Taking advantage of hand held technology and calculator network

CTI MATHEMATICS

Day Workshop
Friday 8 January 1999
InterActive ClassRoom, University of Strathclyde

The TI-89 with Advanced Mathematics Software is a portable symbolic, numeric, and graphing solution for advanced mathematics and engineering coursework. Such tools can replace skills looked for in the past but not the understanding that those skills brought. This workshop, sponsored by Texas Instruments, investigated benefits and drawbacks to the use of handheld technology by students in and out of the classroom, the effect it will have on assessment and the way it can be integrated into courses, particularly when there is network support.

1. Using Classroom Communication Systems with large classes - Jim Boyle, University of Strathclyde

At Strathclyde funding is available for the Natalie project, investigating new approaches to training and learning in engineering. The Vice-Chancellor served on the Dearing Committee, and recognises that education is in transition - traditional ways of teaching are not appropriate to the culture of mass higher education. In particular, there is a different motivation; students have a shorter attention span, but can multi task better, and want breadth rather than depth. Changing one's teaching is hard, but there is evidence that the way we teach is no longer working.

The introduction of technology into the classroom will not be effective unless it is based on our understanding of the way students learn, which means looking at studies of experiential learning or those carried out by Piaget. This has not been a feature in the discipline of mathematics, where the professor of old would still feel at home in today's classroom, unlike the teacher of medical students. Lectures have become too passive, and this is exacerbated by the use of the OHP and printed notes. What is missing is a dialogue between teacher and student, such as takes place using a Socratic method - teaching by questioning.

This is the basis for ClassTalk, a network software system based on TI calculators which provides an effective way to enter into a dialogue with large classes. In a Strathclyde first year mechanics course up to 95 students collect calculators on their way into the InterActive ClassRoom, and log into the network built into the seats. The instructor presents a question, problem or information task, sent via the network. Students discuss and respond with words, sentences, numbers, formulas or multiple choice; the latter can be used to see whether concepts are understood. Group or individual responses are allowed, also dissent; alternatively a confidence level can accompany the answer. The InterActive classroom is also fitted out with a number of radio mikes for instructors and students to use.

The results are displayed on a seating plan management system, so the instructor can see who is logged in and can address students by name. The system also analyses student progress - feedback, tests and grading are available and the instructor can send messages via the network. There can then be discussion of the different views held by students - peer instruction reinforcing the idea of groupwork. As a side benefit, students enjoyed the more creative atmosphere. At Harvard class sizes can reach up to 350 using this software. PRS (Personal Response System) is a simpler system allowing multiple choice only.

The three members of staff involved spend some time assessing the capabilities of the new students on the mechanics course. They seem to have developed strategies for problem-solvin- without understanding basic concepts, and to have manipulative skills without knowing how to apply them. In the real world experts have a set of models to draw on and tweak to suit a particular problem, and the course therefore uses a model-based (or concept-based) problem-solving approach. A few basic models are presented for use with minor modifications, and students identify or create a model and make inferences to produce a solution. Modelling examples include rectilinear motion and damping mechanisms.

2. Modelling with differential equations - case studyfrom Diana Mackie, Napier University

The TI-85 is used in one module of the four-year course "Science with Management Studies". This module requires students to investigate the graphical solutions of first and second order ODES, plot solutions and phase paths of systems of ODEs and explore solutions to first and second order difference equations. A set of TI-85 instruments is available on loan to the 15-20 students taking the course, and are used for the course and the exam. Students may also go to the maths lab and use software learned on other courses, but usually find the calculators more convenient. There is no hard copy output - they are expected to sketch graphs displayed on the screen.

One example of its use is the investigation of damped and forced vibrations. The TI-85 can cope with up to nine variables, and students can examine over-, under- and critical damping by changing parameters. They can look at a transient phase and steady state oscillation, and how this matches the frequency of the forcing function, and. the enhancement of the amplitude when, the natural frequency is close. Epidemic modelling provides another example; students can view changes in the numbers of infectives and susceptibles within a population and examine the phase plots. Traditional methods are also used to teach simpler linear models using ideas of eigenvalues, but students then find the phase plots difficult to understand. With the calculators they can try things out for themselves, and get a better feel for the mathematics.

