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THE EFFECTIVENESS OF THE INQUIRY-BASED TEACHING APPROACH ON TECHNICAL AND VOCATIONAL STUDENTS' MATHEMATICS ACHIEVEMENT IN GHANA

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Abstract

The study investigated the effectiveness of the inquiry-based teaching approach on technical and vocational students' mathematics achievement in Sekyere East District in Ghana. The research adopted a quantitative approach that employed quasi-experimental design. Purposive sampling technique was used to select 80 first-year students from Krobea Asante Technical and Vocational Institute for this study with 40 students each in the experimental and control groups. Data were collected using pre-test and post-test measurements with non-equivalent groups Statistical analysis using the independent sample t-test revealed that students instructed through the inquiry-based approach in the experimental group outperformed those taught via the conventional approach in the control group. Cohen d effect size of 1.13 was obtained indicating that the Inquiry-based teaching approach is more effective in teaching geometry course than the conventional approach. The study recommended among others that teachers in the pre-tertiary institutions should employ Inquiry-Based approach in teaching geometry and its related topics.

Keywords: Inquiry-Based Teaching Approach, Technical and vocational education, lecture method.

Introduction

For students to succeed in today's rapidly changing job market, they need to develop specific skills: problem-solving and critical thinking, influential leadership and teamwork, agility and adaptability, initiative and entrepreneurship, effective communication, information literacy, curiosity and imagination (Wagner, 2014). The attainment of these attributes is linked to the type of education employed, with inquiry-based learning being particularly effective (as seen in the works of Brune, 2010; Kim, 2017; Small, 2018; Masilo, 2018; and others). Inquiry-based learning is a powerful tool that enables students to actively construct their knowledge in the classroom. By asking questions, exploring and conducting investigations, students can clarify misconceptions and deepen their understanding of various phenomena. This approach fosters an open-ended learning environment where students are encouraged to seek answers and make sense of information with minimal guidance from the teacher. The constructivist method empowers students to build a meaningful understanding of the world around them.

According to Bianchi & Bell (2008) there are four different forms of inquiry-based learning: guided inquiry, open inquiry, confirmatory inquiry and structured inquiry, According to Pedaste et al. (2015), these kinds have different inquiry phase cycles. Phase cycles, which assist teachers in lesson planning by breaking up instructional tasks into phases, are crucial to the implementation of inquiry-based learning (Abraham, 1997). Structured inquiry learning was used in this study out of the four categories of inquiry-based learning. Structured inquiry learning helps students become more adept at posing queries and researching issues that arise in the real world (Wonkyi- Mensah & Adu, 2016). In the inquiry-based teaching approach the instructor presents an open-ended question and tasks students to use an investigative process to reach a conclusion backed by evidence. Structured inquiry-based learning often leads to open inquiries, where students formulate their problems to explore when used by a teacher to impart specific concepts, facts, skills, or ideas. The Learning Inquiry Cycle Model and the structured inquiry learning approach are both grounded in Piaget's theory of cognitive development (Bevevino et al., 1999; Abdi, 2014). This instructional method aligns with the inquiry-based nature of mathematics learning and matches the way children learn best (Cavallo & Laubach, 2001).

On the other hand, the conventional approach often creates an environment where the teacher is the focus while students take on passive and uninterested roles. In this model, a serious and stern educator stands at the front of the classroom, delivering knowledge to students who are expected to absorb information without question. Proponents of this teaching approach believe that the teacher is the sole source of knowledge and that students must accept facts without challenging the instructor (Abdi, 2014). As the teacher focuses on imparting information, there is little room for student-led inquiries, independent thinking, or meaningful interactions between peers, often resulting in a passive learning experience for students (Abdi, 2014). The teacher is the centre of attention in this teacher-centred teaching approach, which is the classic lecture technique. Because the teacher is now the only source of knowledge in the classroom, it follows that all students can learn the content at the same pace and with the same level of background knowledge (Abdi, 2014).

