Free mathematics software resources

Which word caught your eye?

Howard Reeves
Hobart, Tas.
<reeves@netspace.net.au>

Computers have been in schools and indeed some mathematics classrooms for more than 35 years. Some schools have chosen to centralise their computers in laboratories, while others have a mix of configurations and networks. Whatever the case, how extensive has been the classroom use of computers for teaching and learning in mathematics? What has their presence added to the classrooms and the learning experiences of students? What effect has there been on the pedagogy of teachers in this time? How has the content of the mathematics curriculum been changed by the presence of computers in mathematics classrooms or in accessible laboratories?

We could attempt to collect some quantitative data about the first question and an examination of past and present published curriculum documents of the states and territories would provide a "picture" of any influence the presence of computers may have had on mathematics content. The other two questions are not so easy to tackle in a scholarly manner. It is not my intention in this article to answer any of the questions! Rather, my intentions are:

- to present some observations about current use of online learning objects developed for the states and territories by The Learning Federation (TLF);
- to raise the awareness of teachers and teacher educators to the existence of these free software resources that are beginning to alter the patterns of computer use, pedagogy and content in classrooms; and
- to present some findings of a recent pilot study in the use of these digital resources.

Access to computers and the availability of suitable software has long been the impediment to a greater use of computers in mathematics. "I only have a couple of computers in my classroom," or "I have to book the computer lab weeks ahead," are common responses, particularly from secondary mathematics teachers, to

justify lack of use of computers. With respect to software, the response frequently refers to cost, availability and suitability.

Software concerns are being ameliorated because mathematics software is now freely available to teachers in Australian and New Zealand schools as a result of an initiative of the Australian state and territory governments and the New Zealand government to develop online curriculum content. *Learning objects* are digital materials designed to engage and motivate student learning. The mathematics and numeracy learning objects are, in the main, small stand-alone interactive tools or programs. They are designed to encourage mathematical thinking by challenging students to explore possibilities, conjecture, analyse, solve problems and reflect on their learning. Mathematics and numeracy learning objects are scaffolded learning tasks in which students received feedback on their learning in a variety of supportive and engaging ways. The development of these learning objects has been undertaken around four themes: counting and quantifying; representing and visualising; variation, transformation and change; and uncertainty and predictability.

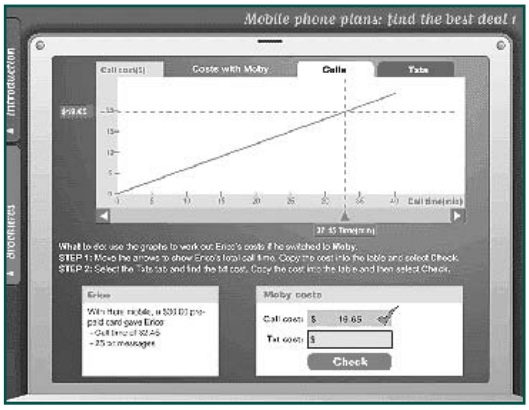
The Learning Federation Schools Online Curriculum Content Initiative was established in 2001 to undertake the development of the digital resources. A substantial number of learning objects in the mathematics area has been published by TLF, and more will be published in the third phase of the initiative which will run until 2009. Concomitantly, TLF and its collaborators — teachers, software developers and curriculum specialists — have developed and used a process by which learning objects are planned, designed, developed and tested to meet demanding criteria and high quality standards. The three-way collaboration is the key to success of the objects.

So what makes the mathematics learning objects distinctive and how do they assist teachers and students?

