Use Technology in Secondary Mathematics Teaching: Preparing Teachers for the Future

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Abstract

Technology is an essential tool for learning mathematics in the 21st century and all Modern school classrooms have access to a range of potential technologies, ranging from calculators and computers to the Internet. This paper examines the use of Information and Communication Technology (ICT) for supporting the teaching and learning of transformations of functions in terms of linear, quadratic, cubic and trigonometry in the secondary school; and identifies some of the ways in which the teaching of functions might be supported by the availability of various forms of technology. An exam was applied and performance comparison between computer and paper-and-pencil groups. Modern technology provides an excellent mean of exploring many of the concepts associated with functions. This paper suggests some of the avenues for exploration.

1. Introduction

Today, teachers guide for students to learn mathematical concepts in mathematics education at all levels. Jonanssen and Carr [1] say that technology is used as a mind tool which can be used to support the deep reflective thinking that is necessary for meaningful learning. The National Council of Teachers of Mathematics [2] stated that technology is an essential tool for teaching and learning math, technology be used wisely by well-informed teachers to support mathematical understanding. Kerrigan [3] has found the benefits of using mathematics software and websites to include promoting students' higher-order thinking skills, developing and maintaining their computational skills, introducing them to collection and analysis of data, facilitating their algebraic and geometric thinking, and showing them the role of mathematics in an interdisciplinary setting . Heid, et. al. [4] considered the teacher in a technology-based classroom a "facilitator" of knowledge; while Healy & Hoyles [5] noted that the use of technology might present problems for teachers who are accustomed to a certain routine of instruction. The Committee for the Association of Mathematics Teacher Educators [6], the teacher preparation programs needs to focus on strengthening the pre-service teachers' knowledge of how to incorporate technology to facilitate student learning of mathematics through experiences that:

i) allow teacher candidates to explore and learn mathematics using technology in ways that build confidence and understanding of the technology and mathematics;
ii) model appropriate uses of a variety of established and new applications of technology as tools to develop a deep understanding of mathematics in varied contexts;
iii) help teacher candidates make informed decisions about appropriate and effective uses of technology in the teaching and learning of mathematics;
iv) provide opportunities for teacher candidates to develop and practice teaching lessons that take advantage of the ability of technology to enrich and enhance the learning of mathematics.

During the last decades, Information and Communication Technologies (ICT) have been introduced in a dynamic way in society and in a far lesser degree in education. Formal education or informal educations of various modes are all affected by ICT. By ICT in education we mean all the contemporary digital tools, such as computers, accessories and Internet that can be used in education helping to fulfil its goals. In general, there are several types of ICT used in mathematics teaching: graphing calculators, Java applets, spreadsheets, Computer Algebra System (CAS), and Dynamic Geometry Software (DGS), etc. The graphing capability provided by DGS helps students make the connections between the numerical, symbolic and graphical representations of a mathematical relationship. The use of ICT, therefore, appears to represent the concept of functions in terms of the strong linkage among the representational 'trinity' of functions: "numerical, symbolic and graphical" representations (Monaghan, [7]). O'Callaghan [8] claims that "function concept is essential to the algebra curriculum and is considered to be the most important concept in all mathematics". Hennessy et al. [9] assert that ICT speeds up the graphing process, freeing students to analyse and reflect on the relationships between graphs and their patterns. In this study, how teachers and students engage within an ICT environment in relation to mathematical functions will be presented.

2. Research method

The study was carried out on a year 10 class (students age 14-15). A pre-exam was applied to the students and according to the results they were separated into two groups, approximately at the same level. The groups were called A and B. The functions concept was instructed by using classical methods to group A in the classroom. The concept taught to group B in a computer laboratory by individual computer has a program prepared by the teacher. Each of the students in this group followed the lesson from his/her computer interactively.

The purpose was to understand how ICT supports the teaching of transformations of functions in terms of linear, quadratic, cubic and trigonometric functions and how students learn by incorporating ICT. The teacher demonstrated transformations of functions using ICT while students were using paper-and-pencil calculation and drawing. This study highlighted how ICT could be used in the classroom practice by observing teaching activities. It also presented the fact that the difficulties of learning this particular mathematical concept generally occurred during the shifting of different representations, for instance, from symbolic to geometric. In trying to find more effective ways to address this problem, it was discovered from the classroom observations that students learned through physically using ICT, rather than simply by observing how teachers incorporated it into the lessons. The graph of different types of functions as follows:

i) Graph of quadratic functions:

Give some different quadratic functions of the form $f(x) = ax^2 + bx + c$ (try different numbers a, b and c) and investigate them in the systematic way.

