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Utilization of Matlab as a Technological Tool for Teaching and Learning of Mathematics in Schools

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ABSTRACT: *The focus of this paper is to describe the use of MATLAB as a technological tool for the teaching and learning of mathematics in schools. Application of this software in the teaching of some difficult topics like vectors and matrices, distance between two points on a co-ordinate plane, graphs of sine, 3D bar, simultaneous and quadratic equations were demonstrated using the MATLAB. Some recommendations were made on how MATLAB can be applied to enhance in the pedagogical process.*

KEYWORDS: Matlab, Teaching, Learning, Mathematics, Technological Tool

INTRODUCTION

Technology has become an essential tool for doing mathematics in today's world. It can be used in a variety of ways to improve and enhance the learning of mathematics (Niess, 2006). As NCTM (2000) highlights in its standards, technology can facilitate mathematical problem solving, communication, reasoning, and proof; moreover, technology can provide students with opportunities to explore different representations of mathematical ideas and support them in making connections both within and outside of mathematics (NRC, 2000). The use of technology in learning mathematics also implies a shift from using the brain power for computational task to using the brain to think critically, communicate clearly, solve problems and apply mathematics to complex scientific and social problems (Ogunkunle & Charles-Ogan, 2013). Mathematics is an essential discipline that appears in every discipline. The world is rapidly developing technologically and of which mathematics is a required instrument because without mathematics there is no modern society. Teaching of mathematics in secondary schools has been dynamic in nature, shifting from learning for learning sake to emphasizing its usefulness in meeting the needs of society (Ogunkunle & Charles-Ogan, 2013).

The use of technology innovation like MATLAB software can improve active involvement of the student in the classroom instruction and also enhances their performances.

Willougby and Wood (2008) noted that learning takes place on computer software without the learners realizing the amount of attention they are paying to the materials. This could be because students seem to focus on their work longer when using technology (Bitter & Legacy, 2008).

Mathematics teachers should not just be contended with being well grounded in the content and pedagogical skills, they should appreciate the compulsive need for them to be well equipped with the advances in an ever-changing technological society. Just as mathematics is the bedrock of technology, the latter has also become increasingly contributive to the growth

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and development of the former. Technology tools are increasingly becoming available to enhance and promote mathematical understanding (Ogunkunle & Charles-Ogan, 2013).

Since educational institutions prepare students to fulfill requirements from the society, many modern methods and technologies have been developed to enhance learning but most of them have one in common today - computer. Computer aided learning has found a way in the learning process from primary schools to universities (Abdullah, Hashim & Yusuf, 2010). Computers are also significantly involved in teaching technology serving sciences like mathematics, physics and information technology. Many software applications are accessible for teaching such as MATLAB, Octave, Scilab and Mathematica. Of all these applications, the most widespread in use at educational institutions is MATLAB, which is considered as standard in technical computing and science (The MATHWORKS, 2012a).

MATLAB is a very powerful tool for computing and simulation. Basic mathematical core provides functions for high performance computing. On top of that, MATLAB provides add-ons (toolboxes) to enhance its usage via adding more functions in specialized fields of technology, economics, medicine or biology. MATLAB is also applied in many publications in different fields. MATLAB is not only exploited in computations but also in the process of teaching and learning. In the MATLAB environment, there are applications that can be created to improve learning (Andreatos & Zagorianos, 2009).

The challenges to the use of MATLAB in teaching and learning of mathematics in schools are premised on the fact that the computer is seen as the most recent cognitive technology that creates new opportunities for mathematics educators (Habor-Peters, 2001). Niess, 2006 emphasized that to be prepared to teach mathematics in this 21st century, the teachers need an in-depth understanding of mathematics (the content), teaching and learning (the pedagogy), and technology(e.g. MATLAB). This means that as teachers think about particular mathematics concepts, they are concurrently considering how they might teach the important ideas embodied in the mathematical concepts in such a way that the technology places the concept in a form understandable by their students.

MATLAB is a very powerful software package that has many built in tools for solving problems and developing graphical illustrations (Attaway, 2012). He also noted that the simplest method for using the MATLAB product is interactively; an expression is entered by the user and MATLAB immediately responds with a result. Attaway(2012) also stressed that it is possible to write scripts and programs in MATLAB, which are essentially groups of commands that are executed sequentially.

Getting into MATLAB proper gives a brief start. MATLAB is a mathematical and graphical software package with numerical, graphical, and programming capabilities. It has built-in functions to perform many operations, and there are toolboxes that can be added to augment these functions (e.g for signal processing).

