

# [O8] Mathtutor: supporting students in learning mathematics

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## ABSTRACT

'*mathtutor*' is a new mathematics e-learning resource for mathematics and science education, which delivers diagnostic tests, video tutorials, interactive exercises, animations and printable text via DVD and the Internet. It has been designed to support students through AS and A2 level mathematics to 1st-year undergraduate programmes in engineering, mathematics and the sciences, and represents the culmination of extensive collaborative work between the EBS Trust and the universities of Leeds, Loughborough and Coventry, supported by funding from HEFCE (FDTL4) and the Gatsby Foundation. This paper begins by highlighting some of the current problems surrounding mathematics in the sciences and outlines the background to the development of '*mathtutor*'. It goes on to describe the structure and key features of this learning resource and concludes by summarising a proposal to apply the same technologies in the development of a multimedia and e-learning resource for mathematics support for students of the life sciences. The latter will apply a contextual learning model in creating a problem-solving e-learning environment.

## BACKGROUND

There has been growing concern within the sciences about students' mathematical abilities. The problems have been well documented by disciplines ranging from engineering, to the life sciences (Phoenix, 1999; Lenton and Stevens, 1999; Savage and Hawkes, 1999; Tariq, 2002a), and have been highlighted by some professions, such as nursing (Cartwright, 1996; Hutton, 1998; Bishop and Eley, 2001).

In the life sciences, which encompass a wide diversity of disciplines, the range and level of mathematical skills required of undergraduates inevitably vary; however, all require a core of numerical ability (Phoenix, 1999). Over recent years concerns have been expressed that many students lack confidence in their ability to deal with basic mathematical concepts and are unable to calculate accurately and efficiently even when using a calculator. They are often unable to manipulate or appreciate numbers and equations, to use scientific notation or to explain and make predictions from data presented in graphs, charts and tables (Lake, 1999; Phoenix, 1999; Tariq, 2002a, 2002b, 2003). Many life science students enter their degree programmes possessing only GCSE Mathematics (or its equivalent) and only a minority possess a

higher mathematics qualification (e.g. at AS- or A2-level). Concerns have been expressed that changes to GCSE mathematics curricula over the years have reduced the expected level of ability of students entering life science degree courses. But even allowing for this, university departments should be able to assume that most students can manipulate fractions and decimals, handle powers of ten and be able to plot and interpret graphs.

Universities have been forced to expand and the cohort of students arriving each year is not only larger but much more diverse in terms of the students' prior academic experiences and achievements. Twenty years ago our science undergraduate populations were far more homogeneous. Nowadays students embarking upon science degree programmes possess a more diverse portfolio of qualifications, ranging from GCSE, through AS- and A2-levels, to diplomas, and may come from work-related backgrounds, as well as from conventional schools and further education colleges. Changes to secondary level mathematics syllabuses in the 1980s and 1990s have allowed students to achieve good grades without having been taught some of the more difficult concepts and skills. In addition, Lenton and Stevens (1999) suggest that difficulties with mathematical concepts in science lessons may arise from the teaching of facts and skills as opposed to teaching through conceptual understanding by science teachers and unqualified teachers of mathematics. The latter situation has been compounded by the difficulties associated with finding sufficient professionally qualified mathematics teachers (Smith, 2004). Today's students need to be provided with new ways of learning maths, and to be offered fresh perspectives on their chosen discipline.

## PROVIDING STUDENT SUPPORT IN MATHEMATICS

Universities have had to implement a variety of strategies aimed at supporting their under-

graduates' mathematical knowledge and skills. Many science disciplines have adopted a range of strategies to help identify entrants' specific difficulties regarding their basic numeracy skills and the mathematics regarded as an essential foundation for subject disciplines, and to support students' academic development (Tariq, 2004). Learning support strategies adopted include:

- *formal mathematics courses or teaching sessions* – the latter may form part of either foundation quantitative subject-specific modules or more generic skills modules for first-year undergraduates. Their primary aim is to ensure that all students understand the basic mathematical concepts necessary within the discipline. But delivering such courses can often feel like an up-hill struggle!
- *tutor-led small group tutorial sessions or workshops* outside the formal curriculum. The problem often encountered here is getting students to engage in a process that can appear to them as offering few returns in terms of any summative assessment and final qualification.
- *dedicated mathematics learning support centres*. Some 50% of institutions have such facilities. Where available, these have proved successful and some provide a most professional service. However, in the main they seem to be used by students of maths and maths-based subjects and the proportion of students using them can be relatively low. There is also the recognition that they might appeal to those students who already possess a high level of maths competence and seldom draw in those students in greatest need of help and support.
- *computer assisted learning (CAL) materials*. These are often self-paced

tutorials and assessment exercises, developed in-house, using software such as QuestionMark™ or web-development software (e.g. Macromedia® Dreamweaver®), and tailored to satisfy the demands of a particular discipline or specific module.