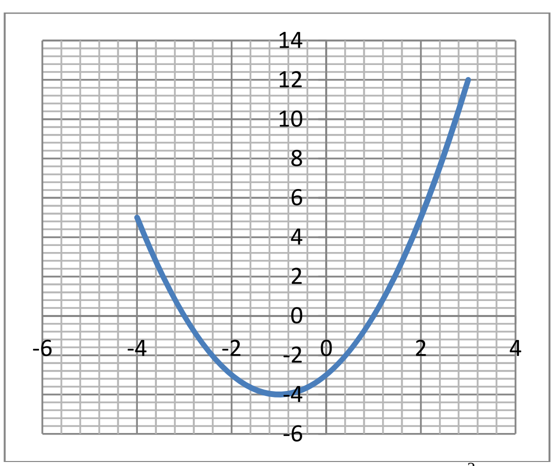

Figure 1: Graph of quadratic function $f(x) = ax^2 + bx + c$
Where a = 1, b = 2 and c = - 3

ii) Graph of cubic functions:

Give some different cubic functions of the form $f(x) = ax^3 + bx^2 + cx + d$ (try different numbers a, b, c and d) and investigate them in the systematic way.

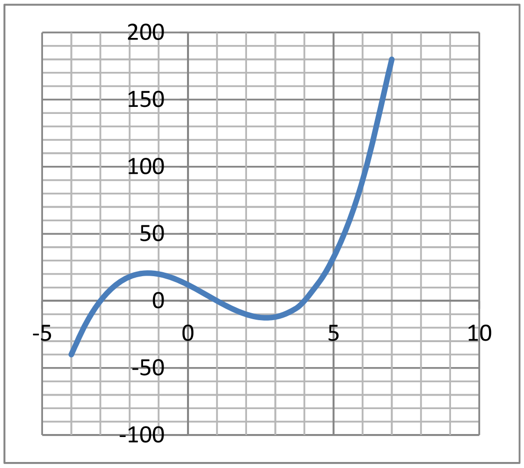

Figure 2: Graph of the cubic function $f(x) = ax^3 + bx^2 + cx + d$
Where a = 1, b = - 2, c = - 11 and d = 12

iii) Graph of trigonometric functions:

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 insights into the nature and differences between functions. Ready access to graphs on demand also allows students to use graphs for practical purposes, such as considering solutions to equations. A number of technology applications offer an opportunity for students to explore the nature of trigonometric graphs and an understanding of why they are periodic. An example is shown in Figure 1 from Maths Online website (Embacher and Oberhuemer [10]). This website includes a significant number of interesting and educationally sound applets related to trigonometry.