The current study was pivoted on the 5E Instructional Model of the Inquiry-Based Learning Approach. The 5E Instructional Model, created by Bybee and Landes (1990) for Biological Science Curriculum Study (BSCS), was adapted for this study to support inquiry-based teaching. The 1962 educational paradigm put forth by J. Myron Atkin and Robert Karplus (see Bybee and Lands, 1990) has been modified into the 5E educational paradigm The distinct phases of the 5E cycle model are as follows: (1) Phase of Engagement: This is the cycle's initial phase, and the teacher's job is to evaluate the pupils' prior knowledge and make connections between it and the ideas being taught. Enough motivation should be provided for the student to take part and develop an interest in learning more about the ongoing activity.

The misunderstandings held by the students should be recognised and addressed in a way that encourages them to look for solutions to dispel them. (2) Exploration Phase: This part of the programme gives the pupils a shared, hands-on educational experience. Using abilities including observation, inquiry, research, testing hypotheses, and peer-to-peer communication, adolescents are encouraged to actively investigate their surroundings throughout this stage. This part of the model primarily represents the portion of the learning cycle in which students engage in inquiry-based activities. This stage fosters the development of concepts and abilities in the students. After that, the teacher only serves as a consultant or facilitator. In addition, the phase permits students to confer with one another, fostering cooperation and a cooperative learning environment in the absence of teacher direction.

Before the teacher formally discusses or explains any terminology, definitions, or concepts, this phase also assists students in dispelling some of their misunderstandings and gaining new experiences. (3) The Explanation Phase: During this phase of the instructional model, teachers and students engage in a collaborative dialogue. They focus on specific aspects of the student's exploration and engagement experiences, allowing students to express their understanding or showcase their skills. Teachers can formally introduce and define concepts, procedures, skills, or behaviours. Students can also seek clarification and ask questions about the ideas they have encountered. This phase involves a two-way exchange of explanations, with students explaining their understanding to peers and teachers and teachers providing clarifications to address any misconceptions.

(4) Elaboration Phase: Activities during this phase aim to encourage students to apply the new conceptual knowledge they have acquired about the ideas previously introduced. Students are motivated to use their understanding in practical ways, reinforcing their learning and providing opportunities for further exploration and application. The exercises in this section should give the student the chance to practise and reinforce newly learned and desired skills. This phase's objective is to support the students in gaining a more comprehensive and in-depth comprehension of the ideas established during the exploration phase.

(5) Phase of Evaluation: In addition to giving teachers a chance to analyse how well their students are meeting the learning objectives, this part of the teaching model encourages students to evaluate their knowledge and skills. Even though the student is formally evaluated in phase 5, informal evaluation occurs at phase 1 and even at other points in the 5-phase cycle. After the elaboration stage, the instructor may choose to conduct a formal evaluation. During this stage, the instructor gives tests in any format that is suitable to ascertain each student's comprehension level (Bybee et al., 2006). This 5E model is therefore implemented in this study to ascertain how inquiry-based teaching methods affect mathematics students at Krobea Asante Technical and Vocational Institute. The main objective of the study was to determine the Effectiveness of the Inquiry-Based Teaching Approach on Mathematics Achievement of Technical and Vocational Students at the Senior High Level in Ghana. To achieve this objective a hypothesis is formulated as follows;

H_o: There is no significant effect on the inquiry-based teaching approach on mathematics achievement of students in Krobea Asante Technical and Vocational Institute.