3. Hands-on session: Using ClassTalk with the TI-86 - lim Boyle

Delegates had the opportunity to log in for themselves and get a student eye-view of the system. Currently this runs off an Apple Mac, with any number of calculators going into one serial port. The network is live - once students have logged in, they can unplug and plug back in without logging in again. They seem to enjoy lean-dng in this envirorunent, since attendance at lectures is now running at 90%. A typical question or task would be of the following form:

"Do you think graphing calculators are:

1. a good thing
2. a bad thing
3. don't care
4. don't know

Discuss in groups of four for 90 seconds and input the result on your calculator"
The results can be displayed as a bar chart to provide the basis of discussion on the merits of each answer and the total class response.

4. The evolution to the 77-89 - Harry Gretton, Sheffield Hallam University

Harry summarised the features of a whole range of n calculators. Their evolution matches the changeintheskillsbaseofourstudents. TheTIsiteathn://www.ti.com/calc/docs/89.htm contains software downloads, examples of good practice and contacts for the different user groups

TI-81 the first graphics calculator
TI-82 like the 81 but with network connections
TI-85 for engineers
TI-80 chosen by the Open University for its students
TI-83 like the 82 but with stats analysis procedures - suitable for International Baccalaureate exams
TI-86 an updated 85
TI-92 contains computer algebra based on Derive and computer geometry based on Cabri. It is allowed in French examinations.
TI-92 Plus has the Flashable Rom, so it can download software for upgrading its system files
TI-73 an updated version of the 80, with connector and Flashable Rom
TI-89 has animation, complex numbers, 3D diagrams with rotating viewpoint, limits, exact mode, sequences

5. Case study - the experience of integrating technology at Sheffield Hallam University

Initially in service teaching to 400 engineers and now for 50 mathematics honours students, the aiin is to integrate technology (graphic calculators, spreadsheets, CAS, CDROM ...) into practice, review the curriculum, teaching style and the way students are encouraged to learn, incorporate key skills and review assessment. Harry described the impact of these changes on staff, students and innovators, and pointed out that mathematicians are in a position of being able to deliver all six key skills outlined by Dearing. Sheffield Hallam's mathematics degree is now designed on the assumption that students will have good access to a range of technology - they are given a copy of the departmental Web site on disc before they come to the university. VirtuaJly all mathematics students buy a graphic calculator, and this year many have bought a TI-92 or TI-89.

6. Hands-on session: Getting a grip on the TY-89:

This session was made possible by the loan of a TI-89 class set by Texas Instruments. It was based on an introduction to the TI-89 written by Sally E Fischbeck, Rochester Institute of Technology, Rochester NY, which can be found at http://www.ti.com/calc/docs/89til2s.htm

7. Discussion on the implications of the TI-89 and calculator networks

Concerns regarding the technology itself

- Using different technologies in the same classroom can cause difficulties and this is exacerbated during assessment. For example, the Napier course was designed around the TI-83; if students were to use a TI-89 for the final exam it would give them an assessment advantage. Perhaps some courses should have a prerequisite of a certain machine.
- Care must be taken with regard to using technology in experiential learning since, unlike paper and pencil work, the intermediate steps can get lost unless downloaded via links to spreadsheets, screendumps, printouts. Students may be carrying out many activities without learning anything unless these steps are monitored.

- Coursework using technology can mean that there is no longer a spread of marks across a range. It can be more typical to get one bunch around a high mark and another at fail level. Examining committees don't like this, nor do employees.