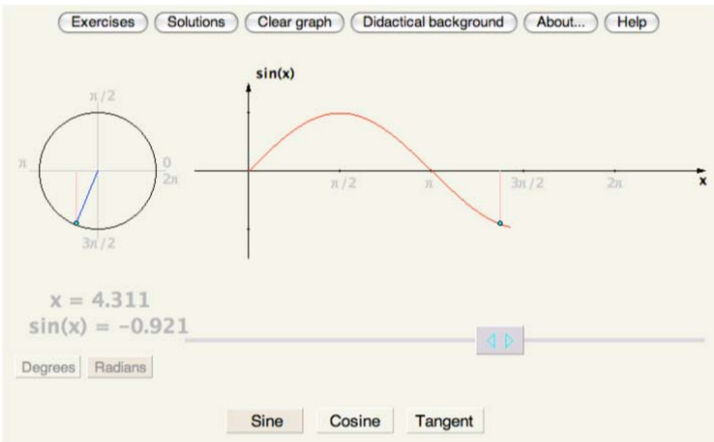

Figure 3: Graph of sine function

3. Data analysis

Programming is an important feature of computer technology and many specific languages have been proposed as means to manipulate mathematical entities. A central assumption has been that programming helps learners to reflect on actions and then favours conceptualisation. Theories have been built to support this assumption. The APOS (Action, Process, Object and Schema) theory (Dubinsky and McDonald, [11]) provided a sufficient theoretical framework for understanding the cases as the cognitive levels could be identified by the characterisations of students' ways of using Autograph. Dubinsky and McDonald [11], approach sees conceptualisation as a construction: the learner first considers actions (executed in command mode), then 'compiles' actions into processes (corresponding to computer procedures) and finally 'encapsulates' processes into new objects (new objects are added to the programming language). Actions can then be again considered on these new objects. This view was challenged by theories about visualisation (Tall, [12]) that proposed to take advantage of the multiple representations of mathematical entities allowed by computer technologies to favour more flexible approaches to conceptualisation. The generalisation of the whole learning procedure as a network of actions, processes and objects gives an indication of the form of cognitive schema. In order to use the framework for analysing the data, the transcription of the collected data was identified in accordance with APOS level and the ways that ICT supports the learning procedure were examined [Allison, [13]).

Cognitive Level	Characterisations
Action	➢ Utilising discrete points of a function- plotting, reading, projecting, etc. ➢ Performing graphs of functions in an analytical context by substituting values in them one by one and by operating the graph of the function based on the evaluation of independent points ➢ Using ICT to type in equations to make the graphs
Process	➢ Describing and relating functions' properties or behaviour in terms of comparing shapes or contours and looking at a number of graphs several times ➢ Comparing coefficients or algebraic terms
Object	➢ Interpreting and relating parts of algebraic expressions or equations ➢ Knowing the rules and properties, students can describe how they transform functions and predict how functions are transformed by looking at the graphs of transformed functions ➢ Making use of properties of functions through ICT
Schema	➢ Linking graphic and symbolic forms to construct a precise symbolisation for the information available in the given graph ➢ Having the whole understanding of the concept of how all multiple representations of functions link together ➢ Flexibly using ICT to present their concept of function

Table 1: Cognitive level and characterisation in APOS theory.

The data illustrates that the paper-and-pencil group had to repeat procedures including substituting values in functions one by one and drawing the graphs based on the evaluation of independent points to make their transformations (the network of Actions, Processes, and Objects) a multitude of times to approach the task. However, the computer group began with inputting functions (Actions), and then skipped Processes. Their mental Objects of functions were brought out to operate the transformations as they had already learnt about how the graphs could be transformed. It can be shown that, with ICT, students were able to perform the task more flexibly and instantly. An exam was applied to both groups. Although both groups had started with 34 students, 18 students from group A and 16 students from group B participated to the exam. The answers of the students were separated into two certain groups, as true and false answers. An answer was accepted as true one if it was given correct result with correct explanation otherwise it was accepted as a false one.

4. Conclusions

True answer percentages obtained from the exam results are given below:

	GROUP A	GROUP B
Question	True answer (%)	True answer (%)
1.	36	67
2.	40	57
3.	61	80
4.	44	71
5.	16	24
6.	12	14
7.	12	29
8.	70	81
9.	19	30
10.	24	36
Mean	33.4	48.9

Table 2: True answer percentage of students.

It is observed from above table, that group B is more successful. It can be said that teaching the functions concept with using computer support has a positive effect in understanding this concept. One of the reasons of this positive effect might be the contributions of computer to the visualization.

This paper has sampled from the available technologies that learners or teachers may have access to for teaching and learning functions in the early years of the twenty-first century, to illustrate the claim that there are many ways in which teaching and learning might change, when compared with earlier approaches. One major change is the opportunity provided by technology to help students engage with functions concepts; a second major change is that students can interact directly with functions ideas through the medium of technology in a more active way than is possible with paper and pencil alone.

Today’s middle school and high school students were born into a world with technology. Using technology during mathematics instruction is natural for them, and to exclude these devices is to separate their classroom experiences from their life experiences. One objective in preparing teachers for the future is to ensure that their classrooms will include the technology that will be commonplace for a future generation of mathematics learners, thus ensuring that the mathematicians, mathematics educators, and citizens of tomorrow experience harmony between their world of mathematics and the world in which they live.

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