Statement of Problem

The world relies on scientific and technological inventions, discoveries of which science and technology cannot exist without a proper knowledge of mathematics. It is therefore of utmost importance that mathematics teachers should be abreast of changes in the educational sector, especially as these relate to teaching and learning of the subject (Ogunkunle & Charles-Ogan, 2013). Mathematics educators have emphasized the efficacy of computer as a teaching and

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learning material in a subject like mathematics. It may, therefore be necessary to prepare the mathematics teachers in Nigeria to be able to use some software in computers in the teaching of mathematics. In most of secondary schools teachers and students compute results on the table or the paper. MATLAB software can be used to visualize different trajectories in just few lines of code for better understanding and imagination of the problem. With additional commands, one can animate whole movement. The question then is, should MATLAB be use by teachers only? Or should students also learn it to know how to create their own scripts and programs? According to Blaho, Foltin, Fodrek and Murgas (2012) writing MATLAB scripts and programs should not be a problem for the students also because of its simplicity. They noted that it would be interesting to students and also learn some basic concepts of algorithm writing. This study therefore tends to apply the software MATLAB in teaching of some difficult topics like vectors and matrices, distance between two points on a coordinate plane, graph of sine and its derivative, plotting a 3D bar graph, graph of simultaneous equations and graph of quadratic equation.

Aim and Objectives of the Study

The aim of the study is to demonstrate different ways of applying MATLAB software in the teaching of some difficult topics as stated above. Specifically, the study intends to:

1. Identify the steps involved in solving vectors and matrices.
2. Demonstrate how to plot the stated graphs like graph of sine, a 3D bar, simultaneous and quadratic equation
3. Show the simulation of tracing and identifying the solution of the various graphs stated above.
4. Demonstrate how to solve distance between two points on a coordinate plane.

METHODOLOGY

A MATLAB software DVD is required and should be installed in the computer. From the start menu, click on MATLAB software, a window opens in which the main part is the command window (see figure 1.1). In the command window, one should see: >> which is called prompt. The prompt also is Edu >> in student edition. In the command window, MATLAB can be used interactively. At the prompt, any MATLAB command or expression can be entered, and MATLAB will immediately respond with the result. During this process, some commands can serve as **will** introduction to MATLAB and allow one get help:

- **Info** will display contact information for the product
- **Demo** has demos of some of the features of MATLAB
- **Help** explain any command ;help help will explain how help works
- **Helpbrowser** opens a help window
- **Lookfor** searches through the help for a specific word or phrase(note: this can take a long time)

To get out of MATLAB, either type quit at the prompt, or choose file, then Exit MATLAB from the menu.

Figure 1.1 below shows a newly opened (empty) Matlab Command Window while figure 1. 2 shows the command window with some basic mathematical tasks performed

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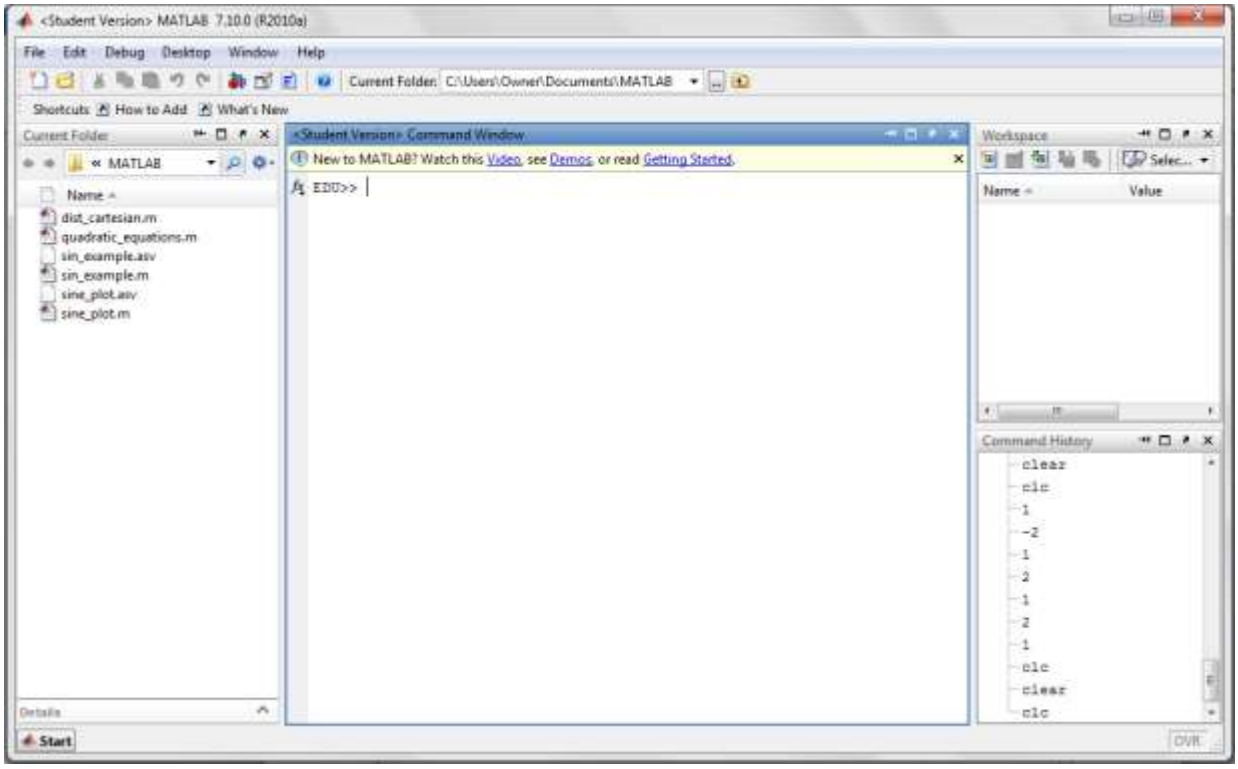

