GeoGebra: A Technological Soft Ware for Teaching and Learning of Calculus in Nigerian Schools

Charles-Ogan, Gladys Ibibo[*]

Department of Curriculum Studies and Educational Technology, Faculty of Education, University of Port Harcourt, Nigeria
*Corresponding author: gladyscharlesogan@yahoo.com

Abstract Technology has grown rapidly in today's world and so the teaching and learning of mathematics have become more and more necessary. A new technological software- GeoGebra is to make the teaching and learning of the subject more practical, easy and simple to understand. Calculus is the mathematics of change. Calculus is an important branch of mathematics which many students find difficult and complex to comprehend. GeoGebra as a dynamic software, easy-to-use which promotes learning and enhance understanding of calculus concepts. It is a free new technological tool, a new means of utilizing technology with visual aids to assist students to interact with mathematical concepts independently or in teams, in the classroom or at home. This study demonstrated practical ways of constructing calculus concepts. Showed the simulations of tracing and identifying the solutions of solving problems in Calculus. The study suggested that Mathematics Teachers should be encouraged to use GeoGebra and other technological tools to improve the quality of teaching Mathematics. Also, GeoGebra should be introduced to Mathematics educators in Nigeria to enable students to explore the world of mathematics in a wider spectrum and think more creatively.

Keywords: GeoGebra software, teaching & learning, understanding mathematics, calculus

Cite This Article: Charles-Ogan, and Gladys Ibibo, "GeoGebra: A Technological Soft Ware for Teaching and Learning of Calculus in Nigerian Schools." *American Journal of Applied Mathematics and Statistics*, vol. 6, no. 3 (2018): 115-120. doi: 10.12691/ajams-6-3-5.

1. Introduction

Promoting more meaningful and result-oriented learning at all levels of education using technological inventions, have become very crucial to the rapid development of the world. One of the major and powerful resources of learning mathematics is the utilization of technology. Teaching and learning of mathematical concepts using technological tools such as GeoGebra are demonstrating innovative and interactive ways of making mathematics interesting. GeoGebra is not yet widely used in teaching mathematics in Nigerian schools. So, to stimulate students' interest in mathematics in Nigeria, a variety of learning approaches must be involved especially the use of GeoGebra.

Teaching and learning with the use of appropriate technology have many advantages such as providing greater learning opportunities for students, enhancing students' engagement and encouraging discovery learning [1]. Many dynamic software tools aimed at improving mathematics education provide visually-rich contents that enable students to comprehend concepts easily. The National Council of Teachers of Mathematics [2] highlightsthe importance of the use of multiple representations inimproving students' mathematical thinking and reasoning. Dynamic mathematical software programmes enable students to make connections among the representations faster and meaningfully, which would be quite difficult to teach, if not impossible at all, without such dynamic tools. Hohenwarter and Hohenwarter [3] asserted that by integrating ICT into daily mathematical instructions teachers will be providing new ways to support students' learning and foster the acquisition of mathematical knowledge and skills.

Since it has become imperative that scientific and technological inventions cannot exist without a proper knowledge of mathematics, it is absolutely necessary that mathematics teachersare conversant with changes in the educational sector especially asthey relate to teaching and learning of the subject [4]. Mathematics teachers should, therefore, be adequately trained to use some new software in computers in the teaching and learning of mathematics.

The trend of using the new scientific software in the classroom now provides mathematics educators opportunity to introduce more and varied forms of multimedia presentations into their classroom activities. One of such software applications is GeoGebra.

GeoGebra is an interactivesoftware on geometry, algebra, statistics and calculus application, intended to improve the teaching and learning of mathematics. According to GeoGebra Community Newsletter [5,6], GeoGebra is a free and multi-platform dynamic mathematics software, for all levels of education, that joins geometry, algebra, tables of graphing, statistics and calculus in one easy-to-use package and is currently available in over 44 languages.It is innovative open-source mathematics software that can be freely downloaded from

www.geogebra.com. GeoGebra works on a wide area of operating system platforms which is installed with Java Virtual Machine.It was createdby Markus Hohenwater and a team of programmers to aid the teaching and learning of mathematics from middle school through college to university level [7].

GeoGebra's basic interface is divided into four components. These are input bar, algebraic view, graphic view and spreadsheet viewData. Objectsare entered into GeoGebra environment through the input bar and spreadsheet view using the keyboard while graphic and algebraic views display the graphical representation of the data and their algebraic equivalence respectively. According to Hohenwater and Jones [8], the multiple representations of objects in GeoGebra environment captures students' interest in learning and encourages experimental and guided discovery learning.

