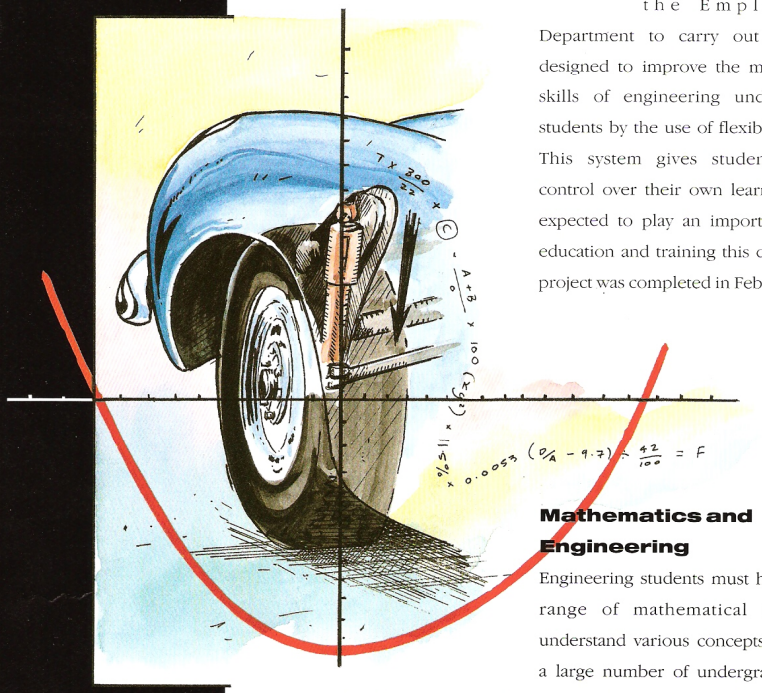
LEARNING TECHNOLOGIES

Computer Algebra and Mathematical Modelling

MAKING MATHS LEARNING EASIER



The University of Sunderland was funded by the Employment Department to carry out a project designed to improve the mathematical skills of engineering undergraduate students by the use of flexible learning. This system gives students greater control over their own learning and is expected to play an important role in education and training this decade. The project was completed in February 1992.

Mathematics and Engineering

Engineering students must have a wide range of mathematical skills and understand various concepts. However, a large number of undergraduates are found to be 'mathematically unadapted'. This is a term meaning that they have intelligence but have a mental block in understanding basic mathematical concepts, a problem experienced by many universities. At Sunderland, students who are weak in mathematics are given the opportunity to attend remedial courses which provide extra tuition. However, these courses have little impact. Despite the extra help, some students still find it hard to grasp the concepts behind certain mathematical operations. In 1987, the University's Computing and Mathematics Department obtained a £55,000 grant from the Employment Department to set up a remedial laboratory for mathematics learning. The laboratory uses computer programs to help the students. This is found to be more effective than traditional teaching. The remedial laboratory is now being marketed as a package called 'Maths to Go'.

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LEARNING METHODS CASE STUDY

However, the project team was keen to see if other methods could be used to help students. The resulting work made use of a learning environment known as a Microworld.

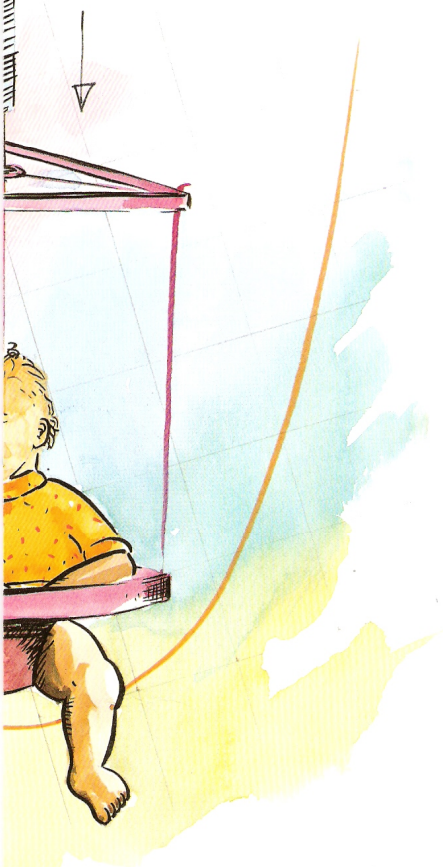
Microworlds

A microworld is a learning environment which provides the student with special computer programs (or software), technical aids and possibly practical materials. These tools enable students to explore and understand real life problems on a computer screen. The problems are often in the form of simulations which can be controlled and manipulated by the student. Microworlds offer a number of advantages over traditional teaching methods:

- They are flexible. Students can work at their own pace and direction.
- They are cost-effective: there is no need for expensive resources or materials.
- They are friendly. Most systems offer on-line help and unlike humans, the computer does not run out of patience when a student consistently fails to grasp an idea or concept.
- They are more efficient because users do not have to spend time waiting for the tutor to help or direct them.
- They are adaptable: students can alter various parameters and see the effects. This may not always be possible in a real life situation.
- They are safe: students cannot harm themselves or damage equipment.
- They can raise interest and motivation because the students are working at a speed that suits them.

- They are effective: students can gain a greater insight into a problem or concept by altering various parameters and studying their effects.
- This type of learning is heuristic. It is closer to how humans acquire knowledge in the real world. A microworld involves learning by trial and error. Knowledge is gained from the student's own experience.

The project consisted of two main strands: the use of System Dynamics and the use of a commercially available mathematics computer program called Mathematica. Both strands made use of the microworld environment.



System Dynamics

System Dynamics was first used in the 1950s to model economic problems. The system uses simple flow charts and diagrams to describe an event. This style of presentation is much friendlier than a screen full of complex mathematical equations or formulae.

The computer system is very easy to use and most users can operate the program very quickly. The software package consists of five microworlds which enable students to build models in the following areas:

- Herbivore Island. This looks at how the ratio of predator to prey affects the size of populations.
- Baby Bouncer. This is used to examine the effects of spring damping or shock absorption – an important engineering concept.
- Electrical Circuits. Students can study the effects of current, voltage and resistance in an electrical circuit.
- Projectile. This examines the behaviour of a bouncing ball.
- Tea Time. In this model students examine the factors which affect the cooling rate of a cup of tea.

The user can alter various parameters and study their effects. The results may be presented in the form of graphs or numbers. By looking at how a model works the student can grasp a concept more easily. For example, in the electrical circuit model, the student can clearly see how an increased voltage affects the resistance in a circuit.

Mathematica

In a conventional mathematics program, the student types a question on a keyboard and the computer instantly displays the answer. The problem with this type of system is that while students receive the correct answer, they gain no insight into how the solution was obtained.

However, the Mathematica program provides a step-by-step description of all the stages involved in a calculation. It is as if a teacher had described the problem on a blackboard.

Mathematica enables students to examine calculations in detail. If the student doesn't understand a specific step, he or she can get additional help from the program or tutor.

Evaluation

This strand examined the same areas but Microworld enabled the user to build the mathematical equation and then solve it using Mathematica.

The project team has so far carried out a small scale evaluation of their work. The results have been encouraging with students describing the systems as 'interesting', 'helpful' and 'easy to use'. The project team plans to start a larger evaluation study in the forthcoming academic year. However, the results so far suggest that the microworld systems offer a flexible, friendly and cost-effective solution to the problem of mathematics teaching in engineeing.

Future Developments

The work produced by the University of Sunderland could also be used in other areas, for example by:

- other departments which also require students to have extensive mathematics skills, such as psychology, technology and statistics;
- other departments which use modelling systems, such as environmental studies and pharmacy;
- other educational institutions who could benefit from the project work;
- industry, which could use Systems Dynamics programs for education and training.

The University has described its work in various journals and at numerous scientific conferences, where there has been much interest. The project team is currently exploring the possibility of gaining funding to commercially exploit its work.

Summary

University courses are becoming increasingly demanding and the student population is rising. These two factors suggest that an increasing number of undergraduates will require extra help if they are to acquire the basic skills demanded by a particular course. This will put increasing pressure on the course tutor's time and resources. For this reason, flexible learning systems are likely to play a greater role in helping students acquire these skills. The work carried out by the University of Sunderland shows how such systems can be efficient and effective.