Peter Samuels

Mathematics Support and New Technologies

Peter Samuels
SIGMA Centre for Excellence in Mathematics and Statistics Support
Coventry University
p.samuels@coventry.ac.uk

SIGMA is about to begin a PhD studentship in "enhancing mathematics support with innovative uses of technology". The purpose of this article is to put forward our views on this research field.

This article builds on a recent article from SIGMA which discusses internet-based and mobile mathematics support [1].

Why new technologies?

New technologies are important to mathematics support for four main reasons:

1. They provide opportunities for new forms of interaction not available via old technologies [2].
2. "Net generation" students (i.e. those born after about 1980, according to some definitions) are familiar with them [3].
3. They enable learning to become much more flexible or "on demand" which is becoming an increasingly important factor as people have busier lifestyles and more students are registered for part-time courses.
4. They may provide a more economical means of teaching. However, this potential reason has been used on its own in the past with disastrous consequences! Too much money has been invested in new technologies without thinking through what potential educational gain they may provide and in what ways. The use of new technologies should be driven by "educational purposes and pedagogy" [4].

Which technologies?

The technologies we are particularly interested in are mobile technologies, especially an integrated (or converged) handset, the widespread availability of which is already becoming a reality in some developed nations, such as Japan [5].

We believe that in a few years' time many people (perhaps a majority of "net generation" students) will have a combination of a 3G mobile 'phone with broadband internet, a video iPod, a Play Station Portable and an Ultra Mobile Personal Computer (UMPC). It will be small enough to fit in your pocket, but large enough to display video, text files containing mathematics and allow interaction such as computer-assisted assessment and digital games.

The nearest product to this specification currently available to our knowledge is the Sony Vaio UX Micro PC which is being sold with a 3G broadband mobile 'phone (giving it broadband

internet connection via Bluetooth). The UX is the "smallest fully functioning PC in the world" with a screen that is only 4.5 inches across. But is also has a full keyboard and can therefore handle all the mathematics support technologies currently available on computer and the internet, such as:

- computer aided learning systems, such as CALMAT [6];
- university internal Virtual Learning Environments, such as BlackBoard/WebCT;
- mathematics-based computer games (such as Zoombinis [7]); and
- mathematics resource websites, such as **math**centre and **math**tutor.

Fig 1 - The Sony Vaio UX Micro PC

The need for new teaching methods

Having all these kinds of support available anywhere, anytime via a highly powerful mobile device enables us to think beyond the limitations and constraints of university degree courses taught in a traditional way.

Traditional teaching methods for university mathematics are failing for several reasons:

1. Many students lack the basic mathematical knowledge required to begin their degree courses and therefore require some form of "bridging" support [8].
2. The greater variation in ability between students registered for the same course means that aiming lecture-based teaching at the mean level of ability of the class is becoming unsatisfactory for a greater proportion of students.
3. The use of technology in teaching mathematics in schools is increasing faster than its use in mathematics teaching at university. Traditional university methods for teaching mathematics therefore appear more outdated.
4. "Net generation" students' familiarity with new technologies provides a powerful opportunity to use new technologies within mathematics teaching in order to engage with their culture. However, failure to do so increases cultural alienation for these students.

Also, the greater cohort variation in UK Higher Education is not just in terms of a linear measure of ability but is multi-dimensional (e.g. changes in the spread of students due to the Widening Participation agenda, and increased numbers of international students and mature students). Therefore, it is appropriate to offer student cohorts a greater variety of learning strategies that may suit these individual differences [9].

How far might this go?

We conceive a new environment of mathematics teaching at university level where degree courses no longer provide the major source of knowledge transmission but are left with other important responsibilities, such as:

- streaming and registering students according to their ability and qualifications;
- setting summative assessment, e.g. coursework and final examinations;
- facilitating social networks with other students;
- maximizing tutor-student contact time for discussions about their formative assessment and their conceptions about the subject: there is research evidence that indicates that this is an effective way to use staff contact time [10].

Instead of using lectures as the predetermined and dominant form of knowledge transmission they could instead be used:

- more for motivation (as in the Personalized System of Instruction [11]);
- as an opportunity to react to students current conceptions using Classroom Communication Systems [12];
- as an opportunity to teach what the students want to learn next, e.g. through email or mobile text messaging, as in Just-In-Time teaching [13]; and
- as a live audience with a small group for video recording and later asynchronous transmission

What support?

Leaving aside these important areas of responsibility which are still left within the primary teaching context, mathematics support would then cover areas such as:

Written notes – including theory, examples and applications, all of which may be context dependent (e.g. engineering). Good examples of these are the notes already available at the **math**centre website.

Video – again including summary theory and worked solutions, e.g. those available from the **math**tutor website.

Diagnostic assessment – we see this going beyond the current 'static' tests to something that is adaptive (according to prior qualifications and the previous answers provided during the test) and integrated with the resources provided. This would be something like Diagnosys [14] connected to the mathcentre and **math**tutor website resources according to the student's responses.

Computer-based formative assessment, e.g. online tests which provide feedback. These can be used for gaining confidence in new areas of knowledge or for perfecting procedural skills (drill and practice).

Computer games – the four types of support mentioned above, although useful and important, lack a "fun" element that most "net generation" students expect from their interaction with mobile technologies. The challenge is to design educational computer games (known as serious games) which are fun and modern (i.e. not "pac-math" style / edutainment which appear totally outdated to "net generation" students brought up on games with high quality interactive graphics) but which also have a significant integrated mathematical content (i.e. which are not "shoot 'em up then do some maths to get to the next level"). We recently put together a project proposal (along with other consortium partners) for a prototype game of this type. Some of our consortium members were members of another European consortium that has looked into the use of computer games in schools level mathematics [15].