2. Calculus with GeoGebra

Calculus is the arm of mathematics which deals with quantities approaching other quantities. It is more or less regarded as a dynamic subject. Therefore, the application of GeoGebra for teaching basic concepts of calculus is fully dynamic, which means that points can be moved along function graphs, parameters are changeable using sliders, and texts adapt automatically to cages [9]. In addition, all possible applications can be easily moved to dynamic web pages, alsocalled dynamic worksheets, which contain an interactive applet with tasks for the students. After uploading these dynamic worksheets to the internet, students are able to access them in school as well as at home without having to download or directly operate the GeoGebra software on their computers. GeoGebra constructions can be intergrated into mathematics classes by providing different forms of dynamic and interactive figures. GeoGebra is an amazing tool for demonstrating Geometry, Algebra, and Calculus concepts but the hardest part is imagining how to apply this software effectively in teaching Calculus concepts.

2.1. Statement of the Problem

Calculus is one of the concepts in mathematics that both teachers and students find difficult to teach and learn. Generally, students face challenges in studing calculus and many struggles to grasp the basic concepts.

The process of learning calculusisa very complex cognitive task that can be difficult for students to understand and so it is very important that mathematics educators learn and know new technics in order to enhance its teaching,capture the interest of students in the classroom and subsequently, improve the performance of students. Several technological tools are available but few are worthy of mention here. These include an interactive whiteboard, calculators, Geometers sketchpad and GeoGebra. With the implementation of the new mathematics curriculum, it is very important to use interactive methods in teaching mathematics by integrating technological tools like dynamic software GeoGebra. GeoGebra software provides a visual and effective learning environment for students to improve their technological knowhow, hence the need for such a software in the teaching of calculus concepts for the better understanding of the subject by students.

2.2. Aim and Objectives of the Study

The aim of this study is to demonstrate different ways of applying GeoGebra software in the teaching of some basic concepts in Calculus. Specifically, the study intends to:

1. Show the different Geogebra's user interface.
2. Demonstrate practical ways of constructing Calculus concepts.
3. Identify steps involved in solving Calculus.
4. Show the Simulations of tracing and identifying the solutions of some problems in Calculus.

3. Methodology
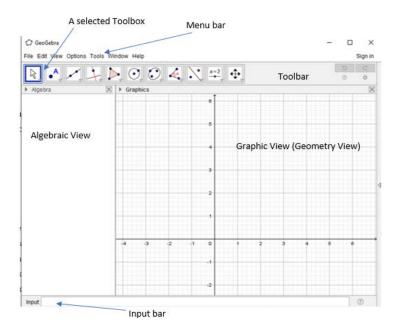
3.1. Parts of the GeoGebra's User Interface

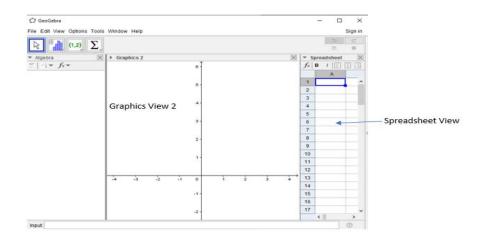**Figure 1.** The GeoGebra's User Interface (1)

Figure 2. The GeoGebra's User Interface (2)

The Menu bar: File; Edit; View; Options; Tools; Window; Help.

The Toolbar: GeoGebra's Tools are prearranged in Toolboxes, comprising similar Tools or Tools that create the same type of new object. You can open a Toolbox by clicking on the lower part of a Tool button and selecting a Tool from the appearing list.

In this second user interface, you will notice that the toolbar option changes as you select spreadsheet view. GeoGebra offers diverse viewsfor mathematical objects, which are displayed in different symbols (e.g.algebraic and graphical) and they are connected dynamically. This means that if you adjust an object in any of the Views its depiction in the other Views automatically adapts to these changes.

The Main Views

Algebra View. Algebraic depictions of objects are displayed and can be entered directly using the (virtual) keyboard (e.g. coordinates of points, equations)

Graphics View: Mathematical objects can be constructed with your mouse or by using a touch pad and changed dynamically afterwards.

Spreadsheet View: You can work with data and explore statistical concepts.

3D Graphics View: Three dimensional mathematical objects can be constructed and changed dynamically.