Figure 1.1: An empty Matlab command window

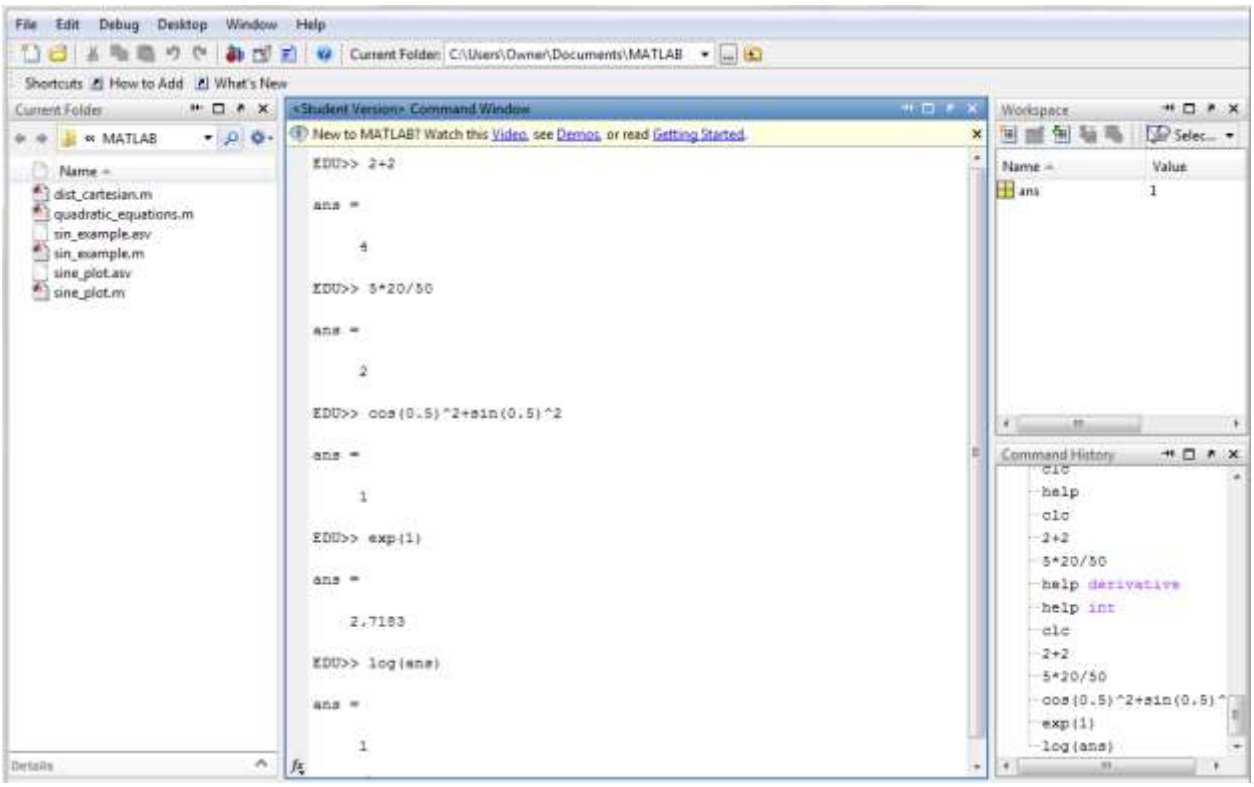

Figure 1. 2: A MATLAB command window with some commands given

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An empty script file is shown in figure 1. 3 Scripts in MATLAB are used to write basic code to perform some mathematical tasks so it can be saved and can always be edited.

