Using Technology to Engage Students in Learning Mathematics

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ABSTRACT

For decades, students have been experiencing problems in understanding mathematical concepts. The use of technology has helped to overcome some of these problems. This paper attempts to share some of the technologies used by secondary school teachers in Singapore to facilitate students' learning, e.g. the use of dynamic geometry software such as the Geometer's Sketchpad (GSP) to help students visualize, experiment and construct new knowledge about geometric properties, and the use of Excel to reduce the tediousness of constructing graphs and enhance students' understanding of functions and graphs.

INTRODUCTION

Teachers often teach mathematical concepts by explaining the concept with reference to textbooks and getting students to work on the drill and practice exercises in the textbook. Teachers also stress the importance of memorizing algorithms, rules, definitions and formulas.

At the receiving end, students learn how to follow algorithms and procedures to get the correct answers. Such methods of teaching may produce "successful" mathematics students who are able to apply algorithms, rules and formulas in solving problems and in obtaining the right answers. However we are not aware whether these students have developed a conceptual understanding of the mathematical concepts taught because they have merely demonstrated the acquisition of procedural knowledge through a series of drill and practice exercises after each lesson.

One way to help students develop a conceptual understanding of the mathematical concepts taught is to allow students to construct their own knowledge during the process of learning these mathematical concepts (Bruner, 1966; Larochelle, Bednarz & Garrison, 1998).

The next section of the paper will describe how teachers have used technology, such as *The Geometer's Sketchpad* (GSP) and *Microsoft Excel* as visualization & simulation tools to help students develop a conceptual understanding of properties of geometry and graphs of trigonometrical functions respectively. *The Geometer's Sketchpad* (GSP) is a dynamic construction and exploration tool that enables students to explore and understand geometry through an interactive process. Through the use of GSP, students can explore geometrical properties more easily and interactively. The graphical features of *Microsoft Excel*, though a spreadsheet, can be used to help students focus on the conceptual understanding of graphical representation.

The availability of interactive and animated visualizations can enhance the learning process significantly (Koh, Koh & Wu, 2004). However IT is just a catalyst for teachers to engage students, the key success factor is not the IT tool itself but how it is being used. The examples given below will probably results in different impact on learning when used with different teaching method.

EXAMPLE 1: USING GEOMETER'S SKETCHPAD (GSP) TO INVESTIGATE THE SUM OF ANGLES IN A TRIANGLE

Conventional Approach

Teachers typically had to get students to find out that the sum of angles in a triangle equals to 180°. For the students to do this, teachers would get students to draw a triangle and take a protractor to measure the interior angles of the triangle. This process of investigation, however, was tedious and very limited as each student explored only one type of triangle drawn by himself or herself. Generally students drew acute angle triangles unless specifically told by teachers to draw obtuse angle triangles. In addition, there were few opportunities for students to use a wide variety of triangles to deduce the angle properties of a triangle.

Using GSP

In this lesson, students used a pre-designed GSP template (Figure 1) to investigate the relationship of the three angles in a triangle. As the students dragged the vertices, they could observe the changes in the angles in the triangle and its shape. Students were able to explore the angle properties using different types of triangles (acute, obtuse & right-angle triangles) and observe how the values of the various angles change with respect to the dimension of the triangles.

The use of GSP in this instance made learning interactive because the students learnt by manipulating and observing an unlimited number of triangles using the pre-designed GSP template. As a result, they could make conjectures on the sum of angles in a triangle.

Teachers shared that students were actively engaged in the learning process and encountered little difficulties in developing their conceptual understanding of the sum of interior angles of a triangle. Teachers also shared that it was obvious that through the use of GSP, the time taken for students to understand the geometrical properties was shorter and retention of knowledge was longer.