Methodology

The study employed a quasi-experimental design, utilising pre-test and post-test measurements with non-equivalent groups. Purposive sampling was used to select Krobea Asante Technical and Vocational Institute among the technical schools in the Sekyere East District, in which 80 first-year students participated. The study comprised two distinct groups that were chosen using the purposive sampling technique. The experimental group comprised 40 pupils, while the control group also had 40 students. Pre-test findings were taken into consideration to guarantee equivalency between the experimental and control groups. The experimental group and the control group were determined to be statistically equal. The achievement test served as the main tool for gathering data. To determine the participants' starting geometry knowledge and comprehension, a pre-test was given to both groups before the intervention. After the intervention, a post-test was used to gauge how well the Inquiry-Based Teaching Approach (IBTA) strategy—which was being studied—worked. There were ten essay-style questions on the test. The test comprised prior questions from the West Africa Examination Council and teacher-made questions based on the Mathematical Association of Ghana's standard senior high textbook.

Intervention Procedures

The two groups were instructed using different teaching methods. The control group received instruction through conventional teaching, while the experimental group was taught using a structured inquiry-based learning approach based on the 5E learning cycle model. Lesson plans were designed to maximise student engagement and participation in teaching and learning activities, deeply involving them in the learning process. These lessons focused on plane geometry topics from Ghana's senior high school curriculum, including the area of a circle and the perimeter of plane figures such as trapeziums, rhombi, kites, and triangles. The instructor followed the 5E phase cycle model in implementing the treatment in the experimental group. The instructor held the students' attention and got them ready to become interested in learning throughout the engagement phase. Students could draw some links between their current learning experiences and pertinent prior information. As a result, the instructor assisted students in structuring their ideas concerning the current learning objectives. After being divided into groups, the students shared the necessary study materials. Individuals in the groups were also given instruction cards, and the instructor then provided a brief synopsis of the lesson and the current assignment. Students were given access to a siren learning environment during the exploration phase, which allowed them to record data, identify variables, plan and organise experiments, make and develop hypotheses, and see trends and remark on them. The teacher's primary purpose in going around was to watch what each group was doing, make recommendations and methods, get data from the students, and provide comments. Additionally, the instructor evaluated the student's comprehension of the subject matter informally.

Throughout the explanation phase, the instructor assisted students in demonstrating their comprehension of the material and making connections between it and earlier topics. The instructor provided questions to help students apply specific mathematical vocabulary, such as circumference and pi in the case of circles, to explain the findings of their investigations. Students were also guided towards coherent and consistent generalisations of concepts. The elaboration phase activities gave students the chance to apply their knowledge to new areas of mathematics, possibly by posing fresh queries and ideas for investigation. During the elaboration phase, students were given a research assignment concerning estimating the value of pi. The evaluation phase was designed to allow students to gauge their knowledge and skills. Additionally, the activities were designed to give the instructor the chance to assess students' learning both formatively and collectively.

In the control group, a teacher-centred method such as the conventional teaching method was used, as students were instructed directly through the question-and-answer methods, with the teacher dominating the process as basic concepts were introduced to students. In the conventional lecture method, the instructor explains basic concepts, asks internment questions, and expects students to reproduce what he has said previously as an answer. A verbatim answer from a student means learning has taken place. This conventional lecture teaching approach, which makes students completely passive in the teaching and learning process, was used while teaching the concepts in the textbook images and teacher explanations served as the control group's teaching tactics. The teacher in this group employed a combination of lectures and discussions to convey the subject matter. The assumption was that all students in the class had an equal capacity for understanding and learning. The instructor wrote definitions and assigned tasks on the board, expecting the students to replicate and follow their instructions.

One fundamental tenet of the theory was that knowledge is information conveyed to students from a pre-existing source—the teacher. Following the instructor's lectures, several concepts were addressed in response to questions posed. For every lesson, a worksheet was specially created. These demanded written answers and served as a reminder of the lessons covered in class. During each lesson, the instructor would typically guide students through the process of solving problems correctly. Most of the class time was dedicated to lectures and discussions based on the instructor's explanations and questions. Both the inquiry and conventional classrooms used the same instructor, textbook, and supplementary materials. The study spanned five weeks, with three weeks allocated for instruction, consisting of six lessons in total, and two weeks for administering pre-tests and post-tests. For statistical analysis, an independent sample t-test was employed by the researcher.

