

# Teaching and Learning Trigonometry with the Technology of Graphing Calculator: Making the Teacher Competent

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## **Abstract**

*Traditional teaching methods and the use of blackboard and chalk are not response to the 21<sup>st</sup> century learners need. Modern technologies provide many opportunities in teaching and learning that are compliant with time. This paper describes the application of graphing calculator in exploring the characteristics and properties of trigonometric functions. The paper focuses on the activities; which seem to be not possible or would be tedious, error prone and time consuming without technology. The paper shows that modern technology provides an excellent means of exploring many concepts of trigonometric functions and properties, which would have been impossible without modern technology.*

**Keywords:** *Trigonometry, teaching and learning, graphing calculator, competent teacher.*

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## **1. INTRODUCTION**

It is obvious that traditional teaching methods and the use of blackboard and chalk are not response to challenges of learner in today era. Information and Communication Technology [ICT] evolves and continues to affect all facets of human endeavour, almost no sector of human activities where technology has not manifested itself. ICT has changed the way humanity think, operate, and even view its environment. ICT is employed in addressing issues, which hitherto were seen unsolvable or would take time to accomplish. For instance; issues in space exploration, weather

forecast and knowledge sharing to mention but a few, have been addressed using ICT. One area where the use of technology has role to play is teaching and learning; starting from knowledge creation to knowledge sharing. In this line the National Council of Teachers of Mathematics [NCTM](2000), stated that technology is essential in teaching and learning mathematics as it influences the mathematics that is taught and enhances students' learning. Education sector has certainly been affected by the coming and influence of ICT worldwide; it has made impact on the quality and quantity of teaching, learning, and research in the institution (Kwasha, 2007). ICT has the potential to accelerate, enrich and deepen skills, motivate and engage students in learning.

Variety of ICT facilities are available today for mathematics teaching and learning, including calculators of different levels of sophistication, computers with mathematical software, tablets with mathematical apps and smart-phones. Technology of various kinds (spreadsheets, calculators, computer algebra systems, dedicated and dynamic mathematics software, interactive whiteboards and the internet) can support teachers and students to investigate, generate, create, and explore mathematical ideas. However, while the calculators are used specifically on rudimentary mathematics, other technologies are of broader use and require significant work and extra resources to be effective for mathematics teaching and learning (Kissane, McConney, & Ho, 2015).

Musa, Mahmud and Jalil (2018), identified obstacles to the usage of technology in teaching and learning in Nigeria to include; inconsistent power supply, computer illiteracy, high cost of internet data and lack of adequate facilities among others. However, the present researchers are of the view that incompetency and lack of awareness of the various technologies available could be the main obstacle to using technology in teaching and learning. It is against this backdrop that this paper intends to explore the application of graphing calculator in exploring some behaviours of trigonometric functions.

## 2. TRIGONOMETRY AND ICT

The Encarta Dictionary (2009) defines trigonometry as a branch of mathematics that deals with the relationships between the sides and angles of triangles and with the properties and applications of the trigonometric functions of angles. Applications of trigonometry are found in physics, chemistry, and almost all branches of engineering, particularly in the study of periodic phenomena, such as vibration studies of sound, a bridge, or a building, or the flow of alternating current, (Encarta Dictionary ,2009). Trigonometry is one of the topics in mathematics that the students in both junior and senior secondary schools in Nigeria need to learn. It is also found to be an integral part of mathematics in the first year of the Nigeria Certificate in Education (NCE). Generally, the topic covers trigonometric functions, trigonometric equations, trigonometric identities, and solving oblique triangles using the Laws of Sines and Cosines.

ICT facilities provide an excellent means of exploring many concepts associated with trigonometry; and if used could make learning joyful and experiential. Specifically, graphs of trigonometric functions can be generated using graphic calculator; the technology allows for the exploration of different behaviours of the graphs as well as their properties. Kissane and Kemp (2009) observed that;

Prior to the availability of technology, graphing trigonometric functions was a tedious undertaking for students, with little practical purpose. Technology provides a mechanism for graphs to be drawn much more quickly, which allows students to compare graphs in order to gain some more insights into the nature and differences between the functions. (p. 3)

This paper describes how graphing calculator can be used to explore the graphs of some trigonometric functions.

