Impact of Activity-Based Instruction on Grade 11 Learners' Achievement in Plane Geometry

Muftawu Adams[1] and Justice Enu[2]

Abstract

The study was designed to investigate the efficacy of activity–based instruction on learners' achievement in geometry. The subjects of this study consisted 83 Grade 11 high school learners from two senior high schools, purposely selected from two towns in the Northern part of Ghana. The study adopts an experimental design involving on a pre-test and post-test control design. The experimental group was facilitated using activity-based instruction while the control group was taught using the traditional 'talk and chalk' teaching approach. The instruments used for data generation were geometric achievement pretest and posttest. The test was based on two geometric concepts (perimeter and area). Learners' achievements on the posttest were analysed using an independent t-test. The study showed a significant difference in the posttest geometric achievements for learners in favour of those facilitated using the activity-based method of instruction. Thus, the use of activity-based instruction proved to be a very effective and promising technique to teach geometric concepts. The study also revealed that there was no significant difference in the academic achievement of male and female learners exposed to activity-based teaching. Based on the findings, it is recommended that mathematics teachers should employ activity-based method to facilitate the teaching and learning of geometric concepts.

keywords activity-based instruction; teaching and learning materials; achievement; geometry teaching

Introduction

Mathematics is commonly regarded as an important component of education. The inclusion of Mathematics in all curricula throughout the world confirms its value in human development. According to Enu et al. (2015), society regards mathematics as the bedrock of technical knowledge required to perform practical tasks in the fields of science, technology and engineering. In realizing the vast applications of Mathematics, Eraikhuemen (2003) posits that "a disciplined and ordered pattern of life can only be achieved through the culture of mathematics" (p. 68). Jayanthi (2019) argues that history of Mathematics reveals that any society that utilizes effectively and efficiently the knowledge of mathematics makes tremendous progress. The implication is that for effective functioning in society, there is the need for all citizens to study and understand Mathematics. Despite the critical role geometric concept plays in our society, students' performance in this Specialized branch of mathematics has not been encouraging. Maphutha et al. (2022) observed that learners' misconceptions and poor performance in Mathematics are the result of poor facilitation of mathematics concepts. The authors note that facilitation

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differs from teaching. Regmi (2012) defined facilitation as a learner-centered approach through which learners learn by sharing and collaborating while teaching means controlling what is to be learned by conveying "a message of control over students rather than student empowerment" (Estes, 2004, p. 146). The abysmal performance of senior high school students in Mathematics, particularly geometry has long been a source of great concern to parents, educational stakeholders, and the government. Aboagye et al. (2021) noted that reports from the West Africa Examination Council (WAEC) show that most students dislike mathematics because of geometry, and as a result, majority of them fail mathematics. Researchers have revealed that students' poor performance in geometry could be linked to various factors relating to a poor foundation of basic knowledge, lack of willingness and readiness to learn geometry and an imbalance teacher–learner ratio (Tsao, 2018). To add to this list, Dinayusadewi and Agustika (2020) identified teachers' pedagogy, students' lack of interest in geometry, lack of basic geometric concepts and lack of use of technology as factors that contribute to students' underachievement in mathematics. From the forgoing contributors of the challenges with teaching and learning geometry, it could be hypothesized that teachers' instructional practices are perhaps one of the main factors that affect learners' performance in geometry. To improve learners' performance, it is imperative to adopt teaching methods that incorporate critical thinking and the development of innovative minds to salvage the situation.

Gurney (2007) argued that when students are taught the right content, have enough learning materials and high ratio of teachers' time on the teaching activities, it enhances effective and efficient learning. Mtitu (2014), on the other hand, mooted that for effective and efficient teaching, learner-centered methods that require teachers to actively involve students in the teaching and learning process must be applied. Usman et al. (2020) posit that activity-based instruction (ABI) is one of the learner-centered approaches. In the words of Barai (2018), effective teachers use ABI to challenge learners to do activities to enhance their autonomy. However, according to Maputh et al. (2022) ABI has been widely used in science but not in mathematics. Therefore, we examined the impact of activity- Based instruction on Basic 11 learners' achievement in plane geometry. The study was guided by the following hypotheses formulated for testing at 5% level of significance:

1. There is no statistically significant difference in the achievement scores of Grade 11 learners taught geometry using activity-based method (experimental group) and those taught using the conventional method (control group);
2. There is no statistically significant difference in the achievement scores of male and female Grade 11 learners taught geometry using the activity-based method.

Literature Review

Geometry is derived from two Greek words: *geo* which means "earth" and *metria* which means "measurement" (Bhattacharya, 2019). Geometry education is essential in our everyday lives because it provides a more comprehensive understanding of our physical environment (Volderman, 1998 as cited in Kambilombilo & Sakala, 2015). Today geometry holds an important position in the mathematics curriculum. Geometric knowledge helps people to visualize and solve problems in many mathematical topics. Geometry has many practical applications in real life such as art, measurement and architecture (see Figure 1).