- *self-help and independent learning resources*, e.g. handouts, instructional guides and/or textbooks (e.g. Phoenix, 1997; Foster, 1998; Cann, 2003, www.mathcentre.ac.uk).

All these approaches are valid but are often local to one institution. What was needed was to build on these activities and consider a national resource that would be available to all students and their teachers.

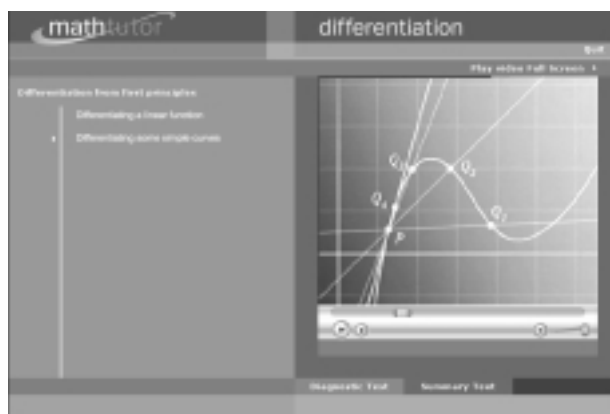
## ENTER MATHTUTOR

'*mathtutor*' and its sister website '*mathcentre*' represent exciting new generic mathematics learning resources, based on the tutorial model of teaching and making extensive use of video and animation (Fig. 1). '*mathtutor*' consists of a series of six DVD-ROMs covering over 80 topics in arithmetic, algebra, geometry, trigonometry, vectors, functions, graphs, sequences and series, differentiation and integration. The level straddles GCSE, AS and A2 mathematics, with a nudge into 1st-year undergraduate programmes. '*mathtutor*' has been designed as a resource to support individual learning, rather than as a discrete course. Each topic is prefaced with a diagnostic test and has associated with it pages of interactive exercises, some 2000 in all. There are over a hundred video tutorial sequences, some of which are quite long – up to an hour – but each video tutorial has a menu for easy navigation. Students appreciate the style of tuition, with a 'live' tutor providing detailed explanations at an appropriate pace for the learner. The built-in facility to stop and re-play each video tutorial is particularly advantageous and the

feel of the tutorials is very much one of personal and intimate teaching. When the algebra section was evaluated in 2004, more than 80% of students found the materials useful or very useful.

'*mathtutor*' has been produced by a team led by the University of Leeds and the EBS Trust who are experts in new media production. On the team are academics from the universities of Coventry and Loughborough together with television producers and technicians. Funding has been jointly achieved through a HEFCE's FDTL4 grant and a matching grant from the Gatsby Foundation. It is anticipated that all the materials will be published in summer 2005, in both disk and web formats.

**Figure 1: Sample screen from '*mathtutor*' illustrating an animation for 'Calculus from first principles'**



## ADAPTING 'MATHTUTOR' FOR THE LIFE SCIENCES

### The challenge

A team of academics is currently working in collaboration with the EBS Trust to adapt aspects of '*mathtutor*' for life science undergraduates. Our challenge is to try and address some of the key issues and concerns highlighted above. In short, our aim is to produce a national multimedia e-learning resource to support students in their

acquisition, practice and application of those mathematics skills essential to the life sciences. Since the life sciences include a plethora of specific disciplines, the first questions we must answer in formulating a strategy to meet this challenge are '*Which life sciences will we cover?*', '*What mathematics are regarded as essential to these disciplines?*' and '*What learning model should we use?*'

An initial pilot project will select a single discipline (e.g. microbiology) or aspect (e.g. cell biology) to cover. Few would argue that it is possible to identify a core level of mathematical ability required by all students embarking on life science degree pathways (Phoenix, 1999; Tariq, 2004), e.g. the essentiality of basic arithmetic; the ability to manipulate algebraic expressions and equations; the presentation and interpretation of graphical data; and if students are to understand movement and rates of change and predict outcomes with confidence they will have to get to grips with elements of calculus.

Our main challenge lies in increasing students' confidence in their ability to engage with the maths, both basic and more advanced, that is an integral part of their life science discipline. The first step involves persuading students that maths can be exciting, that it can provide fresh insights into biological phenomena and that it is increasingly relevant to the life sciences. So how can we get this message across?