### 3. GRAPHING CALCULATORS

Graphing calculator is a handheld device that is capable of plotting graphs, solving simultaneous equations, and performing other tasks with variables. Graphics calculators have been available to schools for almost thirty years now, and can be seen as an improvement on scientific calculators, but with superior capacity to explore and represent key mathematical ideas encountered in the secondary school (Kissane, 2015). The graphic calculators have the capacity of supporting student learning of mathematics in addition to handling the numerical computation; graphs can be drawn quickly with them, properties of various graphs can be explored and comparison can be made about the graphs. It does not allow only for graphs of functions, but also for graphical displays of statistical data and geometric objects to be reproduced and manipulated to support student learning; indeed, in recent years a common term to describe this technology is a *graphics display calculator*, abbreviated as GDC( Kissane, 2015). He pointed that, Graphics calculators were developed mainly to support the teaching and learning of school (and early undergraduate) mathematics, rather than for use by professionals in quantitative environments, and are arguably the first technology targeted for that purpose.

Graphing calculators sometimes appear like the ordinary scientific calculators; however with many functions attached to them. It can also be accessed in a software form online, downloaded (in the form of software) or from the group of Geogebra software. The technology of the graphing calculator is potentially more accessible to students, as it requires neither computer nor internet access; after the download on mobile phone.

### 4. GRAPHS OF TRIGONOMETRIC FUNCTIONS

An approach used by many teachers to introduce graphs of trigonometric functions (for instance  $\sin\theta$ ) is to have students fill table of values and then plot the values on a graph, then the a smooth line is drawn through the points. The graphs are produced usually within the range ( $0^{\circ} \leq \theta \leq 360^{\circ}$ ) and later, the teacher through explanation will try to convince the students that the graph the will repeat itself after every period of  $2\pi$ . Although it is necessary for the students to fill table and draw the graphs, but further exploration will be difficult or will consume much time to accomplish; for instance the issue of exploring the behavior of the graph on negative axis and also the behavior of the graph when the functions are multiplied by a constant etc.

### Graphing Sine Function

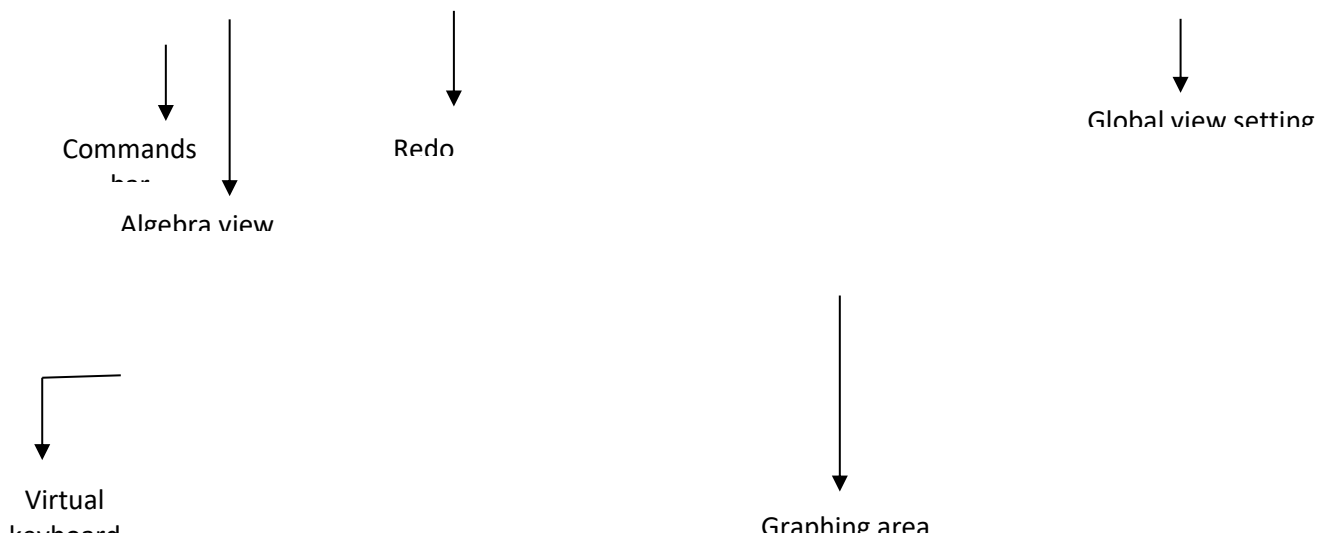
Using graphing calculator it is easy to show the graph of sine function and explore many behaviours the graph possesses. The graphing calculator can be accessed online from the group of Geogebra applications or offline from the desktop (after download).

