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Computer Approach to Analysis and Solution of Graphical Problems in Mathematics

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Abstract: Research findings have not yet formally established that Computer-Aided Instruction (CAI) offers a significant improvement over conventional method of teaching. However, in a meta-analysis of 254 comparative Computer-Assisted Instruction studies, Kulik and Kulik found that the students of varying ability levels all displayed significant positive learning gain when using CAI had better examination score, better attitude toward instruction and computers. This covers a wide range of concepts on how to use Microsoft package to solve mathematical problems graphically. Spreadsheet package is used in giving step-by-step solutions to graphical problems with emphasis on Microsoft Excel. The computerised learning activities in this study will supplement conventional instructions of acquiring skills and thus enhances effective students learning.

Key words: Computer, mathematics, teaching, learning, Microsoft Excel, charts

INTRODUCTION

The outcry of dismal performances of students in mathematics at external examinations like Cambridge, Senior School Certificate organised by West African Examinations Council (WAEC), National Examinations Council (NECO), Universities Matriculation Examination (UME) and Polytechnic and Colleges of Education Examination (PCE) has been on the increase. Many factors have been identified by mathematics educators for the poor students' achievement in mathematics. Research on student's learning has revealed that orientations to learning affect learning outcomes. The perceptions of the learning environments especially that of assessment has also been shown to have a strong influence on the orientations to learning (Entwistle and Entwistle, 1991, 1992; Entwistle *et al*., 1993; Entwistle, 1995). Examinations and tests sometime hamper students attempt to achieve personal understanding because they only show the final outcome but fail to reveal the individual change that has taken place (Tynjala, 1997). Effective teaching and learning of mathematics could only be achieved through introduction of various innovations and skills that are learners-centred to teaching of mathematics. No single method of teaching has been found to be effective. The computer however is considered as the best educational technology in this 21st century. The reason, simply as Chauhau observed is the ability of the individual to act purposefully, think rationally and deal effectively with his environment.

The introduction of computer education under pre-vocational electives at the Junior Secondary School (JSS) level and vocational electives at the Senior Secondary School (SSS) in the National Policy on Education (NPE) is a good development towards enhancing greater learners' participation in the classroom (Federal Republic of Nigeria, 2004). Computer has been noted to facilitate learning of mathematics and other subjects. Jegede (1991) taught Senior Secondary School Biology students with the help of computer and found that their attitude towards the subject improved after the lesson. Matthews (1990) also discovered that the use of Computer-Assisted Algebra System Package had a desirable effect on the learning and teaching of calculus. This study, therefore, aims at demonstrating how Microsoft Excel could be used in effectively teaching and solving mathematical problems graphically.

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MATERIALS AND METHODS

A number of techniques are used in mathematical modelling. Mathematical models can provide concise and unambiguous description of decision problems. Moreover, they enable problems to be explored and investigated through mathematical analysis (Goodwin, 1998). Mathematically, numerical values can be represented in graphical form.

Microsoft Excel is one of the Microsoft Office Suite programs. It is one of the examples of spreadsheet packages apart from QuatroPro and Lotus 1-2-3. Microsoft Excel is an application package meant for solving both statistical and mathematical problems. Spreadsheet program allows the users to present values in graphical form. Graphs in spreadsheet are called Charts. There are different types of chart in spreadsheet. This includes column, bar line, pie, scatter, area, etc.

Charts are used to show proportions of each value in the data set. Data are grouped into related data points. These groups are called data series. When you create a chart with Excel, the categories are plotted along the horizontal or X-axis while the values are plotted along the vertical or Y-axis. Data series originate from single worksheet rows or columns. Each data series in a chart is distinguished by a unique colour or pattern. You can plot one or more data series in a chart except for pie charts.

Charts are created in Excel using Chart Wizard located on the Standard Toolbox. The ChartWizard is a series of dialog boxes that guides you through the steps required to create a new chart or modify settings for an existing chart. When creating a chart with the ChartWizard, one can specify the worksheet range, select a chart type and format and specify how one want ones data to be plotted. One can also add a legend, a chart title and a title to each axis and other chart options.

RESULTS AND DISCUSSION

The object of a graph (short for graphic) is to convey information rapidly and easily. Graphs appear in newspapers, magazines and business publication and take various forms (Durell, 1975).