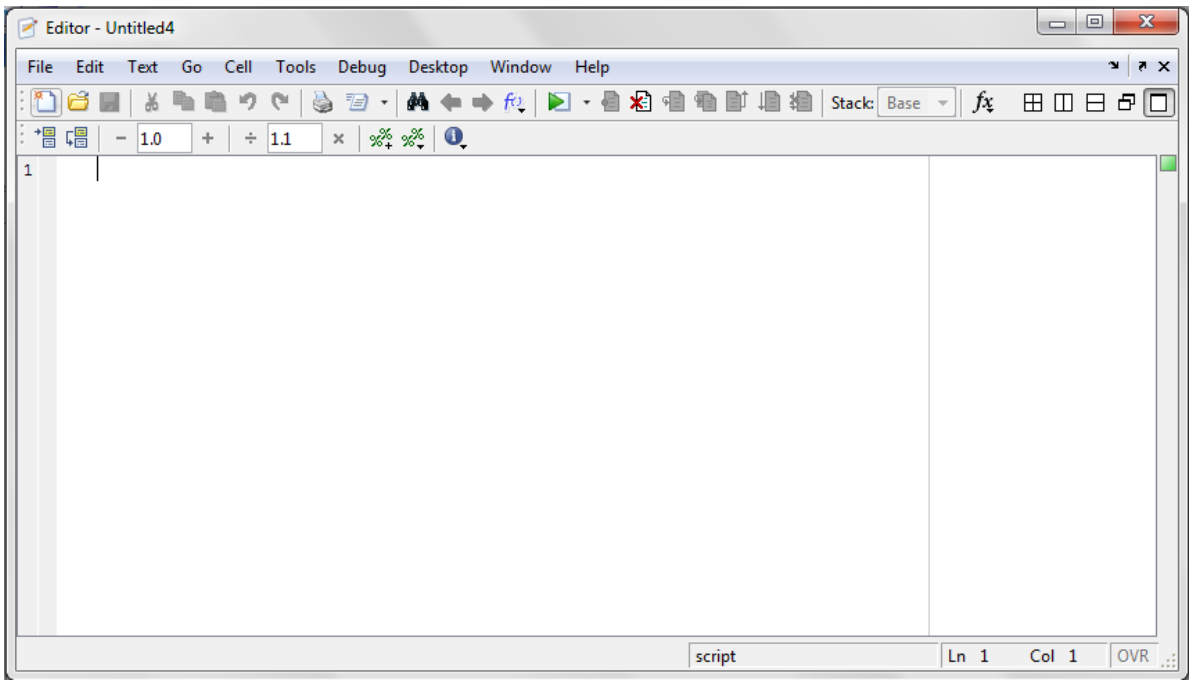

Figure 1. 3: Shows an empty script

MATLAB Examples

Some mathematical examples will be performed using MATLAB so show its many varied functions and use.

Vectors and Matrices

Vectors and matrices are used to store sets of values, all of which are the same type. A vector can be either a row vector or a column vector. A matrix can be visualized as a table of values. The dimensions of a matrix are r x c, where r is the number of rows and c is the number of columns. This is pronounced " r by c ," if a vector has n elements, a row vector would have the dimensions 1 x n, and a column vector would have the dimensions n x 1.

MATLAB is written to work with matrices; the name MATLAB is a short form of "matrix laboratory." Since MATLAB is written to work with matrices, it is very easy to create vector and matrix variables, and there are many operations and functions that can be used on vectors and matrices.

A vector in MATLAB is equivalent to what is called a one-dimensional array in other languages. A matrix is equivalent to a two-dimensional array. Usually, even in MATLAB, some operations that can be performed on either vectors or matrices are referred to as **array operations.** The term "**array**" is also frequently used to mean generically either a vector or a matrix.