Figure 1 Sample of geometric designs in various fields

In the words of Lehner (2018), geometry is an integral part of the design from start to finish, and Architects use geometry to study and divide space as well as draft detailed building plans. According to Habibi (2012), human lives is surrounded by different geometric shapes and geometric situations therefore, children need to have some skills to live in this geometric world. This is to say, the immediate neighborhood of every individual invokes geometric ideas and geometric knowledge is crucial for every individual.

Activity-Based and Conventional Methods of Instruction

The activity-based method is a student-centred instructional approach used by teachers to highlight their teaching styles through an activity. The emphasis of this approach is on hands-on learning. Noreen and Khan Rana (2019) recount that experiential learning is very essential in knowledge acquisition because research has shown that the more one's senses are engaged in an activity, the more one learns and remembers. According to Prince (2004, p.223), "active learning is generally defined as any instructional method that engages students in the learning process". Azuka (2013) claims that activity-based learning allows students to participate actively in the entire educational process rather than just having them "passively" absorb knowledge from lecturers. The activity-based style of instruction is founded on the notion that learning should entail hands-on activities that assist students to relate abstract and hypothetical ideas to real-life situations (Noreen & Khan Rana, 2019). In the reasoning of Ravi and Xavier (2007), activity-based learning is "a situation in which students physically and mentally explore subject matter through simulation of the work environment, manipulation of tools and materials associated with the world of work, or performance of a real work task"(p.7). Çelik (2018) opines that the theory underpinning activity-based learning is based on the principle that children learn better by doing rather than merely observing. He believes that allowing students to explore their learning environment makes learning more motivating, lasting, and capable of improving their academic performance. Boud and Feletti (2013) remarked that activity-based instruction encourages students to "learn how to learn" by subjecting them to a variety of activities. With activity- based instruction, students are engaged in analysing mathematical problems, solving problems, and are also involved in reading, discussion and practical activities (Festus, 2013). On the other hand, conventional teaching method (Traditional techniques of teaching) is an instructor focused technique. Haghighi et al. (2005) cited in Noreen and Rana (2019), mooted that conventional teaching technique comprises primarily of addresses conveyed by the teacher and learners are mentally dynamic, however, physically sit without moving. Contributing to the debate, Teo and Wong (2000) revealed that conventional instruction does not provide room for students to connect

newly learned materials to their previous knowledge.

Gender Differences in Geometry and Mathematics Achievement

Research has confirmed gender differences, even in primary education, suggesting that boys generally have better achievement in mathematics than girls. For example, Aunola et al. (2004) and Mullis et al. (2004) observed a typical gender disparity favouring males in mathematics classrooms. Uduosoro (2011) also observed that female students performed poorly on geometrical concepts when compared to their male counterparts. A study titled "Effect of gender-related differences in academic achievement and retention of senior secondary school students in Geometry" undertaken by Gumel and Galadima (2014) revealed that male students had higher scores on the retention test than their female counterparts. On the contrary, Robinson and Lubienski (2011) argued that over the past 40 years, girls have received somewhat higher grades in mathematics than boys. Their findings were consistent with that of Brown and Kanyongo (2010). A study by Hemmings et al. (2011) on "the influence of prior achievement and attitudes towards mathematics" revealed that female students seem to have a much better understanding of mathematics than their male counterparts. Gherasim et al. (2013) investigated the impact of gender across a variety of factors, including mathematics success among young adolescents and classroom conditions and reported that girls outperformed boys. In an attempt to ascertain "geometry concepts in mathematics perceived as difficult to learn", Fabiyi (2017) conducted a study using 500 senior secondary school students in Nigeria and reported a positive impact of gender on learners' geometric achievement in favour of females. Again, Arhin and Offoe (2015) found no gender differences among pre-service teachers. This shows that until recently, mathematics achievement favoured boys. Contributing to the debate Val et al. (2004) argued that twenty-first-century findings about gender difference in mathematics achievement have shown to be inconsistent.