### **Using the power of contextual problem-solving towards an innovative solution**

We plan to adopt Coles' contextual learning model (Coles, 1997) and apply it to problem-solving in an e-learning environment. Maths is an exciting subject and should be taught in such a way as to complement the biology, rather than as an abstract necessity. So rather than present students with a range of maths topics and then use biological examples to simply illustrate the application of the

mathematical concepts, might it not be better to take some exciting biological topics, case studies and scenarios, present them in a highly visual manner and explore the mathematics within each – teaching students and enabling them to practise the maths required for them to understand and master the topic? Each case study would demand mastery of one or more particular mathematical concepts and skills. There would inevitably be overlap and reinforcement; several case studies might demand the same mathematical skills and there might be several maths topics associated with any one case study. The principle of this approach is that the context (i.e. the case study) triggers students to want (as opposed to need) to learn the maths. This should appeal to students of the life sciences who would see their own subject area as distinct from others and immediately want to delve into a particular scenario. Associated with each case study would be a number of questions, tasks and calculations for students to complete. In addition, students would be provided with online video-based tutorial support for those maths topics and concepts with which they lacked confidence or with which they were unfamiliar; this would be similar to the format successfully applied in '*mathtutor*'. They would also be provided with the opportunity to practise and apply their skills to new case studies, thus linking theory to practice.

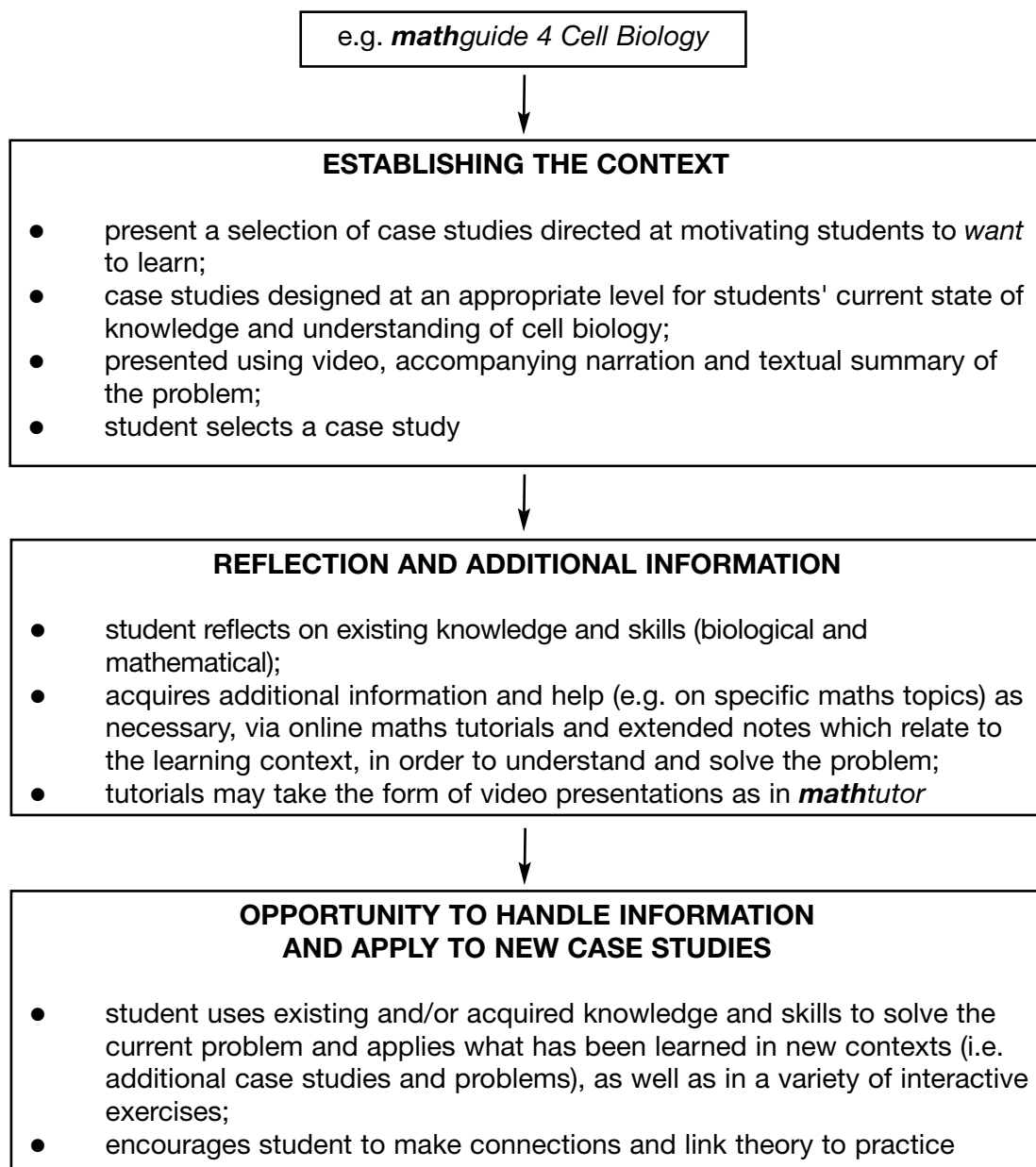
The overall structure and navigation through this innovative learning resource are summarised in Figure 2. Upon selecting a particular discipline or specific aspect, a student will be presented with a list of relevant case studies from which they may make their selection. Each case study will be delivered as a filmed and narrated story involving a real event or biological phenomenon and the necessary mathematics associated with it. From this case study learners will be able to navigate to one or several sections of maths topics required for their better understanding of the maths associated with the case studies. The latter would be presented by a real tutor as

