

TRANSFORMING THE TEACHING OF GEOMETRICAL CONSTRUCTIONS IN NIGERIAN SECONDARY SCHOOLS USING GEOGEBRA CONSTRUCTION TOOLS

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Abstract

Geometrical Constructions is an important concept that underlines the understanding of school Geometry but it is dreaded by many teachers and their students. GeoGebra is a software that offers construction tools that can transform the fear of Geometrical construction into joyful and meaningful learning. Ten Senior Secondary mathematics teachers (Six male and four female) in Zaria Metropolis who voluntarily offered themselves for this study were introduced to Geometrical Constructions using GeoGebra in six lessons. All the teachers in the study possess first degree in mathematics or mathematics Education. They were taught the constructions of triangles, quadrilaterals circumcircles, in circles and many more with the software. Then after the sixth week the teachers were asked to construct the geometrical figures discussed during the workshop with GeoGebra software. The teachers showed proficiency in the construction where most of them carried out the construction correctly without referring to the manual. The teachers were also interviewed about the use of GeoGebra Constructions compare to the use of ruler and compass construction. Eight out of the ten teachers expressed more satisfaction working with GeoGebra than with ruler and pair compasses. They are also willing to teach it in their school. However, two – teachers, one male and one female are of the opinion that we are not ripe for the use GeoGebra in our schools though it is easier, and more interesting. The study recommends that teachers both service and preservice should be introduced to GeoGebra and other Mathematics Soft wares through workshops and seminars to make Nigeria keep pace with modern teaching and learning of Mathematics using technology. Furthermore, National University Commission and National Commission for Colleges of Education should introduce courses on Mathematics Teaching Soft wares like GeoGebra in NCE and B.Ed. Curriculum

Keywords: GeoGebra, Geometry and Construction, proficiency and feasibility



Introduction:

Geometrical Construction is an important topic in Nigeria Mathematics Curriculum from Primary School to Senior Secondary. It is also the backbone of real understanding of school geometry. The construction is usually done using ruler and a pair of compasses Geometrical constructions only. have application in many professions such as architecture, building, survey, mechanical engineering robotics and automation to mention a few. Another importance of Geometrical Constructions according to Courtney and Amstrong (2021) is that it enriches students' visualization and comprehension of geometry and also lay a solid foundation for analysis and proof.

Moreso, on the importance of construction, Williams (2021) showed that constructions geometry protect from fundamental problems such as inconsistencies, hidden assumptions diagram and fallacies. Similarly, Kondratieva (2013) pointed that constructions are used to bridge the gap between theoretical and practical geometry. In addition to this, some results such as getting the exact midpoint of a line segment can only be achieved through constructions or the use of graph. Historically, Geometry Constructions played a central role in the development of geometry, in a null shell, there cannot be effective and efficient study geometry without geometrical of constructions. One more important point to note, is that at least a question on geometrical constructions is asked every year in general Mathematics paper 2 in both WAECSSCE and NECOSSCE; but the researchers, who are examiners for years have realized that, students hardly attempt question on geometrical constructions in the above-mentioned examinations. However, with the availability of Dynamic Geometry

Soft wares such Geometer Sketch Pad and GeoGebra the situation may be improved.

GeoGebra is free dynamic mathematics software that was invented in 2001. It is software that has won so many awards. It is being used in so many countries all over the world. It has been translated into so many languages and many more translations are in the pipe line. GeoGebra is easy-to-use software and does not require advanced knowledge of computer. Any students that can operate an android phone can also use GeoGebra software. More interestingly, there are a lot of free materials and You Tube tutorials on GeoGebra that any learner can use to learn about the software. The software presents mathematics in multiple ways. It offers algebra, geometry, calculus and spread sheet all fully integrated. It is suitable for use from Primary School to University level. GeoGebra is a software that encourages students' centered learning where the role of a teacher changes from the custodian of knowledge to a facilitator. According Regional to Institute of Education, Mysuru (2016) GeoGebra has the following advantages; it encourages Mathematics communication and meaningful learning; it provides visualization of geometrical concepts, it enables students to explore mathematical ideas; it encourages creativity and make generalization easier for students.