The Input Bar

The Input Bar permits you to precisely generate and redescribe mathematical objects in the Algebra View by inserting or adjusting their algebraic statements (e.g. values, coordinates, equations). Example: The input f(x) = x^2 outputs the function f in the Algebra View and its function graph in the Graphics View.

Note: Always hit the Enter key after inputting algebraic data into the Input Bar.

In addition, you can enter Commands in order with no trouble create new or work with current objects.

Example: Typing A=(1,1) and hitting the Enter key creates a free point A with coordinates (1,1), Create another free point B=(3,4) in the same way. Then, type in Line, B] in order to create a dependent line through both points A and B.

You can joggle the focus between the Input Bar and the Graphics View at any time by pressing the Enter key. This allows you to enter expressions and commands into the Input Bar without having to click on it first.

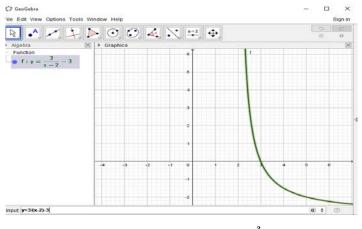**Application of GeoGebra software for Calculus**

Some examples of Calculus expressions will be demonstrated using the GeoGebra software.

The creation files and dynamic worksheets defined in the instances below provide an overview of some basic calculus concepts that can be visualised and investigated using GeoGebra Such dynamic visualisations can sustain mathematical experiments, relations amongst symbolic and graphical representations and arguments about inferences and elementary perceptions.

Example 1: Construct the graph of the function $y = \frac{3}{x-2} - 3$.

Procedure:

Type in the Input bar: y=3/(x-2)-3 and press the Enter key.

Figure 2.1. The output of the graph $y = \frac{3}{x-2} - 3$

Example 2: Construct the graph of the function, Example 2: Construct the graph of the function $y = 2.3^{x+2} - 1$, Example 2: Construct the graph of the function $y = 2.3^{x+2}$.

Procedure:

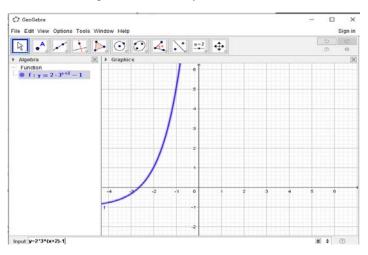Type in the Input bar: y=2*3^(x+2)-1 and press the Enter key.

Figure 2.2. The output of the graph $y = 2.3^{x+2} - 1$.

Example 3: Construct the graph of the function $f(x) = x^3 + x^2 - 4x - 1$.

Procedure:

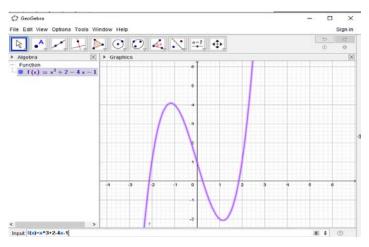Type in the Input bar: f(x)=x^3+2-4x-1 and press the Enter key.

Figure 2.3. The output of the graph $f(x) = x^3 + x^2 - 4x - 1$.

Example 4: Show the Construction of the graph of the inverse of the function $f(x) = 2x + 1$

Procedure:

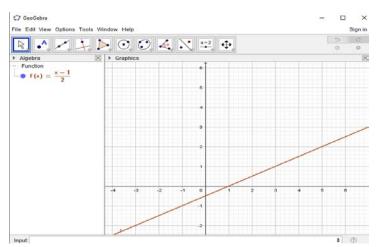Type in the Input bar: Invert(2x + 1) and press the Enter key.

Figure 2.4. The output of the graph of the inverse of the function $f(x) = 2x + 1$.

Example 5: Construct the graph of the function $2x + 4y \leq 12$.
Procedure:
Type in the Input bar: 2x+4y≤12 and press the Enter key.
Note: To get the symbol ≤ in GeoGebra, press down the ALT key + the Shift key and press the (<) Less Than key.
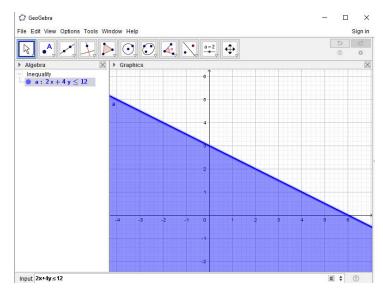

Figure 2.5. The output of the graph $2x + 4y \leq 12$.

