Journal of Elementary Education
Vol.26, No. 1 pp. 139-146

Teaching of Geometric Construction in Junior High School: An Intervention

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Abstract

Geometric construction has been one of the topics in Mathematics that account for poor performance in both internal and external examinations among pupils in Junior High School. This interventional study sought to find the difference in the performance of pupils who were taught geometric construction in abstract and those who were taught practically. A total of 60 pupils were used in the study. A well-structured lesson with Teaching and Learning Materials was used. The pretest and posttest assessments were deployed to ascertain the effect of the interventional teaching methods. Before the intervention, 87% of the pupils scored below the average mark of 50 and only 13% scored above the average mark of 50. The posttest results of the abstract method group were similar to the results of the pretest. However, after the intervention 87% of the pupils scored above the average mark of 50and only 13% scored below the average mark in the practical group. The pupils taught with the practical method performed far better (t = -41.44) in the posttest compared to those taught with abstract method. In conclusion, the use of appropriate methodology, and Teaching and Learning Materials will together make pupils appreciate geometric construction.

Key words: Geometry, construction, mathematics, school.

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Introduction

Teaching geometric construction has always been a challenge in many high schools in Ghana due to unavailability of the appropriate Teaching and Learning Materials (TLMs). Two basic tools required for geometric construction are the pair of compasses and a ruler (straightedge). These tools still remain pivotal in geometric construction in Ghana though pupils in well-developed countries have different experiences with the advent of computers. The technique of measuring is very essential and crucial in geometric construction. Constructions are taught as a fundamental part of a geometry curriculum, but constructions have other values. Some geometric concepts can seem a little abstract to some pupils. However, when geometric construction is taught well, and linked to physical constructions, the idea becomes more concrete in the pupils' mind.

These constructions use only compass, straightedge (ruler) and a pencil. Duval (1998) outlined a cognitive approach to geometry. The three cognitive processes are: visualisation processes, for example the visual representation of a geometrical statement; construction processes (using tools); reasoning processes - particularly discursive processes for the extension of knowledge. The abysmal performance in mathematics among Junior High School pupils is evident in the Basic Education Certificate Examination conducted annually by the West African Examination Council. Baffoe & Mmereku (2010) identified that the performance of JHS pupils in Ghana, in geometry, is lower than the performance of their counterparts in other countries. It has been established that good interventional design is the most effective means of promoting successful learning. Instructional methods should provide cognitive processes or strategies that are necessary for learning. Concrete Representational Abstract (CRA) intervention had been shown to be effective instructional intervention for teaching mathematical concepts and procedures, while also facilitating students' problem-solving in mathematics. The lack of methodological guidelines or instructional design support for teachers impede the effective design and use of CRA interventions in the traditional classroom to promote successful learning of mathematics (Witzel*et al.*, 2008). Due to these challenges, other interventional design (the regular method of teaching) was introduced. The regular method of teaching is referred to as classroom teaching that focuses on abstract concepts and some few illustrations and drawings on the chalkboard or marker board. The regular method of teaching follows a regular structure: activating prior knowledge, presenting relevant information, exercises made by students and continuous feedback by the teacher.

Reasoning skills are an important component of education, and reasoning skills are necessary for understanding mathematics in particular, and they present an important means of developing ideas. Mathematical reasoning refers to the ability to formulate and represent a given mathematics problem, and to explain and justify the solution or argument. Mathematics education can be enhanced if abstract teaching is discouraged. When pupils are involved in various activities in the class as part of the mathematics lesson, the effect of the lesson is greater than that found in rote learning.

The results will add to preliminary data on geometric construction by handling the compass and ruler correctly. This study therefore sought to find out whether pupils will appreciate geometric construction when the appropriate materials and methods are used to teach them.

Materials and Methods

The case-control interventional study was conducted for a period of 6 days. The first day was used for a pre-intervention test (pretest) and the last day was used for a post-intervention test (posttest). All the second year pupils (total of 60) of Brekumanso L/A Junior High School (JHS), West Akyem Municipal Assembly, Eastern Region, Ghana, were recruited for the study. They consisted of 34 (56.7%) boys and 26 (43.3%) girls; with mean age of 14.0 ± 2.3 years.

Pretest

A teacher-made pretest was conducted to measure the pupils' knowledge on the useof ruler and the compass only for geometric constructions. The questions required pupils to construct perpendicular bisectors, angle bisectors, construct angles (90^o, 60^o, 45^o, 30^o). The pupils were also requested to construct equilateral triangle, isosceles triangle, scalene triangle, a triangle given two angles and one side, a triangle given one side and two angles, and a triangle given two sides and the included angle, using a ruler and the pair of compasses only. Each pupil was given a printed question paper and an answer sheet. The pupils used sixty (60) minutes to write the test. All the pupils took the pretest.

Intervention

Two methods were used during the intervention in delivering the lessons; an abstract method (AM) and a practical method (PM). The pupils were randomly assigned to either the AM group or the PM group; each group comprised 30 pupils. The pupils in the AM group were elaborately taught, though without the TLMs (a straightedge and a pair of compasses for the chalkboard). The TLMs were used during the lesson delivery in the PM group. The JHS 2 mathematics teacher was made to deliver the lessons to both groups at different schedules. The teacher was provided with ruler and the pair of compasses, meant for the blackboard. The research intervention was done in 4 days; each lesson lasting one hour. A ruler, the pair of compasses and a pencil were the only tools required by the pupils.