GeoGebra also has geometrical constructions tools. It can be used to carryout geometrical constructions beyond what can be constructed with a ruler and a pair compass. Kodratieva (2013) pointed that with the help of GeoGebra students can easily construct neat and accurate geometrical figures. Furthermore, it allows



many examples at a time making the students to think creatively and explicitly.

Similarly, Courtney and Amstrong (2021) established that carrying out geometrical constructions with GeoGebra tools, help significant students to understand geometric connections that make them become good problem solvers. Ghosh (2023) explained that, the use of GeoGebra enables students to carry out geometrical constructions with high degree of accuracy and also explore constructions in multiple ways using the drag tool. For example, you can discuss the properties of different types of triangles using one figure by dragging the one of the angles of the triangle which enables you change the triangle from equilateral to isosceles to scalene to right angled triangle. Not only these, Maryono el at (2023) highlighted some of the advantages of using GeoGebra tools as, it increases students' confidence in carrying out geometrical constructions, it enables the learners explore geometrical properties of different shapes and it is in agreement with constructivist learning theory among others.

Bozkuta (2018)However, conducted research in order to examine the justification and accuracy on the use Dynamic Geometric software (DGS) in carrying out geometrical constructions, he found out that, very few of the pre service teachers used in the study noticed the difference and similarities between the traditional geometrical constructions and constructions using the DGS tool.

In this study, the researchers of this work discussed the constructions of some simple geometrical figures with the subjects of this research using GeoGebra construction tools. After that the teachers were made to carry out the constructions themselves with the aim of finding out their proficiency in the use of GeoGebra tool and the feasibility of

migrating from traditional geometrical construction to the use of GeoGebra tool.

Statement of the Problem

Geometrical construction is a vital part of geometry. It is used in so many professions such as architecture, building, survey, engineering and many more. Due to the importance of the geometric constructions, the West Africa Examination Council (WAEC) and National Examination Council (NECO) ask questions on it annually in Senior Secondary School Examination. Unfortunately, from the researchers' experience as examiners for many years, students rarely attempt questions on geometrical construction. It is common to find that no student answer question on geometrical construction in a whole examination center. The few students that sometimes attempt question on geometrical construction perform poorly. Not only this, NCE students are not scoring good marks in Mathematics MAT124-Laboratory practical, which is also a course that has a lot of geometrical constructions. The researchers' interaction with the students showed that the students are no taught geometrical constructions in secondary school. Against this background, the researchers want to find out from teachers, if the use of GeoGebra tools can improve the situation

Objectives of the Study

The research was carried out with the aim of:

i. Finding the proficiency in the use of GeoGebra construction tools by mathematics teachers in Zaria Metropolis



ii. examining the feasibility of transforming geometrical constructions from traditional ruler and compasses to the use of GeoGebra construction tools

Research Questions: The study was guided by the following research questions:

- i. To what extent are Mathematics teachers in Zaria Metropolis proficient in using GeoGebra constructions tools
- ii. What is the feasibility of transforming traditional geometrical construction using ruler and pair of compasses to the use of GeoGebra construction tools?

Methodology

The study is an attempt to discuss the feasibility of transforming geometrical constructions from traditional way to a modern way using GeoGebra constructions tools. The research is a case study in nature, a case study of a large secondary in Zaria, a school with many teachers who are first degree and higher degree holders. A case study is a detailed study of a specific subject

or group, place, event, organization or phenomenon.