On the desktop click on the icon



to launch application, a window will appear

as shown below:



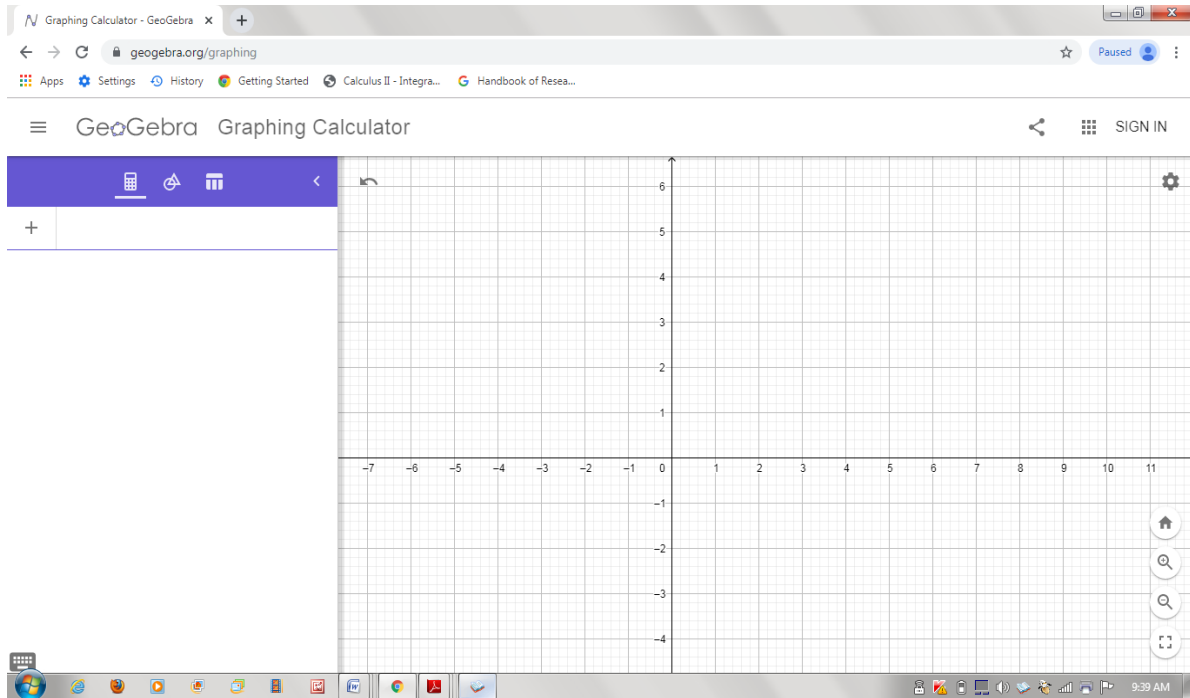


Figure 1: Graphing Calculator interface screen

### Basic tools and commands

1. **Algebra view:** The algebraic representation of object created such as coordinates, equations etc are listed under this view in the order of their creation
2. **Commands bar:** all algebraic input or commands are entered in this bar.
3. **Virtual keyboard:** on selecting this bottom a keyboard appears bearing four bottoms (123 – number value,  $f(x)$  - functions, ABC – letters of alphabets and  $\alpha\beta\gamma$ -Greek letters)

### Number Value View



Figure 2: Interface showing number layout

This Interface is used to input variables and numbers on the input bar. It contains numbers and letters that could be used to represent numbers, inequalities symbols as well as square and square root.

### Functions View

Figure 3: Interface showing functions



This interface provides things like basic trigonometric functions, inverse trigonometric functions, logarithms function, and exponential functions.