Before you can draw a chart in Excel, the numbers that compose the chart must be entered in a workbook. There are five general steps in defining a chart. These steps are:

- Enter the data into a workbook
- Select the data to be charted
- Choose chart from the Insert menu
- Choose chart type from the ChartWizard dialog box
- Define parameters such as titles, sealing colour, patterns and legend

Table 1: Tourism survey in six geopolitical zones in Nigeria

A	B	C	D	E	F
	Tourism survey				
Zone	2000	2001	2002	2003	Total
South-West	1238	968	913	1856	4975
South-East	995	843	994	1405	4237
South-South	1108	786	937	756	3587
North-East	1189	980	852	951	3972
North-West	1185	743	997	1008	3933
North-Central	991	510	378	1579	3458

These five steps should be performed in this order. It is important to know that a chart is linked to the workbook data. Therefore, subsequent changes made to the workbook are automatically reflected in the chart. That is the chart that depends on the data in the workbook where a change is made will also change.

Example 1: A Tourism Centre conducted a survey on the average monthly use of tourist centres located in the six geo-political zones in Nigeria between 2000 and 2003. The worksheet below shows the detail of the attendances in the period (Table 1).

The values in the survey can be transformed into graph. To produce a bar graph showing the number of attendants for each of the zone in 2000-2003 follow these procedures:

- Highlight cells A5...E10. This cell range holds the data needed to produce the graph
- Click Insert menu and then click Chart submenu or simply click Chart Wizard icon on the Standard Toolbar. This will produce Chart Wizard dialog box which prompts the user to carry out four steps toward the completion of the graph
- In the dialog box, the first step is to choose the chart type. Hence, click on Bar under Chart type and then choose the Chart Sub-Type you want to use. In this example, we will use the first subtype available and then click Next
- The second step deals with the Chart Source Data. The Data Range is the default and the range is already highlighted since this has been done earlier. Column radio button is activated because the variables (zones) to be plotted on x-axis are in the same column (Column A). In the Series tab, Series 1...Series 4 are displayed indicating that variable in each column A has four data. Then Click Next
- The third step deals with Chart Options. This has six tabs; Titles, Axes etc. In the Titles tabs, type Tourism Survey as the Chart Title in the bar. In Category (X) axis and Value (Y) axis, type Zones and Attendances,

respectively in the bars. Click Axes tab. Activate Category (X) axis and Value (Y) axis buttons so that the axes names will show on the graph. Click Gridlines and activate the desired Major and Minor buttons under Category (X) axis and Value (Y) axis options. Click Legend tab and activate Show Legend button and indicate the Placement (i.e., the location of appearance) if you want to display legend in your graph. Legend is similar to a key in the conventional geographical maps. Click Data Labels and activate Value button if you want the value of each bar to show on the graph. The last tab is Data Table. The Show Data Table button is activated if you want show the values you used to plot the graph in a table along with the graph. Then Click Next

- The last step is Chart Location. There are two options here. The first one is As New Sheet which makes the graph or chart to appear on a new sheet looking like a plane sheet of paper (e.g., Chart 1) different from the sheet you are currently working on. The second option is As object In which makes the graph or chart to appear on the same worksheet you are currently working on. In this example, we will choose As object In
- Click Finish

Changing the pattern of the bars: In the above chart, each zone has four bars representing each year under review. It is important to note that each bar representing the same year in each of the zone is of the same pattern. Whenever any bar in the chart is selected by single clicking it, those bars representing the same year is equally selected simultaneously. However, the pattern of those bars can be changed. To effect the change, carry out these procedures:

- Point to any of the bars and double click it. This will select the bar of the same group. For example, select the first bar in South-West
- In the Format Data Series dialog box, click Fill Effects…box
- In the Fill Effects dialog box, click Pattern tab and choose the pattern you want. Choose the different colours you want under Foreground and Background box. For example, choose black and white for foreground and background, respectively
- Click OK. This will return you to Data Series dialog box
- Click OK. This will affect the pattern change on the chart

Repeat the same procedures for other three groups of bars representing other years.

Changing chart type: The above chart type (Bar graph) can be changed automatically using the same set of data without necessarily going through series of procedure earlier itemized. To change the chart type, the procedures are:

- Select the chart. This is indicated by eight black colour nodes surrounding the chart
- In the Chart Toolbar, point to Chart Type icon and click the drop down list in the Chart Type box. Choose the new type of chart you want. In this example, let's choose Column Chart. This will instantaneously change the chart as shown below. Meanwhile if the Chart Toolbar is not displayed on the screen, click View menu and click Toolbars submenu. Choose Chart from the emerging submenu. The Chart Toolbar appears on the screen

Pie chart: Pie charts are used to show relative proportions of the whole for one data series only. Data series are a group of related data points.

