

Using Technology for Teaching Engineering and Science

Graphics Calculators

Using the Graphics Calculator to Support Mathematics for Engineering Students

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Abstract

For first and second year engineering students at Napier University, the TI-83 graphics calculator plays a major role in an integrated technological approach to mathematics. This case study reviews the process of integration and its current position in the teaching of students.

Level of Material: First and Second Year

The Execution

The embedding of calculator technology into the curriculum commenced in 1994.

32 students in an electrical engineering class were asked to buy a Texas Instrument TI-82 graphics calculator. Their lectures and tutorials were redesigned so that the calculator could be fully integrated into the teaching process. The aims of the project included promoting conceptual understanding, increasing students' confidence about mathematics and improving the accuracy of their work [1].

A flexible resource was created by connecting the lecturer's calculator to a viewscreen, allowing the lecturer to teach within an ordinary classroom with an overhead projector (OHP). This enabled students to see the display and to follow the steps on their own calculators.

Topics taught during the pilot study included functions, vectors, matrices and determinants, complex numbers, calculus and statistics. Examination questions were reviewed to take account of calculator use and it was made clear to students how much 'working' they must include in their written answer. This was important so that logical thought and the communication of mathematics were encouraged.

The pilot study continued with the equivalent class in 1995. Structured interviews were held with the group using the TI-82 and with a control group studying the same module without the use of a graphics calculator. Students were asked questions which measured their understanding of important concepts. It was found that significantly more of the class who had used the TI-82 demonstrated a better understanding of simultaneous equations, exponential functions, derivatives and stationary points than was the case with the control group [1].

Upon gaining approval from the engineering department, in 1997 the new TI-83 became embedded within the curriculum. The use of the technology was extended to include students on Mechanical Engineering and Science degrees. It became an integral part of the teaching of mathematics to engineering students at Napier University. Today, all first and second year students taking Engineering Maths Modules are encouraged to buy the TI-83 and they are each provided with a set of notes about the calculator.

In the lectures, teaching mathematics is based around four stages: explaining the theory to students; worked examples; examples with the aid of the graphics calculator; and illustrating the maths topics in a context relevant to engineering. In the tutorials, the calculator is used in exercises designed to develop competence in mathematical techniques, and in some cases to develop skills toward mathematical modelling. In both the lectures and the tutorials the calculator provides a visual understanding of graphical solutions and the related arithmetic and plays an integral part in the teaching of mathematics in engineering applications. Generally it enhances the teaching and learning of mathematics and consolidates the coursework.

Pre-requisite Knowledge

First and second year students have a wide variety of mathematical backgrounds. Many students enter first year courses with disappointing maths results; some will have struggled throughout their secondary education and some are mature students re-entering education. Some possess few mathematical skills, for example in basic manipulative algebra and the rules governing mathematical processes.

Students do however have IT skills and in many cases are familiar with graphics calculators. Academics teaching the engineering mathematics modules assume that students have limited mathematical knowledge. The aims of the modules are to break down barriers and help students gain confidence. The calculator is just one feature in that process.

How Are Students With Different Mathematical Backgrounds Supported?

It is important to recognise that the calculator is part of a teaching and support package, which also includes: MathPlus – a drop-in centre, computer based assessment, flexible learning booklets, tutorial exercises and applications, use of mathematical software, staff workshops and module meetings. During class the first year students spend time revising foundation maths and are encouraged to use the calculator throughout the engineering course.

What Support Was Needed?

The calculator is an integral part of today's education system and almost all students have encountered the tool. For those who have problems with using the calculator, assistance is offered at the beginning of the academic year and throughout. An arrangement has been made with Waterstone's in Edinburgh for the students to buy the TI-83 graphics calculator at a reduced price. In return for the barcode the students are issued with a free copy of "Introduction to the TI-83 Calculator".

At the beginning of each semester workshops are run on the graphics calculator for the staff. They are shown the TI viewscreens, which enlarge and project the image of the graphics calculator display so it can be viewed by an entire group of students. During the semester there are regular meetings/discussions with all academics involved in the engineering maths modules.

The Barriers

The main barrier is the students' attitude – many lack confidence. They have had negative experiences in maths and seriously lack study skills. Some students complain about having to purchase the calculator, but most appreciate the value of buying one, as it will be used throughout the four years of the course. In special cases the department will supply one, to be returned once the module is completed.

The Enablers

There is no major difficulty in using the calculator. These days students have the necessary skills to use the technology and its use provides an incentive to learn. Furthermore, when incorporated within the teaching, a calculator such as the TI-83 enables the students to see the maths topics in a context relevant to engineering. It helps them to visualise mathematical concepts. Such IT products are changing the way mathematics is taught and are having a significant impact on the curriculum.

Evidence of Success

Students fill in a standard questionnaire supplied by the faculty. They are asked questions about the various aspects of the module, including what they liked most about the modules and what they liked least. These responses are summarised and circulated to the relevant members of staff and the School of Engineering.

In a recent module questionnaire response, general comments were extremely positive and related to the teaching methods including the use of the calculators. One student stated, "I feel the teaching methods are excellent..." another response was, "The way the class is taught helps me learn more effectively". There were no specific comments relating to the calculator other than one student complaining about the cost of purchase.

How Can Other Academics Reproduce This?

In general the introduction of the calculator raises new issues, as there is a need to change the style and approach to teaching. It is important that academics become familiar with the technology so they can demonstrate to a class of students. Judgments must be made about how much time should be allocated to the use of the calculator. In addition, appropriate types of investigative work must be identified. The financial implications must also be considered. It is vital that all students have the same model of calculator. Students were not required to buy a first year mathematics textbook, and they recognised that the calculator would be useful throughout the four years of the course.

Quality Assurance

All maths modules are validated by the University's Quality Enhancement Services (QES) and any changes have to be approved by a Faculty committee before they are presented to QES. The marking of the assessments is shared so that continuity and consistency are achieved. There are module meetings before and throughout the semester to discuss quality in reference to Napier's LTA strategy.

Reference

- [1] Four Years Experience of Graphic Calculators in the Mathematics Classroom, *Mathematics Today*, 35(1), Scott, T., Jackman, S., Ballantine, H., and Harvey, J., (1999).