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## Technology and the improvement of mathematics education at the tertiary level

Elahe Aminifar  
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# **Technology and the Improvement of Mathematics Education at the Tertiary Level**

**Elahe Aminifar**

B.Sc. Pure Mathematics, M.Sc. Applied Mathematics

A thesis submitted in partial fulfilment of the  
requirements for the degree of

**Doctor of Philosophy**

School of Mathematics and Applied Statistics

University of Wollongong

Australia

December 2007

## **Certification**

I, Elahe Aminifar, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Mathematics and Applied Statistics, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Elahe Aminifar

21 December 2007

## ***Dedicated to***

*My dear Javid who is the inspiration for my life and my study. His love, friendship and support has enabled me to keep the home fires burning through it all. Thank you Javid from the bottom of my heart for being there for me.*

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## Abstract

In recent times, technology is being used more and more in a variety of educational endeavours. This thesis considers the use of technology in the improvement of teaching and learning mathematics in higher education. In particular, it addresses, through three case studies, specific technological solutions to two well documented educational problems: the knowledge gap between secondary school and university level mathematics and how to provide higher level, honours or postgraduate, mathematics offering despite low student numbers.

A literature review provides the context of the problem and an overview of previous attempts at solving this difficulty.

The first case study addresses a common problem concerning students entering university from high school. It has been reported that students who enter university have insufficient mathematics knowledge and skills to take first year mathematics subjects and hence provide a sound mathematical foundation for other subjects. In this study at the University of Wollongong, video learning resources, predominantly worked solutions, have been developed to assist Engineering students in a first year mathematics subject. The four-stage evaluation model of Alexander and Hedberg (1994) was used to determine the effectiveness of the resources involved at each of the stages: *Design*, *Development*, *Implementation* and *Institutionalisation*. Evaluation addresses both the production methods and the learning outcomes. A mixed methodology combining surveys, interviews, and document analysis, was used to triangulate evaluation results at each of the four stages.

In 2006, two different technologies were used to produce video resources for a limited number of mathematics questions. In the first instance this was to determine the ease of production and the students' preferences for the resources. Following this trial, a set of video resources which covered all the topics taught during the first four weeks of the teaching session was developed. These resources were used to examine whether or not they could be used to bridge the gap from high school to university. Analysis indicated

that the resources were used by students whose mean baseline performance was lower than non-users ( $t_{74} = 2.18$ ,  $p = 0.033$ ). In week four the results of Basic Skills Test 2 revealed that students who used the resources improved more than those who did not ( $t_{72} = 2.43$ ,  $p = 0.018$ ), however, catching-up on fundamental mathematical skills was insufficient for there to be an impact on the final results in the subject. Surveys in the middle and at the end of the teaching session showed that students found the video resources were useful in helping them to learn and understand mathematics. Consequently, a set of video resources that covered all mathematics topics in the subject was developed for incoming students in 2007. To ascertain the impact of these resources, two cohorts of students were examined: students from 2004 with no resources and students in 2007 with a complete set of resources. Having established that baseline performance was the same, the students with resources were found to have improved their performance in all assessment tasks compared to students without resources: Basic Skills Test 2 ( $t_{390} = 3.14$ ,  $p = 0.002$ ), assignments ( $t_{456} = 2.80$ ,  $p = 0.005$ ), quizzes ( $t_{456} = 3.49$ ,  $p = 0.001$ ), examination marks ( $t_{456} = 3.03$ ,  $p = 0.003$ ), and final marks ( $t_{446} = 2.38$ ,  $p = 0.018$ ), except in the Mid-Session Test ( $t_{467} = 0.65$ ,  $p = 0.519$ ). The failure rate fell significantly in 2007 compared to the years between 2000 and 2006 ( $Z = 2.10$ ,  $p < 0.05$ ). Students' surveys suggest that while the primary gains have been in algorithmic learning, students consider they have better understanding of concepts. The final stage of institutionalisation reveals that the university has adopted and further extended the approach for the development of mathematics learning resources across disciplines.