4. **Global view setting:** this allows user to set values, graph appearance, and graph view.
5. **Redo/undo arrow:** allows user to undo action or redo it.
6. **Graphing area:** this where the graph appears

#### Steps in Graphing Sine function

The sine function can be drawn by following the steps below;

**Step 1:** Select virtual keyboard or click on the input bottom

**Step 2:** Select  $f(x)$  on the virtual keyboard then select *sin*

**Step 3:** Select  $123$  from the virtual keyboard then select  $x$  – the sine graph automatically appears on the graph area as shown below;

Figure 4: Graph of  $\sin x$

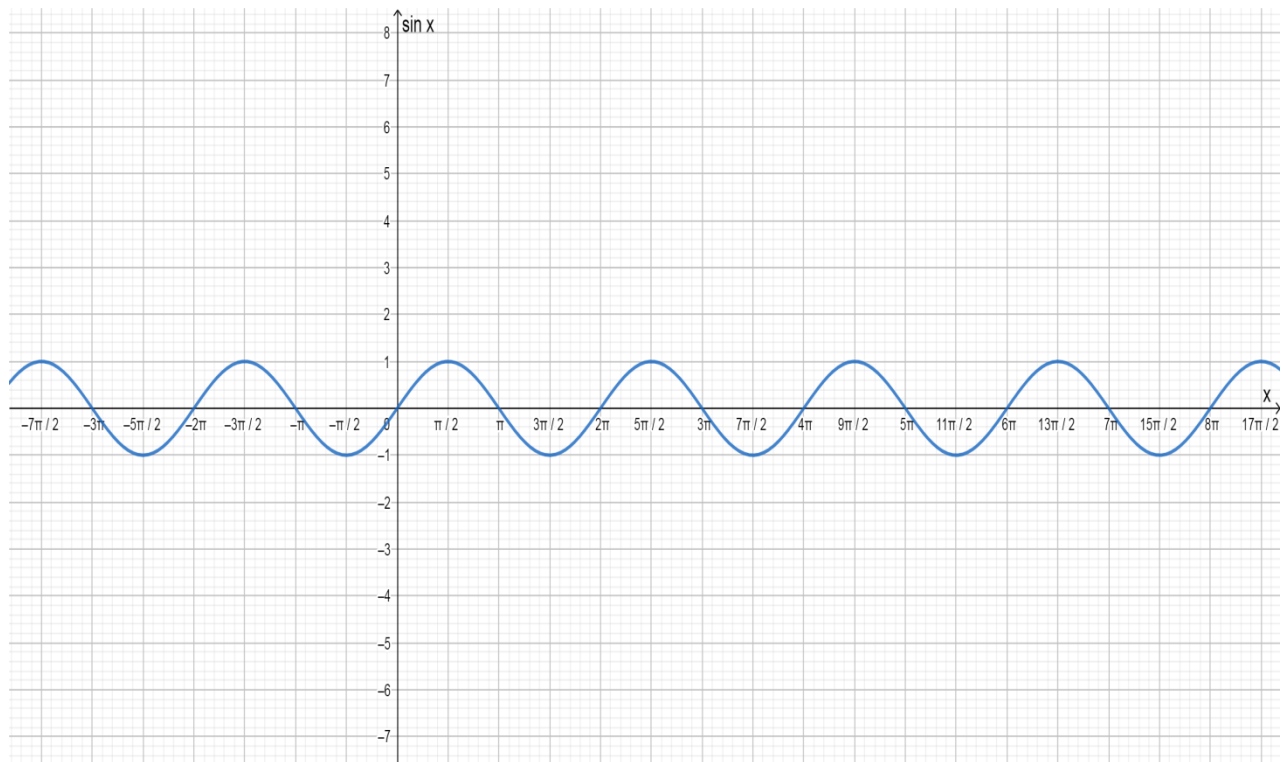


Figure 4 shows the graph produced, the students can see the properties of the sine graph especially the nature of the waves; they can clearly see that they are periodic function with period  $2\pi$ ; the domain of the function is  $(-\infty, \infty)$  with range is  $[-1, 1]$  and that the graph of sine function is symmetric about the origin.