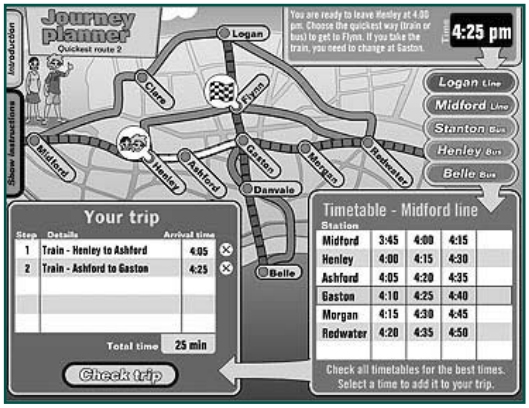
Cutting edge programming tools and ICT

Advances in software such as Shockwave and Flash, delivery of digital material by broadband, and the reduction in the cost and ease with which CD-ROMs are able to be produced are factors which have facilitated the development and sharing of interactive learning objects. The learning objects are fast loading, are useable under both Windows and Macintosh operating systems and can be downloaded to operate on school networks.

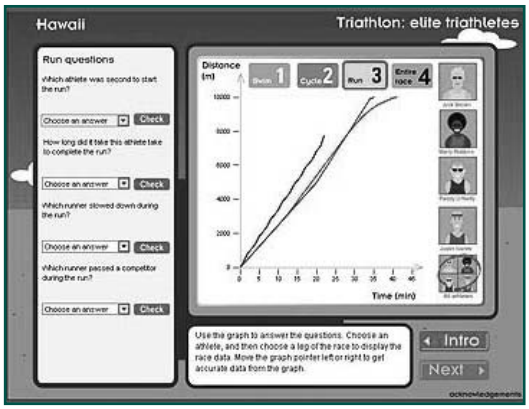
The Learning Federation [TLF] is an initiative with the brief to develop a collection of digital teaching resources for schools. The focus school years are P to Year 10 in the six curriculum priority areas of: science mathematics and numeracy; literacy for students at risk Years 5–9; studies of Australia; languages other English (Chinese, Japanese and Indonesian); and innovation, enterprise and creativity. TLF is managed by Curriculum Corporation and owned by the Australian and New Zealand governments and the governments of the Australian states and territories. It is managed by the Ministerial Council on Education, Employment, Training and Youth Affairs [MCEETYA], and the products of TLF are handed to the education systems for free dissemination and distribution to teachers in government and independent schools.
Teachers' access to learning objects for government and non-government is via the education authority in each Australian state and territory and New Zealand. Individually each education authority has decided how the distribution of learning objects will be undertaken and has its own contact officer. Details of how to contact these officers in your state or territory are available at thelearningfederation.edu.au



Mobile phone plans is a collection of learning objects which taps into students' interest in available features and costs involved in phone different plans. Users of the objects are required to choose the best deals while accommodating the clients' patterns of phone use.



Classroom scenarios to teach students how to read timetables and plan trips on public transport are often difficult to set up. Journey planner is a sequence of learning objects which deals with the mathematical concepts relating time and timetables in a context involving decision-making.



The Triathlon suite of learning objects deals with distance – time graphs in the context of comparing the performances of elite triathletes.

By teachers and education specialists for classroom use

Teachers and education specialists are involved in all aspects of the design and development of the learning objects and all objects undergo classroom trials with feedback being provided by teachers and students.

Student interactivity required

The mathematics and numeracy learning objects are not video clips to sit and watch. They demand interaction by students; they provoke and challenge thinking and they provide a context for teachers and students to engage in rich conversations about important mathematical ideas.

Assisting teachers, not replacing them

The Initiative's goal is not to "cover" the mathematics curriculum or replace the teacher. Rather, the collection of mathematics learning objects is a resource for teachers to choose to use to expand their pedagogical repertoire integrating ICT, and while they do so, assisting them to meet the demands of the curriculum and the different learning needs and modes of their students.

Free access and flexible delivery to students

The products of the Initiative are free to education authorities to deliver to schools in their jurisdiction, and schools are free to make them available to their students as they see fit. Some schools are giving their students access to the learning objects via the school intranet or school website allowing access within and outside school hours.

All of these sequences of learning objects have some common characteristics.

- In each sequence there is a progression of difficulty allowing teachers to choose the entry-point to meet the needs of individual students, and enabling all students to be focussing on the same mathematical ideas.