All the mathematics teachers in the school hold at least first degree in Mathematics, Mathematics Education or a related field, the participants of the study volunteered to serve as the subject of the study. Ten teachers in which six are male and four are female were the subject of the study. The principal researcher conducted six lessons with the teachers for thirty minutes each. The lessons include the constructions of rectangle circumcircle, incircle, equilateral triangle and hexagon. The teachers were asked to repeat the constructions using GeoGebra with the aim to test their proficiency in conducting geometrical constructions using GeoGebra software. The researchers used some material such as 'Introduction to GeoGebra 'as guide in conducting the workshop. The teachers were given both hardcopies and the softcopies of the workshop materials. After, the workshop the teachers were interviewed and were also asked to fill an open-ended questionnaire the responses given by the teachers served as the data for this research



Samples of the constructions done

1. Incircle



2. Hexagon





3. Circumcircle



Results

The findings of the study are divided into two categories: first the teachers' proficiency in GeoGebra constructions and secondly their views on the feasibility of migrating from compass and ruler constructions to GeoGebra constructions:

Teachers Proficiency in GeoGebra Constructions:

All the teachers who partook in this study have heard about GeoGebra before specifically seven out of ten teachers have seen GeoGebra either with their colleagues or friends in the school. However, none of the teachers in this study has used the software to teach his or her students. The

teachers did not encounter any problem during the workshop as the procedures of carrying out Geometrical Constructions using GeoGebra similar are to the procedures of carrying out Geometrical constructions using compass and ruler. More so, all the constructions conducted in this study are simple and straight forward. It is only the constructions of hexagon that has many steps. After the sixth lesson, the researcher asked the teachers to construct all the figures discussed without looking at the manual. The result of those that got the constructions correctly at the first attempt is represented by the figure below:



Fig. 1: The result of those that got the constructions correctly at the first attempt



The bar chart shows the number of teachers that got the constructions of each figure correctly at the first attempt without referring to the manual for the steps of the constructions. Most of the teachers that could not get it in the first attempt, made it in the second attempt. It was only one teacher that did the construction of hexagon thrice before he got it correctly. All the teachers showed happiness and satisfactions with GeoGebra construction tools. More so, the teachers express their readiness to continue to practice GeoGebra constructions until they become more proficient in it.

Feasibility of transforming ruler and Compass constructions to GeoGebra

Most of the teachers in this study are happy with the constructions they have carried out with GeoGebra construction tools, they are willing to migrate from ruler to compass to GeoGebra but their fear is that their students will not use it in their final examination either WASSCE or NECOSSCE. MT06 expressed his views as follows:

GeoGebra constructions are faster and easier. The steps are easier to remember than the traditional ruler and compasses, yet I will not take much of my math period to teach it to students because they will not use it in their final examinations.

Furthermore, some of the teachers expressed their satisfactions with the flexibility of GeoGebra constructions and its neatness. In such a way that one can easily erase wrong constructions by simply clicking the undo icon without leaving any mark on the figure, traditional unlike the constructions. Furthermore, GeoGebra constructions tools have provision for both the learners and teachers to check the steps followed in carrying out the constructions. The students can cross check his or her work by simply clicking the appropriate buttons so also the teacher can assess the students using same method. This was the view of many teachers one of them, MT03 opined

In my opinion GeoGebra construction is neater and more flexible than the traditional ruler and compasses construction. A student can change the constructions several times by just clicking a button without leaving any mark or making the paper dirty unlike the traditional constructions

More so, the teachers in this study are of the opinion that GeoGebra constructions can increase students' interest in geometrical constructions since the students are very talented in the use of digital tools. So also, the students can use their android phones to download and use GeoGebra software for constructions and solve other mathematical problems, however, two teachers- one male and one female hold a contrary view. According to them that we are not ripe for the use of GeoGebra because many schools and parents can neither afford computers nor android phones for their students. MT02 and M04, they explained as follows:

No doubt, the use of GeoGebra construction tools would increase students' interest and confidence in geometrical constructions and mathematics because they are digital natives. Our fear is that many schools and many parents may not afford to buy digital devices for their schools or for their wards.

All the teachers agree that the use of GeoGebra constructions is timely because of the digitalization of many officials' matters including examinations.

We are of the opinion that geometrical constructions using GeoGebra will perfectly fit into Computer Based Test Examinations since many schools are migrating from paper pencil examination to CBT examinations including WAEC.