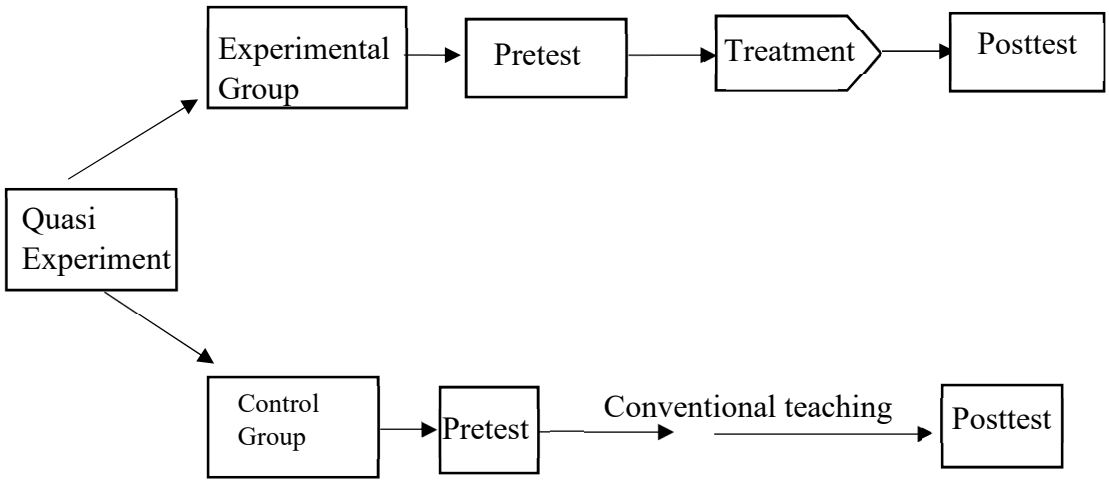

Figure 2 Pre -post-test control and experimental group design

Methodology

Experimental design is recommended when the aim of a study is to test the effect of an experimental treatment on the outcome by controlling all external factors that may have an effect on the outcome (Creswell, 2014). Drawing upon this idea, quasi–experimental design was chosen for the current study to

examine the impact of activity–based instructional strategy on students' geometric achievement. This is because in a typical school situation it is very difficult to reorganize classes to accommodate a research study. The quasi - experimental design used in this study is shown in Figure 1. The participants of the study were Basic 11 learners studying in a public senior high school. The groups were randomly assigned since there was no initial difference in their mean scores in the pre-test. In this context, 83 learners, 43 in the experimental group and 40 in the control group were assigned to the study groups.

Before the actual study, the test instrument was administered to a group of Grade 11 learners from different schools not involved in the main study to check for the reliability of the test questions. A test–retest approach of one week apart under the same condition produced a reliability coefficient of 0.84 and 0.76 for the pre-and post-test respectively.

A pre-test was carried out at the beginning of the study to establish learners understanding of geometric concepts. For the intervention, a geometric activity lesson was prepared by taking into account the principles of the activity-based instruction method. The lessons were designed in a sequence of increasing difficulties and hence learners were expected to enhance their geometric understanding (See Table 1). In the control group teaching was carried out with the aid of the "lecture method" or "conventional" technique. The applications were carried out in parallel with the Grade 11 learners in a three–week period, two hours per week for each group, 6 hours in total.

Table 1 The intervention lessons conducted in this study

Lesson	Focus	Materials Used	Duration (hours)
1	Introduction of plane geometry concept, with the aid of manipulatives to calculate the perimeter of plane shapes exercise sheet	Manipulatives, Activity sheet	2
2	Calculate the area of a circle through hands-on activity	Manipulatives, Activity sheet	2
3	Reinforcement questions on area and perimeter	Manipulatives, Activity sheet	2

The test instruments consist of pre-test and post-test of geometric achievement (GAT). Both tests contained 12 items. Items 1 to 10 were multiple-choice items of which each stem is followed by four options lettered A to D from which to choose only one correct answer. Items 11 and 12 were two (2) subjective items on area and perimeter in plane geometry. Correct attempts at questions 1 – 10 each carried one mark each, while the rest carried 5 marks each. The questions for the test were adapted from past year papers of West African Secondary School Certificate Examination Core mathematics.

Table 2 Independent t-test results for pre-test GAT scores of the two groups

Group	N	Mean	Std. Deviation	t- value	df	Sig/p- value
Control	40	6.23	3.190			
				.398	81	0.692
Experimental	43	5.93	3.535			

The first lesson introduced the concept of perimeter involving square, rectangle, triangle and parallelogram. Learners used manipulatives to support the learning concepts (Figure 2). The post-test was administered to learners after conducting all the intervention lessons to measure the impact of the intervention lessons. Independent t–test comparing the means of pre-test and post–test was done using Statistical Package for Social Science (Version 26) to determine if there is a significant difference: hence determining whether the intervention lesson has any impact towards learners' achievement in the strand.

The results in Table 2 indicated that there was no statistically significant difference in the pre-test scores of the control group (Mean = 6.23, SD = 3.19) and the experimental group (Mean = 5.93, SD = 3.54); [t (81) = 0.398, p = 0.692]. An indication that both groups were on the same level before the intervention (activity-based teaching).