Posttest

The researcher conducted a posttest after the intervention to ascertain how effective the methods had been. The researcher used the same questions used in the pretest for the posttest. The instructions and conditions of the pretest were used for the posttest. All the pupils took the posttest.

Statistical Analysis

Data was analysed with Statistical Package for Social Sciences (SPSS Inc., software version 20.0). Means and standard deviations for age, pretest and posttest marks were calculated and compared by one-way ANOVA. Frequency counts and percentages for pretest and posttest marks were done. P value < 0.05 and t test were considered for statistical difference between the marks obtained in intervention groups.

Results

Table 1 presents pretest scores distribution on geometric construction. None of the pupils scored above 69 marks. Table 1 indicates that whilst 52 (86.7%) of the pupils scored below the 50 marks, only 8 (13.3%) scored above the 50 marks.

Table 1
Pretest score distribution on geometric construction

Mark	Frequency	Percentage (%)
90-100	0	0.0
80-89	0	0.0
70-79	0	0.0
60-69	2	3.3
50-59	6	10.0
40-49	16	26.7
30-39	14	23.3
20-29	12	20.0
10-19	8	13.3
0-9	2	3.3
Total	60	100

Table 2
Posttest scores distribution on geometric construction for AM group

Mark	Frequency	Percentage (%)
90-100	0	0.0
80-89	0	0.0
70-79	0	0.0
60-69	1	3.3
50-59	3	10.0
40-49	9	30.0
30-39	7	23.3
20-29	7	23.3
10-19	3	10.0
0-9	0	0.0
Total	30	100

Table 2 presents posttest score distribution on geometric construction for AM group. None of the pupils scored beyond 69 marks and below 10 marks.

Table 3

Posttest scores distribution on geometric construction for PM group

Mark	Frequency	Percentage (%)
90-100	3	10.0
80-89	5	16.7
70-79	6	20.0
60-69	5	16.7
50-59	7	23.3
40-49	3	10.0
30-39	1	3.3
20-29	0	0
10-19	0	0
0-9	0	0
Total	30	100

Table 3 indicated that whilst 26 (87%) of the pupils scored above the 50 marks, only 4 (13%) scored below the 50 marks. The *t*-test revealed statistically significant difference (t= -41.44, p=0.00) between the performance of pupils in the posttest between AM group and PM group (Table 4).

Table 4

Comparison of the posttest marks between intervention groups

Test	Mean ± SD	*t*-value	*p*-value
AM group	36.4 ± 14.8	-41.44	0.00
PM group	70.1 ± 15.5		

SD: standard deviation

Discussion

The pretest showed the pupils had little knowledge and understanding of geometric construction (Figure 1). Table 1 indicates that 87% of the pupils scored below the 50 marks, only 13% scored above the 50 marks. The pretest revealed pupils could easily construct lines but the use of the compass was difficult for them. They preferred to use the protractor for the construction of angles.

After the intervention, the pupils in the PM group appreciated the use of a ruler and the compass for geometric construction. Table 3 indicated that whilst 87% of the pupils scored above the 50 marks, only 13% scored below the 50 marks. This was a significant improvement from the pretest conducted earlier before the intervention. The *t*-test revealed statistically significant difference (t= -41.44, p=0.00) between the performance of pupils in the posttest between AM group and PM group

(Table 4). A good number of pupils demonstrated good skills in the use of ruler and a pair of compasses for geometric construction. Pupils in the PM group truly made sense of the geometric construction lesson taught from day 2 to day5; they were not just manipulating lines. Instead, they were purposefully and meaningfully reasoning about the appropriate steps in constructing angles and triangles. They were not blindly using the protractors, as they did in the pretest. The pupilsthus, developed powerful conceptual structures and patterns of reasoning that enabled them to apply their mathematical (geometrical) knowledge and understanding, in their mathematical reasoning (Battista, 1999). Pupils in the AM group could not make personal sense of the ideas of the use of a ruler and the pair of compasses. This was evident in their performance in the posttest (Table 2).The inability of pupils in the AM group to construct figures can be attributed to lack of appropriate TLMs and poor teaching methods. The inadequate number of appropriate TLMs has contributed immensely to pupils' inability to understand the procedure for constructing simple geometric figures. The significance of adequate TLMs in teaching a topic like geometry which is the bedrock of engineering and technological development, cannot be over emphasised. The use of physical facilities such as models will help grasp the idea of geometry which seems to be abstract (Sarfo*et al*., 2014). It is the facilities in terms of infrastructure, equipment and materials that afford the students the opportunity to acquire the necessary knowledge (Sarfo*et al*., 2014). In the present study, the researchers used both TLM and well-structured lesson for the intervention. The posttest showed a significant improvement after the intervention in the PM group. The pupils in the PM group improved after they had experienced the four lessons structured to improve their understanding of geometric construction. The posttest performance of the AM group suggests that no matter how structured a geometric lesson is, TLMs are still needed. Adolphus (2011) suggested among other factors that inadequate provision of teaching and learning materials and facilities do not motivate teaching and learning of geometric construction.

Pupils might have been performing abysmally in mathematics, especially geometric construction, because they do not appreciate how they are being taught. It is imperative on the teacher to deploy appropriate teaching methods suitable for his/her pupils in the delivery of mathematics topics. Pupils should also be given enough time to practice what they have learnt. Mathematics education cannot be improved if topics like geometric construction are taught in abstract.

Conclusion

The posttest conducted, after the intervention, underscored pupils in the PM group performed better when the basic skills involved in teaching of the concept was delivered properly using TLMs. It can therefore be concluded that the appropriate use of TLMs helps to improve pupils' performance.

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