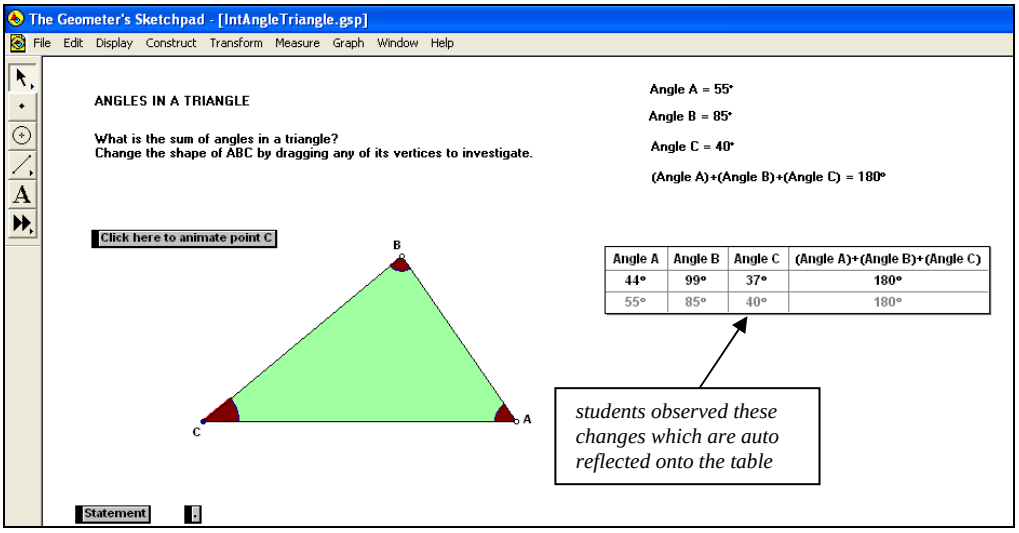


Figure 1. Using GSP to investigate the Sums of Angles in Triangle

EXAMPLE 2: USING EXCEL SPREADSHEET AS AN OPEN TOOL FOR PROBLEM SOLVING

The focus of the Lower Secondary Mathematics syllabus is mathematical problem solving. (MOE, 2000). Students can use Excel's rich source of mathematical functions as an open tool to carry out mathematical investigation and analysis.

Teachers use real-life problem to make it more authentic for the students. Take for example the following problem:

> *Kumar decided to take a loan of $100 000 to buy a house at an interest rate of 5.5% p.a. with a monthly repayment of $1400. When is he able to completely repay the entire amount?*

Conventional Approach

In real-life, the interest incurred per month will be less as Kumar pays his loan monthly so it would not be possible to solve using algebra. Students will have to calculate the amount owned at the beginning each month, calculate the amount of interest for each month and then the amount of he owns the bank after his monthly repayment. Typically, students will use a calculator which is tedious and time-consuming.

Using MS Excel

Excel spreadsheet can enable the students to perform the calculation easily and quickly. Teachers can even challenge the students to make decision on which bank to loan from giving different model of interest rate and repayment mode. In this example, the use of Excel spreadsheet has trivialized the process of calculation to generate the number of month required to repay the loan (Kutzler, 1999).

No. of Month	Amount owed at beginning of each month	Interest	Amount owed at end of each month after monthly repayment
1	$100,000.00	$458.33	$99,058.33
2	$ 99,058.33	$454.02	$98,112.35
3	$ 98,112.35	$449.68	$97,162.03
4	$ 97,162.03	$445.33	$96,207.36
5	$ 96,207.36	$440.95	$95,248.31
•	•	•	•
•	•	•	•
•	•	•	•
83	$ 6,527.52	$ 29.92	$ 5,157.44
84	$ 5,157.44	$ 23.64	$ 3,781.07
85	$ 3,781.07	$ 17.33	$ 2,398.40
86	$ 2,398.40	$ 10.99	$ 1,009.40
87	$ 1,009.40	$ 4.63	$ (385.98)