In the tourism survey, we can produce the pie chart for the data relating to the outcome of the survey. To deal with pie chart, only data in a single row or column could be used. In the example, each cell in the range F5:F10 shows the total attendances for each zone for the period under review. Hence this cell range would be used for pie chart. Follow these procedures to produce the pie chart:

- Select cells A5…A10, hold on Ctrl key (i.e., do not release the key) and select cells F5…F10. This is called selecting alternate column
- Click on Chart Wizard on the Standard Toolbar. In the Chart Wizard dialog box, choose Pie as Chart Type and the first chart sub-type
- Click Next and Next again
- In step 3, type Tourism Survey as the chart title
- Click Legend tab and activate show legend and bottom placement
- Click Data Labels tab. Activate Category Name and Percentage buttons and then Click Next
- Activate As new sheet and then Click Finish

The pattern in each sector of the pie chart can be changed as discussed earlier in bar chart.

Exploding pie chart: Pie chart or graph can be exploded to highlight certain values. To explode pie chart simply means pulling out the slices or sectors in the pie. For example, we might want to explode the zone that has the highest percentage. This will explode only one slice in the pie chart. The procedures are as stated below:

- Click the pie (i.e., South-West)
- Click and hold on the slice you want to move or explode
- Drag the slice away from the centre of the chart

These procedures will shown the result. To explode all the slices, click and hold on the pie and then drag away the pie from the centre of the chart. To collapse or bring the exploded slices to normal, click and hold on the exploded slice. Then drag back to the centre of the chart.

Quadratic chart: Spreadsheet chart techniques can also be used to plot mathematical quadratic graphs.

Example 2: Plot the graphs of $y_1 = x^2 - 5x+4$ and $y_2 = x - 2$ on the same axes between $-1 \leq x \geq 6$. The values of independent variable (x) and dependent variables (y_1 and y_2) look like the table below when entered on worksheet (Table 2). To transform the data in the spreadsheet to a desire XY chart, the procedures to follow are:

- Select cells B1…I3 and Click Chart Wizard icon on the Standard toolbar
- Select XY (Scatter) chart type and choose Scatter with data points connected by smoothed lines under chart sub-type
- Click Next to accept Chart Data Source
- Click Next. Type One Linear-One Quadratic Graph, x-axis and y-axis as Chart Title, Values (X) axis and Values (Y) axis respectively. Under gridlines, activate major x and y-axes buttons and Click Next again
- Choose the location you want to use and then Click Finish

Table 2: Values of dependent and independent variables

A	B	C	D	E	F	G	H	I
X	-1	0	1	2	3	4	5	6
Y_1	10	4	0	-2	-2	0	4	10
Y_2	-3	-2	-1	0	1	2	3	4

The roots (or solutions) of the quadratic equation and the point of intersection between the two graphs can be found using the chart by reading the values accurately.

Line chart (Trigonometry): The line chart can be used to produce the trigonometry values. Excel has most of the mathematical and trigonometric functions built into it. If you need to use the sin, cos, tan functions, they can be typed into any cell and invoke the appropriate function to find their values. By default, the trigonometry value of any angle in spreadsheet is in radian. To calculate trig functions in degrees you must convert them otherwise excel will calculate them in radians. The formula that converts an angle in radian to degree is: = sin (angle*pi ()/180). The values of sin θ, cos θ and tan θ (in degree) for the range of angle $0 \leq \theta \geq 360$ at interval 30° look like the Table 3 when entered into a worksheet. To find the sin, cos and tan values for the angles, the procedures are:

- Activate cell B3 and enter the formula = SIN(B1*PI ()/180)
- Copy the formula in B3 to cells C3…N3
- In cell B4, enter the formula = COS(B1*PI()/180) and copy the formula to cells C4…N4 and
- In cell B5, enter the formula = TAN(B1*PI()/180) and copy the formula to cells C5…N5

The output is shown in Table 4. The value of tan 90° or tan 270° is infinity (∞). So, these should adequately be effected manually on the worksheet.

Example 3: Using the same scales and axes, draw the graphs of $y_1 = 3 \sin^2 x$ and $y_2 = 2\cos^2 x$ for values $0° \leq x° \leq 180°$ at interval of 15°. Use graph to deduce the solution of the equation $2\cos^2 x = 3\sin^2 x$. To solve the above stated problem, the first step is to create a table of values in form of a worksheet as shown in Table 5.