## Graph of multiple of sine function

It is possible to investigate the behavior of a sine graph when the whole function or the argument it is multiplied by a number. This achieved by inputting the number behind “sinx” between “sin” and ‘x’ in the command bar. For example, the graphs of  $2\sin x$  and  $\sin 2x$  are shown below;

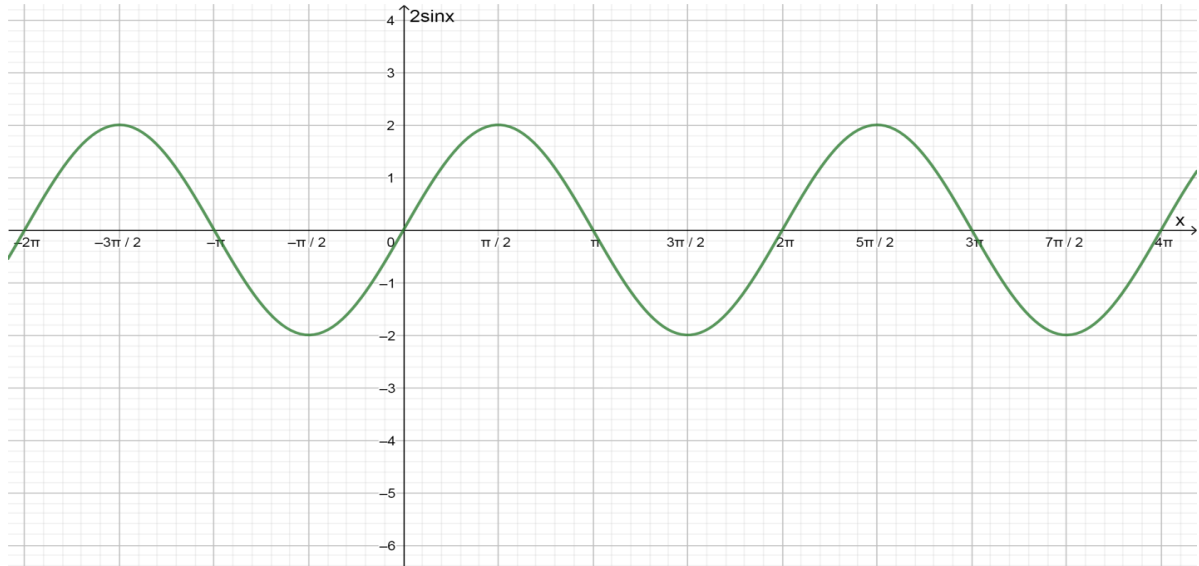
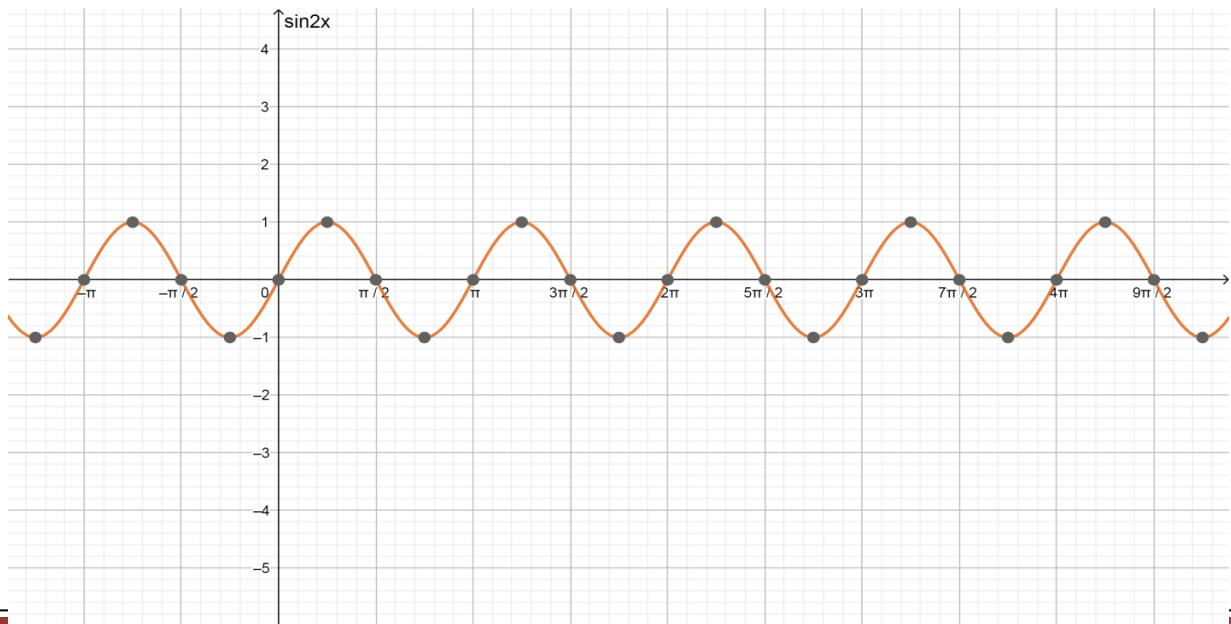