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Example 1: Vectors & Matrices

A: Vectors

Given the vectors x=[2 4 6 8 10] and y=[3 6 9 12 15] ,

solve for

$$z = \frac{xy + \frac{y}{x}}{(x+y)^{(y-x)}} + 12^{\frac{x}{y}}$$

This can be done directly on the command window like shown below

```
EDU>> x=[2 4 6 8 10]

x =

     2     4     6     8    10

EDU>> y=[3 6 9 12 15]

y =

     3     6     9    12    15

EDU>> x=2:2:10;
EDU>> y=3:3:15;
EDU>> z=(x.*y+y./x)./((x+y).^(y-x))+12.^(x./y)

z =

    6.7415    5.4965    5.2579    5.2421    5.2415
```

B: Matrices

Given the matrices A, B, C and D as shown below

$$a = \begin{bmatrix} 2 & 1 \\ -1 & 4 \end{bmatrix} \qquad b = \begin{bmatrix} -1 & 3 \\ 0 & 2 \end{bmatrix} \qquad c = \begin{bmatrix} 2 \\ 1 \end{bmatrix} \qquad d = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

```
>> a=[2 1;-1 4]
a =
   2   1
  -1   4
```


ISSN 2053-2229 (Print), ISSN 2053-2210 (Online)

```
>> b=[-1 3;0 2]
b =
   -1     3
    0     2

>> c=[2;1]
c =
    2
    1
>> d=[1 0;0 1]
d =
    1     0
    0     1
```

We can perform some mathematical operations with them in the command window as shown below:

```
>> a+b
ans =
    1     4
   -1     6

>> a*d
ans =
    2     1
   -1     4

>> a.*d
ans =
    2     0
    0     4

>> a*c
ans =
    5
    2

>> a.^b
ans =
   0.5000    1.0000
   1.0000   16.0000
```


ISSN 2053-2229 (Print), ISSN 2053-2210 (Online)

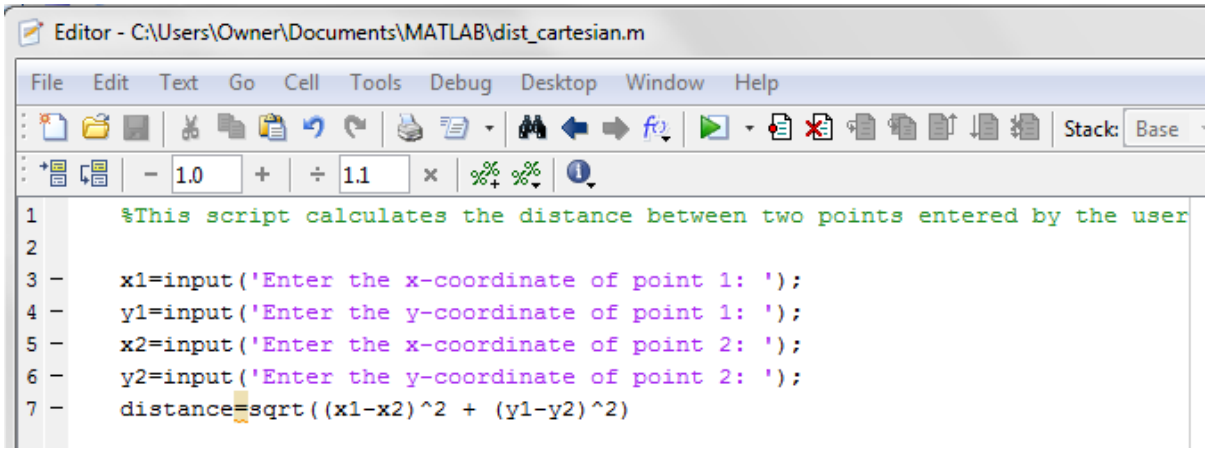
Example 2: Distance between two points on a coordinate plane

Sample question: The distance between two points (x_1, y_1) and (x_2, y_2) on a Cartesian coordinate plane is given by the equation

$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

Calculate the distance between any two points (x_1, y_1) and (x_2, y_2) specified by the user. In this example, we'll use the points (-3, 2) and (3, -6)

Script code:



Output:

```
Enter the x-coordinate of point 1: -3
Enter the y-coordinate of point 1: 2
Enter the x-coordinate of point 2: 3
Enter the y-coordinate of point 2: -6

distance =

    10
```