Table 3: Range of independent variable values (θ)

A	B	C	D	E	F	G	H	I	J	K	L	N	O
	0	30	60	90	120	150	180	210	240	270	300	330	360
Sin													
Cos													
Tan													

Table 4: Computed values of dependent and independent variables

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Θ	0.000	30.000	60.000	90.000	120.000	150.000	180.000	210.000	240.000	270.000	300.000	330.000	360.000
Sin	0.000	0.500	0.866	1.000	0.866	0.500	0.000	-0.500	-0.866	-1.000	-0.866	-0.500	0.000
Cos	1.000	0.866	0.500	0.000	-0.500	-0.866	-1.000	-0.866	-0.500	0.000	0.500	0.866	1.000
Tan	0.000	0.577	1.732	∞	-1.732	-0.577	0.000	0.577	1.732	∞	-1.732	-0.577	0.000

Table 5: Range of independent variable values (θ)

A	B	C	D	E	F	G	H	I	J	K	L	M
X	0	15	30	45	60	75	90	105	120	135	165	180
Sin^2x												
$3Sin^2x$												
Cos x												
$2Cos^2x$												

Table 6: Computed values of dependent and independent variables

A	B	C	D	E	F	G	H	I	J	K	L	M
X	0.000	15.000	30.000	45.000	60.000	75.000	90.000	105.000	120.000	135.000	165.000	180.000
Sin^2x	0.000	0.500	0.866	1.000	0.866	0.500	0.000	-0.500	-0.866	-1.000	-0.500	0.000
$3Sin^2x$	0.000	1.500	2.598	3.000	2.598	1.500	0.000	-1.500	-2.598	-3.000	-1.500	0.000
Cos x	1.000	0.966	0.866	0.707	0.500	0.259	0.000	-0.259	-0.500	-0.707	-0.966	-1.000
$2Cos^2x$	2.000	1.866	1.500	1.000	0.500	0.134	0.000	0.134	0.500	1.000	1.866	2.000

Procedures:

- Activate cell B3 and enter the formula =SIN(2*B1* PI()/180) and copy it to cells C3…M3
- In cell B4, multiply the content of B3 by 3 using the formula =B3*3 and copy it to cells C4…M4. In cell B5, enter the formula = COS(B1*PI()/180). This formula only finds the values of Cos x for each angle. Copy it to cells C5:M5
- To find $2cos^2x$ in cell B6, square the content of cell B5 (i.e., B5 raised to power 2) and then multiply by 2. The formula for raising B5 to power 2 is =POWER (B5,2). Multiplying the formula by 2, i.e., =POWER (B5,2)*2 gives the value of $2cos^2x$. Thereafter, copy the formula in B6 to cells C6:M6
- The formulae in cells B4…M4 are recopied to cells B7…M7 which is titled $3Sin^2x$. This is to ensure that equations y_1 and y_2 follow each other so that the values can easily be selected together. The Table of values is as shown in Table 6
- Select cells B4…M4 hold on shift key and select B6..M6; click Chart Wizard icon on the Standard toolbar
- In the Chart Wizard dialog box, choose Line chart type and then Line with markers displayed at each data value chart sub-type then Click Next and Next again
- Under Chart Options, enter all the options you want in your chart, click Next and then Finish

It should be noted that the learner must acquire the skill of converting angles in radian to degree.

Moreover, adequate understanding of the skills resulting the rudiments of solving graphical problems using computer approach.

CONCLUSION

Acquiring basic skills through the use of computer has really justified the inclusion of Computer Aided Instruction (CAI). As it can be seen above, some concepts including graphical problems perceived by many to be too difficult to learn can be taught using Spreadsheet package (MS-Excel). Perceived difficult topics by students in mathematics could be simplified for easy learning with the use of computer software packages such as Geometrical Sketch Pad, Microsoft Excel and Microsoft Word etc.

RECOMMENDATIONS

The researchers are in agreement with Etukudo's (2002) recommendations that:

- Mathematics teachers should be trained on how to prepare and use simple Computer-Assisted Instruction package
- Schools should be equipped with computers for purpose teaching and learning of concepts in mathematics
- Computer where so ever it is available should be used to teach any group of students irrespective of whether they are computer literate or not, by means of simple and easily understood packages which can be explored with the help of down or up arrow keys
- In-service training should be provided for mathematics teachers who are not vested with the knowledge of computers and for those who are already computer literate to provide them with the opportunity of updating their skills since computer is dynamic field
- Teachers should make efforts to have a total mastery of different packages that can be used to teach various mathematics topics as no single package can comprehensively address all the topics

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