Discussion

GeoGebra is free mathematics software that combines the features of many mathematics soft wares and it is suitable for the teaching of mathematics from primary school to tertiary institutions. In this study the researchers tried to find the proficiency of mathematics teachers in the use of GeoGebra construction tools and also to find out the feasibility of transforming the traditional ruler and compass constructions to the use of GeoGebra tools.

Regarding the first research question, the subject of the study showed high proficiency in using GeoGebra construction tools. None of the teachers showed any sign of anxiety in the use of GeoGebra software. One hundred percent of the teachers were able to construct equilateral triangle at the first attempt without referring to the construction guide. More so, ninety percent were able to construct rectangle at the first attempt. All the teachers who could not get the correctly of the other constructions geometrical figures in the first attempt got it in the second attempt. The least of all, is the construction of hexagon which involve many steps. At the first attempt, six out of 10 teachers got it correctly, then three out of ten teachers got it right at the second attempt and one teacher did it thrice before he could construct it correctly. Generally, the researchers are satisfied with the proficiency of the teachers in using GeoGebra software for constructions. The researchers are of the opinion that the students can work with GeoGebra better and faster than their teachers since the latter are digital natives.

Secondly, on the opinion of the teachers concerning the feasibility of the changing from the traditional method of constructions to GeoGebra constructions, the teachers agree that GeoGebra constructions are modern, neater, faster, more accurate than

the traditional method. The teachers also opined that GeoGebra constructions give room for exploration of Geometrical properties, it can also increase students' interest and confidence and it is also suitable for CBT examinations. This is in agreement with the previous findings of Kondratieva (2013) who found that the use of GeoGebra software allows the students to make neat and accurate geometrical constructions so also Ghosh (2023) who established that GeoGebra constructions enables one to perform geometrical constructions with high degree of precision. It is also in line with the findings Maryono (2023) who stated that GeoGebra constructions improve students' confidence and positive attitude towards constructions. It also enables them to explore properties of different geometrical shapes. However, the findings of this study differ from that of Bozkuta (2018) who reported that very few teachers noticed the difference and similarities between the traditional method of constructions and that of DGS. Notwithstanding, the teachers who participated in the study have the following reservations.

GeoGebra is not being used to examine the students in the school examinations and the curriculum is over loaded with topics to be taught, the teachers have no option rather to give emphasis and attention to the traditional method until GeoGebra is accepted as a means of examining the students.

Many teachers express the fear that government may not be able to build computer laboratories in public schools where teachers can effectively use to teach their students constructions using GeoGebra. So also, the proprietors of many private schools may not afford to establish computer laboratories in their schools. Similarly, looking at the present economic situation, many parents cannot afford to buy android phones or computers for their wards to use



in learning mathematics using GeoGebra. Another fear raised by the teachers is that the examples used in this study are simple and straight forward examples, until questions similar to the ones in WAECSSCE are solved using GeoGebra before they can finally express their stand on the feasibility of changing from ruler and compass to GeoGebra constructions.

Conclusion

GeoGebra is software that provides great opportunities of integrating technology into the teaching of mathematics but the use of GeoGebra has remained in research level in Nigeria. In this study, the researchers have been able to establish the proficiency of mathematics teachers in the use of GeoGebra construction tools. Mathematics teachers can use GeoGebra to construct geometrical figures without much difficulty. Moreso, teachers in this study have opined that GeoGebra constructions are faster, neater than the traditional ruler and compass constructions. However, this study has some limitations; the constructions used in this study are simple. Further research that will look at deeper and more demanding construction questions can support the integration of GeoGebra in the teaching of constructions in our secondary schools

Recommendations

The following recommendations were made based on the findings of the study:

- 1. National University Commission (NUC) and National Commission of Colleges of Education (NCCE) should introduce courses on teaching soft wares such as GeoGebra in teacher education programs.
- 2. National Education Research and Development (NERDC) should review the school curriculum so that teachers and communities can adopt

some new innovations such as teaching with GeoGebra Soft wares in their schools.

3. National Mathematics Center, Abuja should organize a series of workshops on teaching soft wares like GeoGebra in order to enhance the integration of technology into mathematics classroom in Nigeria.

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