Table 3 shows the post-test scores for both the control and experimental group. An independent t-test was also conducted to test the first null hypothesis that 'there is no statistically significant difference in the achievement scores of the Grade 11 learners taught geometry using conventional method

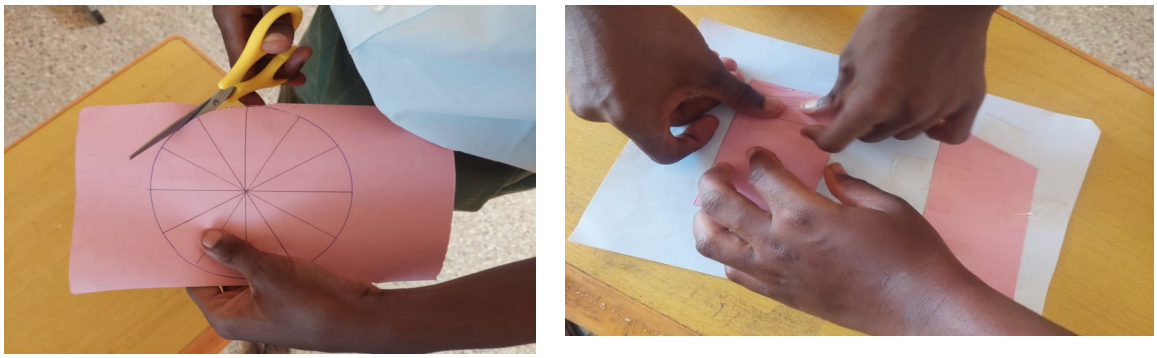

Figure 2 Cards used during hands-on activity involving area of a circle

Results

To test the first null hypothesis that 'there is no statistically significant difference in the achievement scores of Grade 11 learners taught geometry using conventional method (control group) and those taught geometry using activity-based method (experimental group)' before the treatment, an independent t-test was conducted (see results in Table 2).

(control group) and those taught geometry using activity-based method (experimental group)' after the treatment or intervention.

From Table 3, the results, Control Group (Mean = 6.95, SD = 2.754) and Experimental Group (Mean = 9.49, SD = 4.437); [t (70.906) = -3.155, p = 0.002] indicate that the mean

Table 3 Independent t-test results for post-test GAT scores of the two groups

Group	N	Mean	Std. Deviation	t- value	df	Sig/p- value
Control	40	6.95	2.754			
				-3.155	81	0.002
Experimental	43	9.49	4.437			

scores of the experimental group increased significantly, and this was observed to be statistically significant (p-value = 0.002, which is less than the alpha-value 0.05). Based on this, the null hypothesis was rejected in favour of the alternate hypothesis, and it was concluded that there was a significant difference in geometric achievement test (GAT) scores between students taught geometry using the conventional method and those taught using the activity-based method.

Finally, a third null hypothesis that 'there is no statistically significant difference in the achievement scores of male and female students taught geometry using the activity-based method' was tested to see if there was gender influence on the experimental group learners' performance after the intervention (see results in Table 4).

Discussion

The analysis revealed that even though both the control and experimental groups improved in their geometric understanding in the post-test when compared to the pre-test, there was a significant difference between the two groups in favour of the experimental group. This finding is consistent with Azuka (2013) who in her study on "activity-based learning strategies in mathematics classrooms" found that students understood mathematical concepts and recorded higher retention when they were taught with the activity-based method.

In terms of gender and academic achievement in geometry, the study found no significant difference in the scores of male and female students of the experimental group. However, the mean values showed that male students had a slightly higher post-test mean score than their female counterparts. Even though males had a slightly higher mean score compared to that of the females it was not significant. The implication here is that activity – based instruction is gender friendly. This finding is in line with Enu et al. (2013) who found that there is no significant difference among male

Table 4 Comparison of the performance of post-test GAT scores of male and female learners in the experimental group

Gender	N	Mean	Std. Deviation	t- value	df	Sig / p - value
Male	26	10.23	4.302			
				1.371	41	0.178
Female	17	8.35	4.527			

The results in Table 4, Male (M = 10.23, SD = 4.302); Female (Mean = 8.35, SD = 4.527); and [t(41) = 1.371, p = 0.178]), show there was no statistically significant difference in the achievement scores of male and female learners taught geometry using the activity-based method.

and female learners in mathematics gender achievement test.

Conclusion

Based on the findings of the study, two main conclusions were reached: (a) Teaching geometry using the activity-based method enhances learners' academic performance and also has the potential of helping students overcome their fear of geometry; (b) Gender did not influence learners' geometric achievement.

Recommendations

Based on the study's findings, the following recommendations are made:

- Teachers should employ the activity-based method for teaching geometry and other topics in mathematics to help enhance students' academic performance since it has proven to be very effective.
- In-service training and workshops, in the form of continuous professional development, should be organized for teachers to help them become acquainted with modern and practical instructional methods such as the activity-based method for teaching mathematics, especially geometry.

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