Analysis and Discussions

From Table 1, it can be observed that the control group had a higher mean score than the experimental group on the pre-test, although this disparity was not deemed statistically significant.

Table 1: Comparison of the Experimental and Control Groups' Group Statistics for Pretest Results in the Academic Achievement Test

Group	N	Mean	Std. Deviation	P-Value
Control	40	23.23	6.40	.126
Experimental	40	21.20	5.30	

The data from Table 1 indicate that despite the control group outperforming the experimental group in terms of means and standard deviations, the observed distinctions did not reach statistical significance (p = 0.126). The intervention process followed immediately after the pre-test. A mean score analysis for both groups was conducted, as presented in Table 2. The results of the post-test exhibited a p-value below 0.001, signifying statistical significance at the p=0.05 level. This suggests that the variance in mean scores between the two groups was not incidental and can be attributed to the treatment received.

Table 2: Comparison of the Experimental and Control Groups' Group Statistics for Post-test Results in the Academic Achievement Test

Group	N	Mean	Std. Deviation	P-Value
Control	40	29.00	4.920	.000
Experimental	40	33.18	1.81	

Statistically significant at the p=0.05 level

The effect size

There are several ways of calculating the effect size of research work. However, this study employed the Cohen’s d to calculate the effect size of the means between the two groups. To further evaluate the intervention's impact, the Cohen’s d was determined to assess its effect on students' comprehension of the mathematical concepts under investigation. In this study, Cohen’s d of 1.13 was determined. Cohen's d of 1.13 implies that about 87.1% of students in the experimental group performed above the mean of the control group (Becker, 2000). This indicates a 57.2% overlap between the two groups, resulting in a 78.8% likelihood that a student selected randomly from the experimental group would achieve a higher score than a randomly chosen student from the control group, indicating superior performance by the experimental group.

Since the experimental group achieved a much higher score, we can conclude that the inquiry-based instruction was beneficial to the students' performance on the post-test. Specifically, the results suggest that, when teachers use IBTA in the classroom, the understanding of their students can increase massively. The findings put forth that IBTA is substantially effective in increasing the scores of achievements in mathematics. This result is consistent with the results obtained by Brune (2010), Pandey et al. (2011), Carvalho et al. (2011), Akpulluku et al (2011), Abdi (2014) and Mensa-Wonkyi & Adu, (2016).

Conclusions

The study's findings revealed that students responded positively to learning mathematics through the inquiry-based teaching approach. This is an inference from the mean score of the students from the experimental class. Moreover, implementing inquiry-based teaching in high school mathematics classes requires structured inquiry to align activities with lesson objectives so that both facilitator and student objectives can be achieved in that lesson. Additionally, the research investigated how the inquiry-based teaching method influenced students' understanding and performance in mathematics classrooms. It was observed that this approach accommodates various learning styles by incorporating auditory explanations, visual demonstrations, and opportunities for kinaesthetic learners to model concepts, thus ensuring comprehension for all types of learners. Unlike conventional lecture methods, inquiry-based teaching fosters both conceptual and procedural understanding, leading to enhanced mathematics achievement levels among students.

Recommendations

The following recommendations were made from the study:

1. Teachers, especially Mathematics teachers must adopt the Inquiry-Based Teaching Approach in the teaching of mathematics.
2. Workshops on Inquiry-Based Teaching must be organized by head of department in collaboration with the head of school for instructors to be familiar and comfortable in the use of Inquiry-Based Teaching in their classroom.
3. A well-planned Inquiry-Based Teaching relies on the availability of teaching and learning materials. It is therefore important for head of department to liaise with the head of school to provide teaching and learning materials to teachers to encourage the teachers to plan an activity based lessons such as the Inquiry-Based Teaching.
4. Teachers at the senior high school must encourage each other to use Inquiry-Based Teaching in their classrooms.

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