The second case study addressed the use of two-way communication technologies for teaching and learning for geographically dispersed students at the tertiary level and in particular, for mathematics. To do this, the author of this thesis worked in an apprenticeship model with the guidance of the Manager of Learning Facilities and Technologies at the University of Wollongong to compare a selection of Real Time Communication (RTC) technologies using several criteria. These were based on the needs of teachers and students, the institutional infrastructure and the literature. As there are a variety of Real Time Communication (RTC) technologies, a two-stage evaluation was adopted. In the first stage, a list of RTC technologies was composed based on criteria found in advertising and promotional materials. In the second stage, each of the short-listed RTC technologies was trialled to determine their effectiveness and efficiency in

teaching and learning. At the end of this case study, one of the RTC technologies, which provides multiple video and audio tracks of all participants as well as application sharing such as shared desktop and whiteboard, namely Access Grid, was installed and trialled.

With two other universities, also funded by the International Centre of Excellence for Education in Mathematics (ICE-EM), the opportunity arose for the third case study focussing on the question, ‘How do universities provide a wide range of subjects to honours and upper level students when numbers of mathematics students and staff are small?’. The aim of installing a room-based node on the Access Grid was to teach and share the mathematics and statistics subjects with other Australian universities which had installed a room-based node. Three lecturers and eight students were interviewed and surveyed to evaluate the use of the Access Grid in teaching and learning these subjects. The lecturers and the students were tolerant of many technical failures, expecting them as part of the process of introducing new technology and recognising the opportunity provided by sharing classes. Two issues were identified: the need to train staff in the use of new pedagogical approaches and the fact that lecturers did not necessarily perceive the communication difficulties experienced by their students.

The thesis concludes with a look to the future of technology in mathematics education and makes recommendations for embedding video resources within subjects in the other disciplines. Recommendations are also made for the use of synchronous technology such as Access Grid in teaching and learning.

## **Publications**

The following presentations and publications have been emerged from this thesis so far.

### **Paper in a Refereed Journal**

1. Aminifar, E., Porter, A., Caladine, R. & Nelson, M. I. 2007, 'Creating Mathematical Learning Resources - Combining Audio and Visual Components', *ANZIAM Journal (EMAC2005)*, vol. 47, pp. C934-C955.

### **Papers in Refereed Conference Proceedings**

1. Aminifar, E., Caladine, R., Porter, A. & Nelson, M. I. 2007, 'Beyond Videoconference: Increased Functionality to Enhance Media-Rich Interactions in Teaching and Learning', in *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education*, Québec City, Canada.
2. Aminifar, E., Caladine, R., Porter, A. & Nelson, M. I. 2006, 'Online Solutions to Mathematical Problems: Combining Video, Audio and Stills on the Web', in *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education*, Hawaii, USA.
3. Caladine, R. & Aminifar, E. 2007, 'The Future of Real Time Communication in Online Learning', in *Proceedings of 2007 Information Resources Management Association International Conference, 18th Annual IRMA International Conference*, Vancouver, Canada.
4. Porter, A., Caladine, R., Nelson, M. I., Aminifar, E. & Williams, G. 2007, 'Access Grid Rooms: The Plan, the Reality', in *Proceedings of Fourth East Asia Regional Conference on Mathematics Education*, Penang, Malaysia.

### **Papers in Conference Proceedings**

1. Aminifar, E., Porter, A., Caladine, R. & Nelson M. I. 2006, 'Evaluation of Using Technology for Teaching and Learning Mathematics', *8th Iranian Mathematics Education Conference (IMEC-8)*, Shahrekord, Iran.
2. Aminifar, E., Porter, A. & Caladine, R. 2005, 'Evaluation of Web Conference and Collaboration Tools for Teaching Mathematics and Statistics', *International Statistics Institute Conference*, Sydney, Australia.
3. Aminifar, E., Porter, A. & Caladine, R. 2004, Teaching Mathematics with Information and Communication Technologies, paper presented at the 2004 Research Methods, Statistics and Finance Conference, University of Wollongong, Australia.

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