EXAMPLE 3 : USING EXCEL TO ENHANCE VISUALISATION AND UNDERSTANDING OF GRAPHS

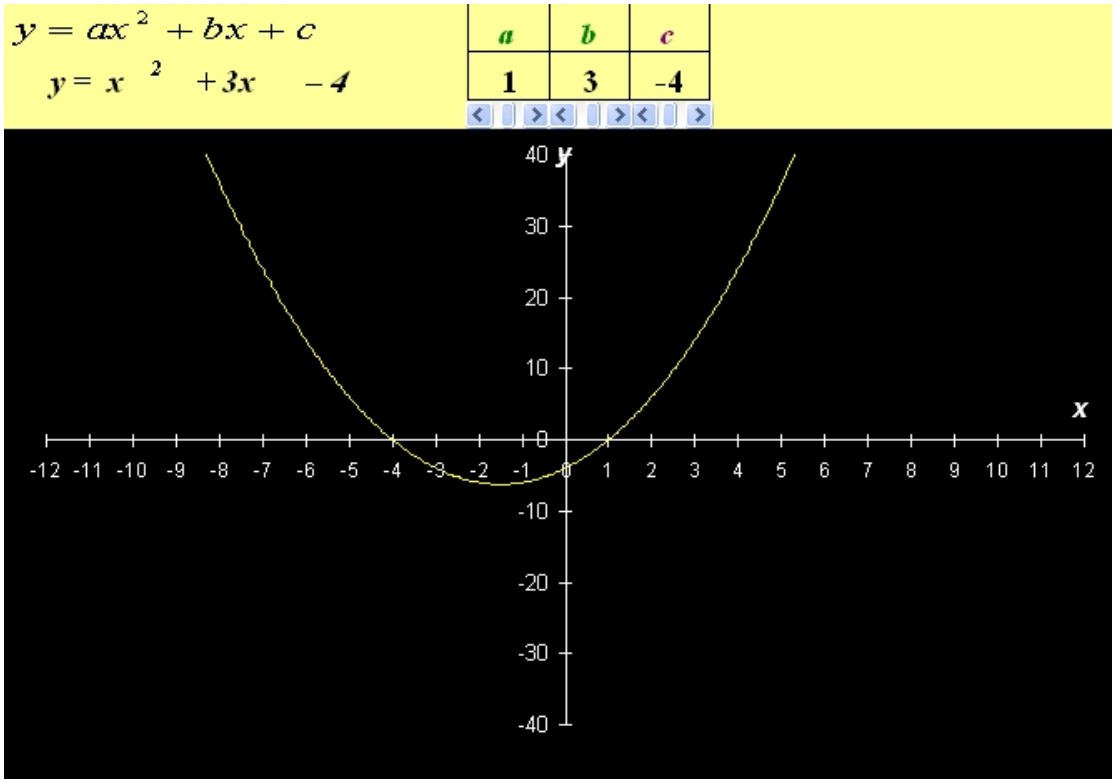
Conventional Approach

To get the students to deduce the relationship of the graph and the coefficients of the equation. Teachers can get students to observe the pattern from pre-drawn graphs and deduce the relationship. This method of comparison is usually limited to a few graphs with pre-determined coefficients of the equation.

Using Excel

In the example below, students can use a pre-designed Excel template to vary the coefficients of a quadratic equation. From observing the pattern, students will be able to deduce some relationship between the graph and the coefficients of the equation. The advantage is this is

interactive, by changing the coefficients *a*, *b* and *c*, students can observe how the graph changes. The coordinates will be automatically calculated and graph plotted for the students. In this way, students can save time plotting the graphs.

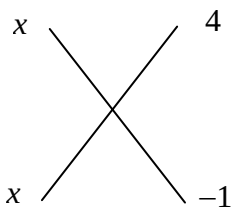


(source: Ms Loy Chong Hwa, http://www.mmpda.com/pastwinners.aspx)

Teachers can extend the use of the pre-designed template to get students to understand what is meant by the roots of the quadratic equation.

<u>Conventional Approach</u>

Teachers typically get students to factorise the quadratic expression using the cross method as shown below.



For the corresponding quadratic equation $x^2 + 3x - 4 = 0$, the roots can be solved as follows: $(x + 4)(x - 1) = 0$ implies $x + 4 = 0$ and $x - 1 = 0$, so $x = -4$ or 1. Students were then taught that the roots of the equation are –4 and 1. They were taught to carry out this mechanically and most of them may not understand what "the roots of an equation" mean.

Using Excel

Using the same MS Excel pre-designed template, students can investigate the relationship between the equation and the roots of the equation by looking at the graph. The roots of the equation are actually the values of x when y is 0. This can be observed easily from just looking at the intersection between the graph and the x-axis.

The two examples above show how the use of pre-designed Excel templates has facilitated students in recognizing patterns or relationships and visualizing the graphs.

CONCLUSION

Learning is an active process. To help students develop conceptual understanding of the mathematical concepts taught is to allow students to construct their own knowledge during the process of learning these mathematical concepts (Bruner, 1966; Larochelle, Bednarz & Garrison, 1998).

The investigative approach, presented in the three examples above, shifts the emphasis of learning mathematics from rote-learning to self discovery, which not only enhances the students' understanding of mathematical concepts through the application of these concepts in problem solving but also kindles their interest to further explore the mathematical concepts. We also observe students moving away from acquiring merely procedural knowledge to conceptual knowledge.

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