

Graphics Calculators

Teaching Mathematics to “Science with Management” Students Using A Graphic Calculator

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Abstract

The introduction of the graphics calculator has provided the fourth year students taking Science with Management Studies with an interactive learning tool. This case study reviews its introduction into the course Discrete and Continuous Models at Napier University.

Level of Material: Fourth Year

The Execution

The module Discrete and Continuous Models is offered to fourth year students enrolled in a BSc Science with Management Studies. The objectives of the course are to formulate and solve models involving differential and difference equations for a range of applications in physical sciences, biology and management, and to investigate the behaviour of solutions of discrete and continuous models.

During the last five years, the content of the course has remained the same. Any changes have been brought about by the introduction of technology. Initially a software package called Nodes was used to help the students produce graphical solutions. Later this was replaced with the TI-86 graphics calculator and the computer package Mathwise.

Throughout this period the emphasis of the course began to shift towards a combination of traditional mathematics and graphical output, to assist the investigation and interpretation of behaviour models. The alternative approach to learning, teaching and assessment presented by the technology began to motivate the students and encourage interaction.

Today the calculators are provided to the students during the course. They are used to plot solutions of differential equations, to construct phase plots and to explore solutions of discrete models. These tools enable the students to produce answers more easily and in a different form. Mathwise is used for revision and reinforcement. The overall assessment of the course also changed to an examination in which the calculator is used (70%) and a computer/calculator based assignment (30%). The assignment involves the investigation of a model given by a pair of differential equations in which the TI-86 is used to produce a phase portrait of a particular case. The results are interpreted and discussed in a report. The 13-week teaching programme is a combination of lectures, calculator workshops which provide an opportunity to practise basic techniques, Mathwise labs and tutorials.

In early lectures the students revise the solution methods for first and second order equations. Linear and non-linear models are also introduced. Students are familiar with this material but little time has been spent on looking at models in depth. The next stage of the programme looks at systems of differential equations and the construction of phase portraits using a graphics calculator or a computer package. There is also an in depth study of models from physical and social science e.g. predator-prey, competitive species and epidemics (see Model – Epidemics question). The final part of the course looks at difference equations.

For the academic the calculator is used in the teaching process, illustrating changes within the models as they occur. The TI viewscreen can be used to enlarge the image from the graphics calculator and display it on an OHP screen. Throughout there is an ongoing process of relating the graphical output to the analytical solution and the traditional mathematics.

For the students, carrying out the coursework requires a genuine understanding of the mathematics and the procedures involved. The calculator provides the means to create a graphical representation of the phase portrait. It is a learning tool, which enables both the academics in the teaching environment and the students to achieve something that could not be achieved without it. It also assists the students to learn something more effectively and efficiently than they could otherwise [1].

Pre-requisite Knowledge

The class presents varying levels of attainment. For some their overall mathematical background is limited, for others a lack of recent study of differential equations can prove a problem.

How Are Students With Different Mathematical Backgrounds Supported?

The class is small, therefore there can be ongoing individual support. The students use Mathwise modules to revise differential equations.



The Barriers

Approval of the external examiners had to be obtained to include the calculator in the course structure. They are now supportive. There are no major problems in using the calculator in the teaching process or as part of the module assessment and the examination.

The Enablers

The calculators are provided on loan and each student is given a manual.

Evidence of Success

The feedback from the students is extremely positive. The students enjoy the work and put in a lot of effort. The assessment work is detailed and indicates a high level of understanding.

How Can Other Academics Reproduce This?

- To integrate the calculator within a module academics must have a clear understanding of the role it will play.
- Approval is required if the technology is to be used as part of the coursework, assessment and also in the examination.
- The coursework must be relevant and interesting. There must be a strategy in obtaining the calculators and making them available to the students.
- Class time must be allocated to use the calculator, e.g. calculator workshops.

Quality Assurance

All modules undergo an annual review where feedback on teaching and assessment is examined. Comments back from the students are extremely favourable.

Reference

- [1] The Use of IT to Support Mathematics for Science and Engineering, <http://ltsn.mathstore.ac.uk/workshops/math-support/Mackie.pdf>, Mackie, D., (2002).

MA40007 Tutorial

Model: Epidemics

1. Solve the epidemic model:

$$\frac{dS}{dt} = -rSI$$

$$\frac{dI}{dt} = rSI - \gamma I$$

on your graphics calculator, given $r = 0.1$ and $\gamma = 6$ for the following cases:

$$S_0 = 100 ; \quad I_0 = 5, 10, 40$$

$$S_0 = 80 ; \quad I_0 = 5, 10, 40$$

$$S_0 = 60 ; \quad I_0 = 20$$

$$S_0 = 40 ; \quad I_0 = 10$$

- a) In each case, (i) plot the phase path for $0 \leq t \leq 5$;
 (ii) use the TRACE facility on your calculator to estimate
- The maximum number of people infected at any one time;
 - S_∞ ;
 - The duration of the epidemic;
- (Assume the epidemic has ceased when $I < 0.1$)
- (iii) deduce the total number of people who catch the disease as a percentage of the population.
- b) Construct a phase portrait and explain the behaviour of the model.

Reference: *Modelling with Differential Equations*, Ellis Horwood, Burghes, D. N., and Borrie, M. S., (1982).