- All mathematics learning objects demand action on the part of the user. The student is required to assume an active role in the learning object scenario in which the mathematical ideas are being presented.
- All learning objects have a structure that provides scaffolded learning and feedback.
- There are instances where learning objects have been presented as tools, enabling students and teachers to explore, investigate, make and test their own conjectures.

Some observations and finding of current research

Tentatively, based on small samples (700 students in Years 5 and 7, in 40 classrooms in 20 schools) and using a limited range of learning objects, it can be claimed that there is improvement in student learning outcomes in classrooms where learning objects are being used. The results of a "good practice" pilot study undertaken by Professor Peter Freebody (University of Queensland) and colleagues in 2006 are beginning to emerge. Students in middle school years in the ACT, NSW and Queensland schools had classroom access to number- and chance-related learning objects for a period of six weeks in March–April 2006. Against the performance of students in control classes in the same systems, students with access to the learning objects showed "reliable differences" in their level improvement between pre- and post-testing than those students without access during the six week focus on the curriculum content, particularly in the area of chance. In the use of number-related learning objects there was "an improvement" at Year 7 but not at Year 5. This requires further investigation.

School visits to observe how teachers

Random or not? is a sequence of learning objects in which the content focus is randomness and variation. Set in the context of a fruit jube packaging machine, students explore the relative frequencies of same jube type runs, alternating sequences of jubes and the number of the most commonly occurring type in the packaging tubes. This sequence of objects (soon to be released) will include a tool with which students will be able to make and test their own conjectures.

School canteen is a sequence of learning objects which deal with ratio, proportion and best buys in a scenario in which the student is restocking the school canteen. The more demanding objects in the sequence require students to consider the prices in a number of catalogues and involving different packaging units.

The results of the pilot study referred to in this article were presented in an address by Peter Freebody at the Curriculum Corporation Conference "A vision splendid — ICT: research, pedagogy, implementation for schools", Adelaide (15–16 August 2006).

were using the learning objects in their classrooms, were also an important part of the pilot study. This will be expanded in 2007 as a result of the concept study. From discussions, reflections and feedback, teachers are reacting strongly and positively to the learning objects and are reporting high motivation of students across all teacher and student demographics.

At the beginning of this article, I suggested that TLF learning objects are beginning to alter the pedagogy of teachers and the mathematical content. In the case of pedagogy, the ease of use of the learning objects in classrooms has given teachers lacking confidence a means by which they can integrate computer use into their teaching repertoire as well as access to some software to use. Prior to their involvement in the study and their exposure to the software, teachers reported major variations in their knowledge of the existence and use of TLF content. They, without exception, crave models for integration of ICT into their classroom practice and knowledge about how other teachers are "doing it."

During school visits I saw a wide range of classroom configurations ranging from three to five computers in the classroom being used as one of a number of rotations or activities students moved through in a lesson or series of lessons, to pre-booked class visits to variously-configured computer laboratories in which students had sole or shared use of a computer. The role of the teacher within these structures varied just as much from little or no interaction with the computer-using group, to engagement of students in purposeful discussions.

What I was expecting to see — but did not see where in-classroom computer access was limited, and in the absence of projection equipment — was some attempt to set up a computer and "huddle" students in such a way that there was larger scale interaction between the teacher and students. My belief is that there is potential in using learning objects in this way to stimulate and sustain rich mathematical conversations and discussions.

As for content changes, teachers are using learning objects around which to build their lessons in mathematics content areas where they have previously been reluctant to venture. Teachers are being supported to be risk-takers. In the classroom visits associated with the pilot study, teachers admitted that they were venturing into content areas, particularly with respect to chance, where they were previously reluctant to go. The learning objects gave them a scaffold on which to build their lessons and contexts in which to initiate discussions.

Further reading

Freebody, P. (2005). Learning objects are tracking well. *EQ Australia*, Issue 3, Spring.