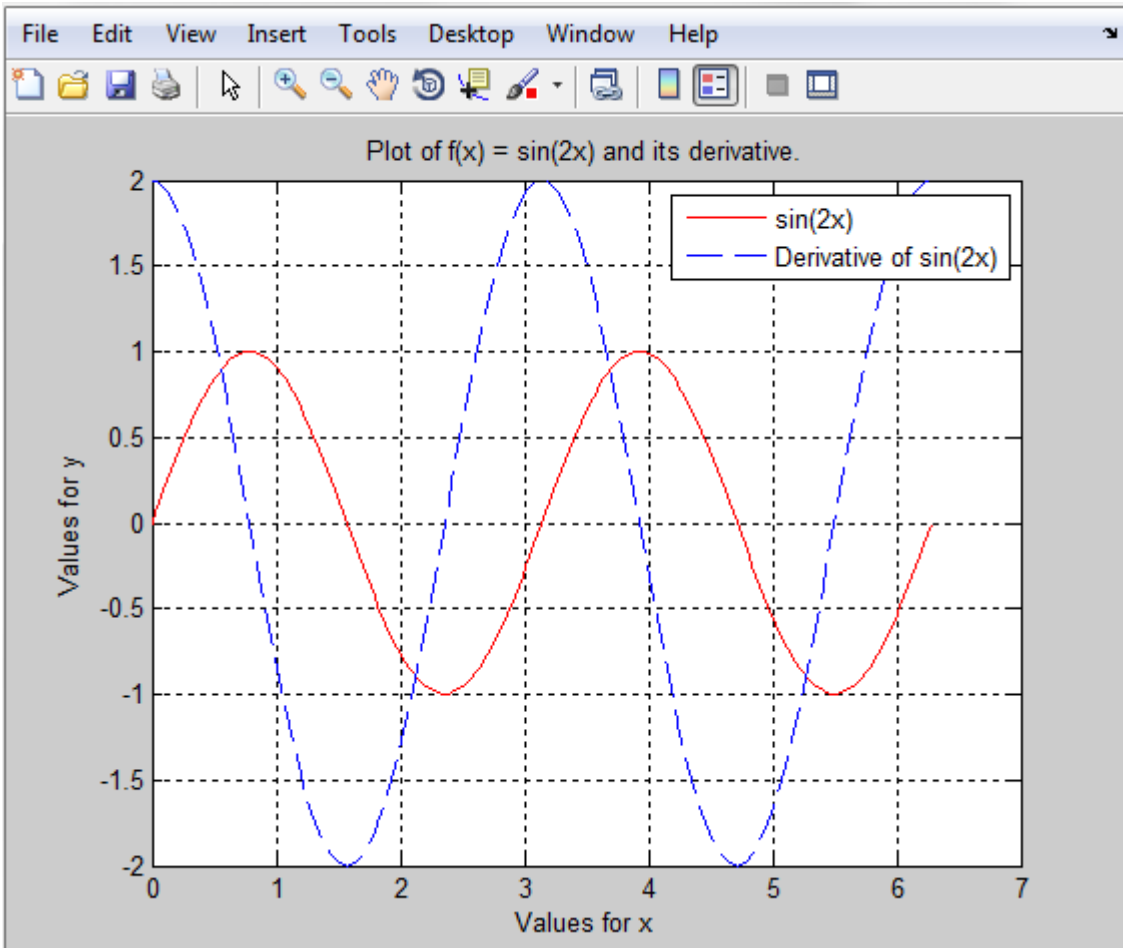

ISSN 2053-2229 (Print), ISSN 2053-2210 (Online)

Example 3: Graph of sin(2x) and its Derivative

Script code:

```
x=0:2*pi/200:2*pi;
y1=sin(2*x);
y2=2*cos(2*x);
plot(x,y1, 'r-',x,y2, 'b--')
xlabel('Values for x')
ylabel('Values for y')
title('Plot of f(x) = sin(2x) and its derivative.')
legend('sin(2x)','Derivative of sin(2x)')
grid on
```

Output plot:



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Plotting a 3D Bar Graph

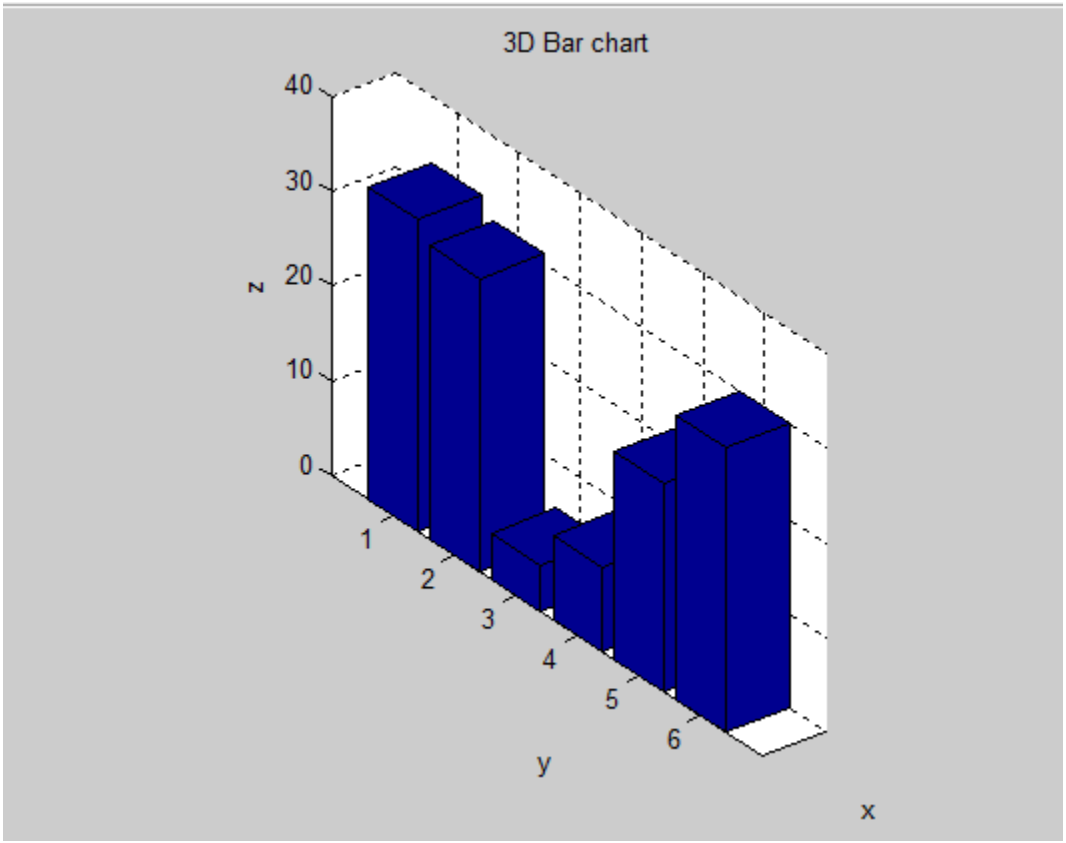
For computing output data, functions and scripts provides set of commands necessary. It is very difficult reading plain data and so need some mechanism to represent these readings. MATLAB contains several plotting commands for 2D and 3D figures (Blaho, Foltin, Fodrek & Murgas, 2012). Create grid for 3D space through meshgrid command in plotting 3D graphs. Changing plot properties is another important knowledge but students find it difficult to understand this concept so need to create handler to plot and using get and set commands to change line colour or type. Creating interactive experience for users with no prior MATLAB knowledge can use objects like buttons, labels, inputs, or check box.

Example 4: Plotting a 3D Bar Graph

Script code:

```
%3D bar graph
y=1:6;
z=[33 31 5 9 22 30];
bar3(y,z)
xlabel('x')
ylabel('y')
zlabel('z')
title('3D Bar')
```

Output:



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Example 5: Simultaneous Equations:

Sample question:

The two different ways of solving the simultaneous equations will be explored: using 'solve' function and using 'plot' function

Using solve function: performed in the command window

```
EDU>> clear
EDU>> syms x y
EDU>> answer=solve('x-y=2','x^2+y=0',x,y);
EDU>> x=answer.x

x =

  1
 -2

EDU>> y=answer.y

y =

 -1
 -4
```

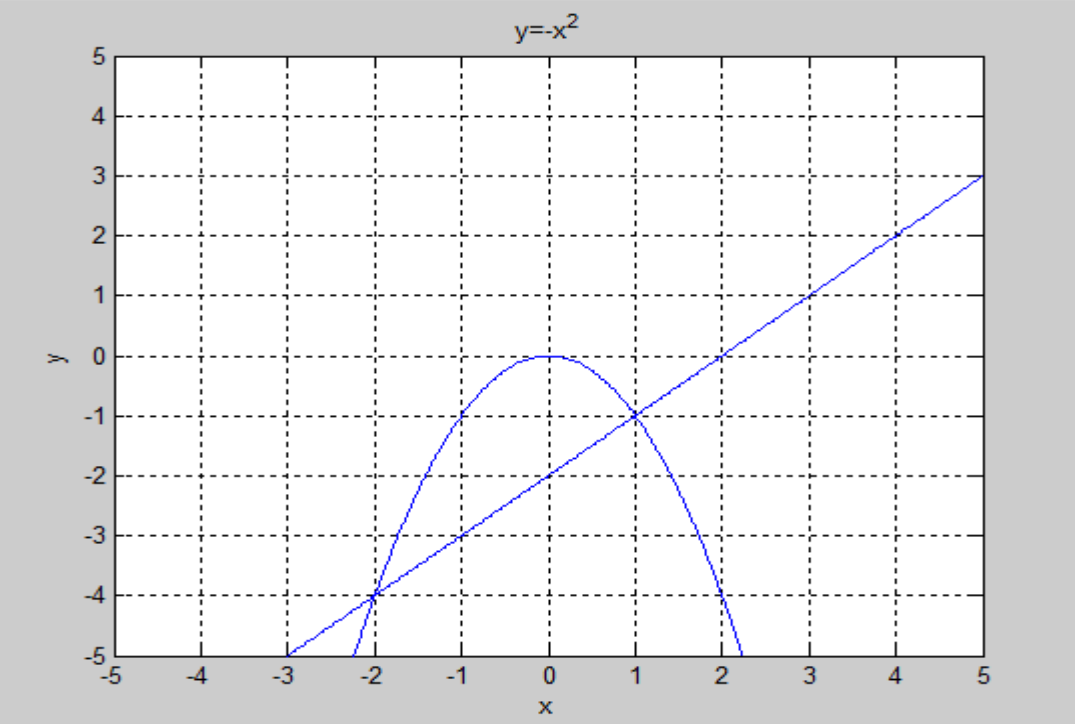
Using plot function:

