://nmc.edu.ng/

[4] West African Examination Council (2019). *2018 Chief Examiner's Report for Mathematics*. Accra: Ghana.

[5] Ensor, P., Dunne, T., Galant, J., Gumedze, F., Jaffer, S., Reeves, C., & Tawodzera, G. (2002). Textbooks, teaching and learning in primary mathematics classrooms. *African Journal of Research in Mathematics, Science and Technology Education*, *6*(1), 21-35. https://doi.org/10.1080/10288457.2002.10740537

[6] Ezejitu, P. (2009). *Effect of cooperative learning on the achievement of secondary school students in Biology*. (Unpublished B. Sc. Ed thesis, Abakaliki, Department of Science Education, Ebonyi State University).

[7] Otobo, K. (2012). *Effect of Guided Discovery method of instruction on the achievement of junior secondary school students in computer studies, Abakaliki*. (Unpublished B. Sc. Ed degree thesis. Department of Science, Ebonyi State University).

[8] Gallenstein, N. (2005). Engaging young children in science and mathematics. *Journal of Elementary Science Education, 17*(2), 27-41. https://doi.org/10.1007/bf03174679

[9] Ali, A. C. (2004). *Relational concept of mensuration in teacher training colleges in Ghana*. Unpublished Long essay

[10] Chikamai, K. (1998). Gender differences, a factor in Computer Science achievement in Secondary Schools in Nigeria. *The Academic Forum, 1*, 157-160.

[11] Okwute, O. A. (2015). *Effect of guided discovery method on mathematics achievement of low and high averted secondary school students in FCT Abuja, Nigeria*. (Published master thesis, Department of Mathematics Education, Ahmadu Bello University).

[12] Lubis, A. B., Miaz, Y., & Putri, I. E. (2019). Influence of the Guided Discovery learning model on primary school students' mathematical problem-solving skills. In *Elementary School Forum (Mimbar Sekolah Dasar)* (Vol. 6, No. 2, pp. 253-266). The Indonesia University of Education.

[13] Obed, O. O., & Deebom, T. M. (2019). Effect of guided discovery teaching technique on students' academic achievement in machine shop practice in Rivers State Universities. *International Journal of Latest Research in Humanities and Social Science (IJLRHSS), 2*, 100-109.

[14] Odogwu, H. N. (2002). Female students' perception and attitude to mathematics: A bane to their SMT education. *ABACUS. The Journal of the Mathematics Association of Nigeria*, *27*(1), 19-29.

[15] Armstrong, J. M. A. (1990). Why females do not like mathematics: The effect of parental expectations. *Journal of Research in Mathematics Education, 12*(6), 3-14.

[16] Clark, V. L. P. (2019). Meaningful integration within mixed methods studies: Identifying why, what, when, and how. *Contemporary Educational Psychology*, *57*, 106-111.

[17] Cambell, D. T. & Stanley, J. C. (2007). *Experimental and quasi-experimental designs for research*. Chicago: Rand McNally.

[18] Polkinghorne, D. E. (1989). Phenomenological research methods. In R. S. Valle & S. Hailing (Eds.), *Existential-phenomenological perspectives in psychology* (pp. 41-60). New York: Plenum.

[19] Sharp, J. A., Peters, J., & Howard, K. (2017). *The management of a student research project*. Routledge.

[20] Agyei, D. D., & Voogt, J. (2012). Developing technological pedagogical content knowledge in pre-service mathematics teachers through collaborative design. *Australasian Journal of Educational Technology*, *28*(4), 547-564. https://doi.org/10.14742/ajet.827

[21] Brophy, J. E., & Good, T. L. (1986). Teacher behaviour and student achievement. In M. C. Wittrock (Ed.), *Handbook of Research on teaching* (3rd Ed.). New York: Macmillan Publishing Company.

[22] Burns, B. A., & Hamm, E. M. (2011). A comparison of concrete and virtual manipulative use in third-and fourth-grade mathematics. *School Science and Mathematics*, *111*(6), 256-261.