Example 6:
   a) Construct the graph of the function $f(x) = x^3 + x^2 - 4x - 1$.
   b) Show and calculate the extreme values and roots of $f(x)$.
   c) Determine and construct $f'(x)$.
   d) Construct a tangent to f
Procedure:
   a. Type in the Input bar: f(x)=x^3+x^2-4x-1
   b. Type in the Input bar: Root[f(x)] and press the Enter key. Then Type again in the Input bar: Extremum[f(x)] and press the Enter key.
   c. Type in the Input bar: f'(x) and press the Enter key.
   d. Type in the Input bar: Tangent[A, f] and press the Enter key
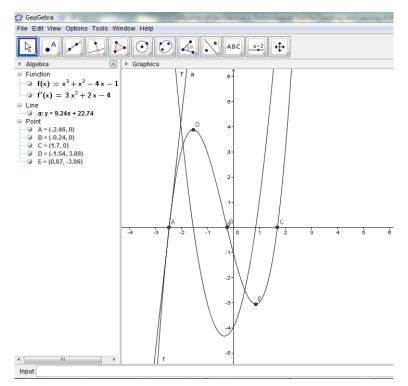**Note:** this must be done in the same work (file).

Figure 2.6. The output of the graph of Example 6

4. Conclusion

GeoGebra dynamic software gave the teacher and students the opportunity to work through the calculus concepts together through exploration and visualisation. This encouraged a more interactive teacher-student relational environment where everyone worked as a team to guide, help and assist one another to reach the required goals. Students were able to experience a hands-on method of learning which enhanced their understanding of the calculus concepts.

This study demonstrated a new teaching method using GeoGebra software as a tool in their instructional activities. Students can download this software free and can use it from home. The software provided teachers and students with a free new technological tool,a new way of using technology with visual aids to help students to interact with the mathematical concepts individually or in groups in the classroom, or at home, or at any convenient place according to needs of the teachers and students using computers GeoGebra software can be used as a complementary activity to the regular classroom setting, where students can get immediate feedback on their results, in the classroom activities as well as in their homework.

Therefore, GeoGebra as a dynamic software can be used as an effective learning tool to promote learning and enhance understanding of mathematical concepts such as calculus.

5. Recommendations

1. Mathematics Teachers should be encouraged to use GeoGebra and other ICT packages in the teaching and learning of Mathematics.
2. The government should provide ICT Laboratories in schools where the GeoGebra software can be downloaded or installed and used in the teaching and learning process.
3. Training programmes should be planned and arranged for mathematics teachers regularly to keep them abreast of new technological tools in the teaching and learning process.
4. This software should be introduced to mathematics educators in Nigeria so that students can explore the world of mathematics in a wider spectrum and make be able able to think critically and creatively.

References

[1] Shadaan, P. & Leong, K. E. (2014). Effectiveness of using GeoGebra on Students' Understanding in learning Circles. *The Malaysian online Journal of Educational Technology(MOJET).* 1(4), 1-11.
[2] The National Council of Teachers of Mathematics (NCTM 2000). Principles and Standards for School Mathematics Reston, VA; Author.
[3] Hohenwarter, J. & Hohenwarter, M., & Lavicza, Z. (2009). Introducing Dynamic Mathematics Software to Secondary School Teachers The Case of GeoGebra *The Journal of Computers in Mathematics and Science Teaching* 28(2), 135-146.
[4] Ogunkunle, R. A. & Charles-Ogan, G. (2013). Dependence on Calculators for Acquisition of Basic Skills in Junior Secondary School Mathematics. *Journal of Research inDevelopment (JORIND).* 11(1), 228-232.
[5] GeoGebra Community Newsletter (2012). GeoGebra. Retrieved form GeoGebrawiki, July.
[6] GeoGebra Community Newsletter (2013). GeoGebra. Retrieved form GeoGebrawiki, April.
[7] Hohenwarter, M. & Preiner, J. (2007). Dynamic Mathematics with GeoGebra. *Journal of Online Mathematics and its Applications* ID 1448, 7(1), 2-12.
[8] Hohenwarter, M & Jones, K. (2007). Ways ofLinking Geometry and Algebra:the case of GeoGebra. Proceedings ofBritish Society for Research into Learning Mathematics 27.
[9] Hohenwarter, M., Hohenwarter, J., Kreis, Y. & Lavicza, Z. (2008). Teaching and Learning Calculus with Free Dynamic Mathematics software GeoGebra. TSG16: Research and Development in the Teaching and Learning of Calculus ICME 11, Montmerry, Mexico, 1-9.