Script code:

```
1 -     syms x y
2 -    answer= solve('x-y=2','x^2+y=0',x,y);
3 -    x=answer.x;
4 -    y=answer.y;
5 -    ezplot('y=x-2',[-5,5])
6 -    hold on
7 -    ezplot('y=-x^2',[-5,5])
8 -    grid on
```


ISSN 2053-2229 (Print), ISSN 2053-2210 (Online)

Output plot:



From the plot, the solutions are at the points where the two plots meet:

X= -2 and 1

Y= -4 and -1

Example 6: Solving Quadratic Equations

Sample question: Consider the quadratic equation $ax^2 + bx + c = 0$. The solution to this equation is $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$

The term " b2 − 4ac " is called the discriminant of the equation. The nature of the discriminant determines the number and type of the roots as follows:

Discriminant value	Number and type of roots
Positive	2 distinct real roots
Negative	2 complex roots
Zero	1 repeated root

a. Write a program in a script file to solve for the roots of a quadratic equation. The program should:

(1) Read the input values of a, b, and c;
(2) Calculate the roots; and
(3) Output the results, including a statement about the type of the roots (e.g., "There are 2 distinct real roots.").

ISSN 2053-2229 (Print), ISSN 2053-2210 (Online)

Script code:

```
%This script finds the roots of a quadratic equation

%To get the coefficients a, b, and c from the user
a=input('Enter a value for a: ');
b=input('Enter a value for b: ');
c=input('Enter a value for c: ');

%To determine the discriminant
discriminant= b^2 - 4*a*c;

%To determine the roots
disp('Roots of quadratic equation:')
if discriminant == 0
    disp('Repeated root...')
    root = -b/(2*a)
elseif discriminant > 0
    disp('Distinct real roots...')
    root1 = (-b+sqrt(discriminant))/(2*a)
    root2 = (-b-sqrt(discriminant))/(2*a)
else
    disp('Complex conjugate roots...')
    root1 = (-b+sqrt(discriminant))/(2*a)
    root2 = (-b-sqrt(discriminant))/(2*a)
end
```

Output for each (called from the command window):

A: Using the equation $x^2+x+1=0$

```
Enter a value for a: 1
Enter a value for b: 1
Enter a value for c: 1
Roots of quadratic equation:
Complex conjugate roots...

root1 =

  -0.5000 + 0.8660i


root2 =

  -0.5000 - 0.8660i
```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B: Using the equation $-2x^2+x+2=0$

```
Enter a value for a: -2
Enter a value for b: 1
Enter a value for c: 2
Roots of quadratic equation:
Distinct real roots...

root1 =

   -0.7808


root2 =

    1.2808
```

C: Using the equation $x^2+2x+1=0$

```
Enter a value for a: 1
Enter a value for b: 2
Enter a value for c: 1
Roots of quadratic equation:
Repeated root...

root =

    -1
```

CONCLUSION

This study demonstrated the integration of MATLAB software in the teaching of the various topics such as vectors and matrices as well as plotting graphs of sine, 3D bar, simultaneous and quadratic equations. MATLAB software usage is intended to improve the understanding of these difficult topics among the senior secondary school students. The experience of using MATLAB to support the teaching and learning of mathematics topics may have a strong impact on the learning strategies of students. It is therefore possible that with good course design, students and teachers can have some degree of control over what topics, that MATLAB software can be effective for improving performance in mathematics.

RECOMMENDATIONS

- Mathematics teachers should be encouraged to use MATLAB software to teach some difficult topics to improve students' performance.

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- Government should provide necessary technological materials to improve teaching of mathematics.
- Government should send teachers for technological training regularly to be abreast with new ideas.

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