Multi-user communication – another important and exciting element of new technologies is the ability to use them to support co-operative learning communities. This can be seen in computer games where popular Multi-User Virtual Environment internet games are highly immersive (and addictive to some) [16]. It is also a potential element of university internal Virtual Learning Environments [17] which include email and discussion boards for communication between students and instructors. Both these elements could be combined together into multi-user mobile learning.

Which methods and theories?

Below is a list of teaching methods and educational theories (not already mentioned in the article) which we believe are or may be relevant to the use of new technologies in mathematics support. It is not an exhaustive list but it gives an indication of the kind of methods and theories which we are considering.

- Mobile learning [18];
- Resource-based learning [19];
- Constructivism – an active approach to learning where the learners discover new concepts for themselves [20];
- Computer-Assisted Personalized System of Instruction (CAPSI) – this is an innovative teaching method which is being used to teach discrete mathematics at Brunel University and could be delivered via mobile technologies [21]; and
- Cooperative learning [22]

The greatest barrier: mathematics lecturer's perceptions?

Finally, we make the observation that the greatest barrier to change in mathematics teaching at university level may not be the availability of new technologies, resources and effective teaching methods for using them, but the perceptions of mathematics lecturers towards mathematics teaching methods and new technologies [23].

References

1. Lawson, D. A., Carpenter, S. L. and Croft, A. C. (To appear) Mathematics Support: Real, Virtual and Mobile. International Journal of Technology in Mathematics Education.
2. Shaffer, D. W. and Kaput, J. J. (1999) Mathematics and virtual culture: An evolutionary perspective on technology and mathematics education. Educational Studies in Mathematics 37, 97-119.
3. Oblinger, D. and Oblinger, J. (2005) Is it age or IT: First steps toward understanding the net generation. In Educating the Net Generation (Oblinger, D. and Oblinger, J., eds.), pp. 2.1 - 2.20, EDUCAUSE.
4. Kirkwood, A. and Price, L. (2005) Learners and learning in the twenty-first century: what do we know about students' attitudes towards and experiences of information and communication technologies that will help us to design courses? Studies in Higher Education 30(3), 257-274.
5. Woo, S. (2006) Service Convergence Evolution and Trends in Japan. Research on Asia Group, Tokyo.
6. Cook, J. and Milne, S. (2005) Encouraging Effort. In Helping Everyone Learn Mathematics, Loughborough, UK.
7. Hancock, C. and Osterweil, S. (1996) Zoombinis and the art of mathematical play. In Hands On! Hands On Math and Science Learning, available online from http://www.terc.edu/handson/s96/zoom.html.
8. Bamforth, S., Crawford, A., Croft, A. C. and Robinson, C. (2005) A pre-sessional course: retaining engineering students through mathematical and transferable skills support. International journal of electrical engineering education 42(1), 79-87.
9. Currell, G. and Dowman, A. Teaching students with diverse backgrounds: A learning framework for basic mathematics

and statistics in science. In Maths for Engineering and Science, LTSN MathTEAM Project, available online from http://www.mathcentre.ac.uk/staff.php/all_subjects/guides/mathsteam/resources/resources/109.

10. Yorke, M. (2001) Formative Assessment and its Relevance to Retention. Higher Education Research & Development 20(2), 115-126.

11. Keller, F. S. (1968) Goodbye, teacher... Journal of Applied Behavioral Analysis 1(1), 79-89.

12. Nicol, D. J. and Boyle, J. T. (2003) Peer instruction versus class-wide discussion in large classes: a comparison of two interaction methods in the wired classroom. Studies in Higher Education 28(4), 457-473.

13. Novak, G. M., Patterson, E. T., Gavrin, A. D. and Christian, W. (1999) Just-in-Time Teaching: Blending Active Learning with Web Technology. Prentice-Hall, Upper Saddle River, N.J.

14. Appleby, J. C., Samuels, P. C. and Treasure-Jones, T. (1997) Diagnosys - a knowledge-based diagnostic test of basic mathematical skills. Computers & Education 28(2), 113-131.

15. Learning patterns for the design and deployment of mathematical games (2006) Literature Review, available online from http://lp.noe-kaleidoscope.org/outcomes/litrev/

16. Metrick, S. and Epstein, A. (1999) Emerging Technologies for Active Learning Part 1: Multi-User Virtual. Environments. LNT Perspectives 10, available online from http://www2.edc.org/LNT/news/Issue10/feature3a.htm

17. O'Donoghue, J. (2006) Technology Supported Learning and Teaching: A Staff Perspective. Idea Group Inc., Hershey.

18. Attwell, J. (2005) Mobile technologies and learning: A technology update and m-learning project summary. Learning and Skills Development Agency, London.

19. Brown, S. and Smith, B. (1996) Resource-Based Learning. In Staff and Educational Development Series, Kogan Page, London.

20. von Glaserfeld, E. (1996) Learning and adaption in constructivism. In Critical Readings on Piaget (Smith, L., ed.), pp. 22-27, Routledge, London.

21. Brinkman, W.-P., Rae, A. and Dwivedi, Y. K. (2007) Web-based implementation of the Personalised System of Instruction: A case study of teaching mathematics in an online learning environment. International Journal of Web-based Learning and Teaching Technologies 2(1), 39-69.

22. Johnson, D. W. and Johnson, R. T. (1984) Cooperative Learning. Interaction Book, Edina.

23. Deaney, R., Ruthven, K. and Hennessy, S. (2006) Teachers' developing 'practical theories' of the contribution of information and communication technologies to subject teaching and learning: an analysis of cases from English secondary schools. British Educational Research Journal 32(3), 459-480.