Figure 5: Graph of  $2\sin x$

From figure 5 the students can see that the amplitude now is 2 i.e. range is  $[-2, 2]$  but the period and symmetric properties remain as that of  $\sin x$ .





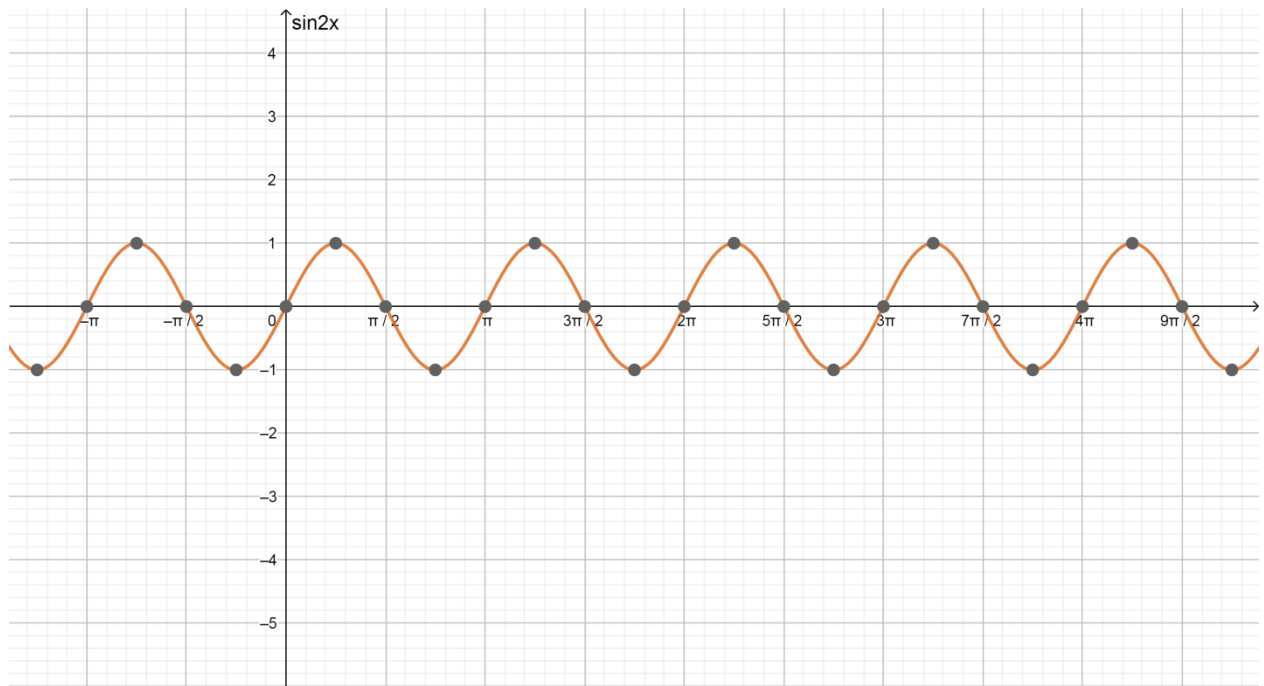
*Figure 6: Graph of  $\sin 2x$*

Figure 6 reveals that the period is  $\pi$  unlike  $\sin x$ , which is  $2\pi$ , but the remaining properties are the same; range is  $[-1, 1]$  and that the graph of  $\sin 2x$  is symmetric about the origin. This of course will be fascinating to students.

Engaging students with many of such examples will certainly lead the students to develop generalisation on the behavior of the functions when it is multiplied by a number or the angle is multiplied. It will also likely to be a powerful new opportunity for students themselves to explore many possibilities.