in '*mathtutor*' and there would be an extended text version of each tutorial available for printing. What would be interesting would be to explore supplementary exercises which would enable learners to practise the maths they had learned, but to make such exercises relate directly to appropriate biological case studies, i.e. once again contextualising the maths. Here we could also incorporate extensions to the maths, taking the learner to new and exciting

developments in biology which involve fascinating maths.

Although the aim is to create a form of problem-solving distance learning or mediated self-study tool, the resource developed could be integrated into lectures, tutorials or practical classes within specific modules or programmes.

**Figure 2 Proposed model for a life sciences multimedia learning resource**



## Scope of the project

The project aims to embrace most of the principal disciplines within the life sciences and to cover the maths necessary for a full understanding of all the case studies presented. The resource will offer something of an alternative course in maths for the life sciences, with the emphasis on the life sciences first and then the underlying maths that students need. We aim to make everything highly visual, realistic and full of movement and excitement.

If you are interested in participating in this project please contact Jim Stevenson (jim@ebst.co.uk) or Vicki Tariq (vtariq@uclan.ac.uk).

## REFERENCES

- Bishop R. and Eley A.** (2001) Microbiologists and maths. *Microbiology Today*, **28**, 62–63.
- Cann, A. J.** (2003) *Maths from Scratch for Biologists*. Chichester: John Wiley and Sons
- Cartwright M.** (1996) Numeracy needs of the beginning registered nurse. *Nurse Education Today*, **16**, 137–143.
- Coles C.** (1997) Is problem-based learning the only way? In D. Boud and G. I. Feletti (eds) *The Challenge of Problem-based Learning*, 2nd edition, Kogan Page, London.
- Foster P. C.** (1998) *Easy Mathematics for Biologists*. Amsterdam: Harwood Academic Publishers.
- Hutton B. M.** (1998) Do school qualifications predict competence in nursing calculations? *Nurse Education Today*, **18**, 25–31.
- Lake D.** (1999) Helping students to go SOLO: teaching critical numeracy in the biological sciences. *Journal of Biological Education*, **33**, 191–198.
- Lenton G. and Stevens B.** (1999) Numeracy in science. *School Science Review*, **80**, 59–64.
- Phoenix D. A.** (1999) Numeracy and the life scientist! *Journal of Biological Education*, **34**, 3–4.
- Phoenix D.** (1997) *Introductory Mathematics for the Life Sciences*. London: Taylor and Francis.
- Savage M. and Hawkes T.** (1999) *Measuring the Mathematics Problem*. A report published under the auspices of: the LTSN for Maths, Stats and OR, the Institute of Mathematics and its Applications, the London Mathematical Society, and the Engineering Council.
- Smith, Adrian** (2004) *Making Mathematics Count: Inquiry into Post-14 Mathematics Education*, DfES.
- Tariq V. N.** (2002a) A decline in numeracy skills among bioscience undergraduates. *Journal of Biological Education*, **36**(2), 76–83.
- Tariq V. N.** (2002b) Numeracy skills deficit among bioscience entrants. *LTSN Bioscience Bulletin*, No. 7, p. 8.
- Tariq V. N.** (2003) Diagnosis of mathematical skills among bioscience entrants. In *Diagnostic Testing for Mathematics*, LTSN Maths TEAM Project, pp.14–15.
- Tariq V. N.** (2004) Numeracy, mathematical literacy and the life sciences. *MSOR Connections* **4**(2), 25–29.