The need for different assessment practices

- Examples may be available via the International Baccalaureat (IB), the Australian Association of Maths Teachers (who use IB exams), Advance Placement Exams (USA), and the Harvard Calculus Consortium (can buy into this). There was also a paper on this topic given at the ICME-8 meeting in Seville 1996 (see further reading, below). It has been published on the Internet at http:/ /ued.uniandes.edu.co/servidor/em/recinf /tgl8/Kissane/Kissane-l.htmi
- One example could be "Give five ways of solving this problem, listing advantages and disadvantages of each one, or stating which you would choose and why". Students need to learn that there are different ways to solve a problem. Indeed, they will approach problems in different ways from their lecturers.
- An engineering department is turning out accredited practitioners and they have to be competent. Measurement of competence doesn't have to be based on a first attempt - in an interactive situation students will submit work several times, getting feedback each time, and can eventually achieve the required level.
- However, we may also want to know who is better than average - and employers certainly want to know this. While traditional exam marks of 75% show success at something, it could just be at exam-passing skills.

The effect of technology on the curriculum

- The availability of technology means that fewer techniques have to be taught. For example, the learning of standard integrals took up a lot of time in traditional A level study, which could have been spent in learning to think mathematically. Concepts are learned from a variety of examples, but there is no longer a need for these to invoive difficult symbolic manipulation.
- Engineering maths has a fixed curriculum, but a lot of maths methods taught to engineers are now redundant. Students need to learn how to solve a problem given the many tools available. However, it may be difficult to get engineering departments to agree to cut down on the topics to be taught without loss of teaching time. If that happened, then there would be no space to introduce newer maths topics as thev arise. One way of approaching this is to replace a syllabus with a list of learning outcomes, eg "must understand differentiations".
- It is right that there should be a difference of approach between the teaching of mathematics and engineering students. Perhaps more care needs to be taken in incorporating say the TI-89 into the curriculum for honours mathematics courses, whereas engineering students need to be able to use them as tools where this is relevant.

Teaching and learning issues

- Teaching and learning issues were paramount in the discussion and the view was expressed that the teaching of understanding should be considered separately from the use of technology, and integrated into a teaching strategy."
- Group activities in a large auditorium need to be kept short, otherwise some groups finish before others. Multiple choice questions are ideal for this.
- Distance learning can effectively use some of these group learning techniques. The ClassTalk system can link individuals in different geographic locations. The Open University has developed conferencing systems and virtual discussion groups.

• For some, the format of the day showed that a variety of methods is effective in promoting engagement. Evidence from the States backs this up (see further reading, below).
• There is a need for role models - we can provide this for our students by showing we are willing to change and improve our own leaning/teaching by the creative use of technology. Training is needed for others who are resistant to change.

Motivation
• One problem is to get students to do any work at all. If technology enthuses the students they will work in the classroom, but it is not possible to present as much material by this means. Do they then go away and engage in learning at a deeper level? One Strathclyde group exposed to interactive methods in the second year asked for them again in the third on the basis that they are more efficient.. "we learn in the classroom and don't have to do so much work at home'. Those of us good at maths may recognise this as one of the reasons we chose to specialise in it.
• One speaker commented that much mathematics in the past had been developed because of the ways that engineers and physicists were thinking. If their mathematical education is cut down, some of this process may be lost. There was consensus around his view that we have to breed in our scientists the need to look more closely at their problem solving methods, identify where they need more mathematics understanding and learn it themselves.

8. Further reading

Roles of Calculators in the Classroom, edited by P Gomez and B Waits. This includes all the papers given as part of Strand 18 of the ICME-8, which took place in Seville in 1996, and has been published electronically at
http: / /ued.uniandes.edu.co /servidor/em/recinf /tgl8/Base/TGI8-ICME8-l.htmi

Interactive-engagement versus traditional methods by Richard R Hake, Department of Physics, Indiana University, Bloomington, Indiana 47405, has been accepted for publication in the American Journal of Physics. A six-thousand-student survey of mechanics test data for introductory physics courses indicates that the classroom use of interactive-engagement methods can increase mechanics-course effectiveness well beyond that obtained in traditional practice. The full paper can be seen at
http://carini.physics.indiana.edu/SDI/ajpv3i.pdf

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