### **Proof of Trigonometric Identities**

It is possible to check, using graph the validity of trigonometric identities; though this is not a formal prove; however, it allows the students to discover that the given identities are identical graphically. For instance to show that  $\sin 2x \equiv 2\sin x \cos x$  using graphing calculator, we need to generate the graphs of  $2\sin x$  and  $2\sin x \cos x$  separately and compare them.



*Figure 7: Graph of  $\sin 2x$*

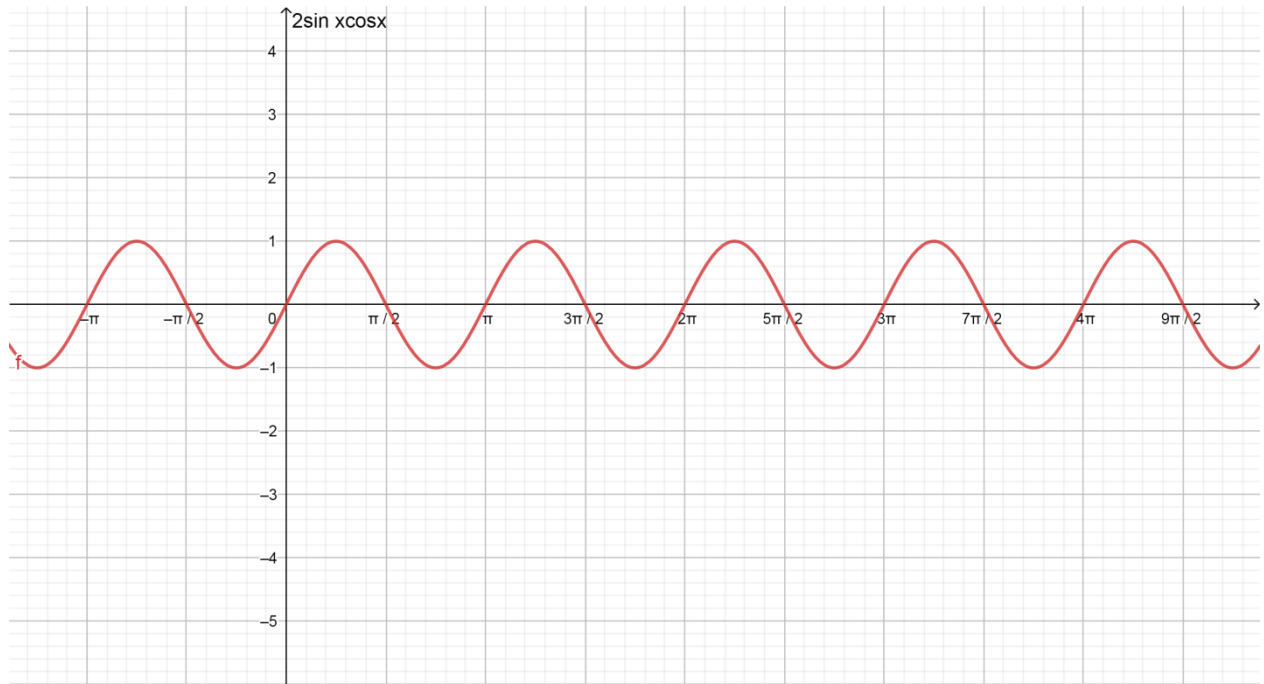


Figure 8: Graph of  $2\sin x \cos x$

Figure 7 and figure 8 show that the two identities  $\sin 2x$  and  $2\sin x \cos x$  are identical, the graphs are similar in all respect. Despite this is not a formal proof, but a sort of verification as well as away of clarifying the nature of an identity; it also provide a quick means of determining whether or not an expression appears to be an identity (to decide whether a proof is worth searching) (Kissane & Kemp, 2009).

### CONCLUSION

The graphing calculator is one, from available technologies that students or teachers may have access for teaching and learning trigonometry. The graphing calculator can be seen as a powerful assistant to explore certain behaviours of trigonometric functions in a fascinating manner; many of which were not possible practically or would have been time consuming, error prone and tedious if were to be done manually. Using graphing calculator to generate trigonometric functions, examine and manipulate further on the graphs, could give the students more time to focus attention on the important properties and principles. The use of graphing calculator will be fascinating and time saving to both teachers and students.

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