

Using Technology to Provide a Supportive Mathematical Pathway into University

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As a result of Government initiatives implemented to broaden student engagement in learning, universities are striving to increase their mature-aged and low socio-economic numbers. As these students are often the most susceptible to attrition, providing the necessary guidance and support is essential. With many students from this demographic studying externally it is becoming increasingly important to innovatively engage them. Through the use of Tablet PCs, comprehensive Electronic Study Guides have been created that are able to effectively guide and support students completing bridging mathematics courses.

Keywords: electronic study guide; Tablet PC; external study, bridging mathematics, feedback, technology

Introduction

The changing social and economic climate has resulted in the Australian Government developing a vision of a socially inclusive environment [1]. This vision emphasises the importance of higher education and has resulted in a number of monetary incentives aimed at increasing the education participation rate of mature-aged students and students from low socio-economic (LSES) backgrounds [2]. As a result, a broader demographic of students is wishing to gain entry into University and with the current resource boom, many are attempting to enter engineering or science degrees.

CQUniversity Australia (CQU) has been consistently recognised as having the highest LSES participation rates of any Australian university (approximately 43%) and was awarded five stars for indigenous participation and cultural diversity of the student body [3]. In a recent 2011 'I'm all ears' Student Forum the CQU Vice Chancellor, Scott Bowman, acknowledged that opening the doors to more students must be accompanied by appropriate academic support [4].

To assist the transition of this 'non-traditional' demographic into university, CQU provides: a suite of bridging programmes (CQUniACCESS) to prepare students for entry into university (regardless of their former skills and educational achievements); dedicated academic support centres to assist undergraduate students with writing and mathematics; and in 2011 the university is trialling a new 'BE-Successful' readiness programme to identify and assist 'at risk' students prior to the commencement of their undergraduate programme.

The Mathematics Learning Centre (MLC)

The MLC's key responsibilities are to:

1. Deliver mathematics courses into CQUniACCESS programmes;
1. Provide academic assistance and resources to undergraduate students experiencing difficulty with a mathematical component of their programme.
2. Provide resources for students captured by the 'BE-Successful' readiness

programme.

Bridging Mathematics Courses

The MLC offers three levels of bridging mathematics courses into CQUniACCESS programmes:

Transition Mathematics 1 (TM1)

TM1 is a course in elementary mathematics. It is designed to have the student commence work on the foundation concepts, rules and methods of basic mathematics. The main aim of this course is to provide a refresher in the fundamentals of basic mathematics, which are necessary to develop mathematics as a unified body of knowledge. Topics covered in the course include number types, operations with numbers (including rules of precedence), percentages, introductory algebraic manipulation, introductory statistics, exponents (indices), solving algebraic equations, coordinate geometry of a straight line and units and their conversions. These are the concepts that form the base for the hierarchical development of mathematics.

Transition Mathematics + (TM+)

TM+ is an intermediate mathematics course. Students are able to tailor the course to their future study plans by completing core and optional modules. TM+ is designed to follow on from a study of introductory mathematical concepts, such as TM1. The course has been developed to give students introductory knowledge of various mathematical topics including statistics, standard deviation, probability, absolute values, inequalities, simultaneous equations, quadratic equations, functions, logarithms, trigonometry, geometry, variation, ratio, proportion, financial mathematics, annuities and series and sequences.

Transition Mathematics 2 (TM2)

TM2 is a technical mathematics course, designed to follow on from TM+. It is the required preparatory course for the study of first year tertiary mathematics in applied science and engineering. TM2 includes additional algebra, matrix algebra, trigonometric ratios, trigonometric functions and their graphs, vectors and oblique triangles, plane analytic geometry, derivatives, applications of the derivative, integration and applications of the integral.

Depending on the current level of mathematical competency (assessed through an entrance test) and undergraduate requirements, students can enrol in either TM1 or TM+. Students requiring the TM2 prerequisite must complete TM+ first.

Approximately 1500 students were enrolled in a bridging mathematics course in 2010, with 66% being enrolled in TM1. As a result of the demand in students wishing to gain entry into engineering and science degrees, the enrolments in courses have been continuing to increase. Accommodating the diverse mathematical backgrounds of such a large cohort of students, especially when the majority have either not studied for a considerable length of time and/or have completed very little mathematics at a secondary level, is extremely difficult. This is a major issue faced by the MLC and is exacerbated when courses are delivered externally, which is the only mode of delivery for TM+ and TM2 [5]

One way to support student learning is through the provision of comprehensive learning packages for the bridging mathematics courses. These consist of a Course Outline, a detailed Study Guide (consisting of a course overview, sample tests and module tests), an MLC textbook (consisting of detailed explanations, worked examples, exercises, review exercises and full-worked solutions). These extensive resources, coupled with on-campus lectures, have been found to provide the necessary support for

internal students. Unfortunately, although external students are able to contact a lecturer via phone or email, they often find it extremely difficult to learn from text-based materials, especially as “the nature of mathematical sciences dictates that students need to hear the instructor explain the concepts and ideas” [6]. In order to actively engage external students and provide the support necessary for success, the MLC has utilised the benefits afforded by technology.

Technology

The use of technology is becoming a significant element in the teaching/learning context. However there is an increasing onus upon the role of the lecturer to ensure that students are able to interface with technology in a meaningful and purposeful way. The effective integration of technology into mathematics classes can have many positive effects, including improved attitude and increased engagement with mathematics, but these positive effects are dependent on how well the technology is used [7]. According to Pomerantz and Waits [8] “The medium is the message”. Individual impressions are shaped by the nature and form of the technologies used to encode and decode experiences. The technology conveys the critical and dominant information through its role in influencing the views, ideas and attitudes of the user. This principle is significant in the development of programmes which need to consider both the affective and cognitive domain of students’ learning. A multi-sensory approach provides a variety of mediums appropriate to a range of learning styles and allows students the opportunity to interact with the technology at their own level. A range of media, utilising the present defining technologies, fosters and enhances ways of thinking and the learning generated.

The MLC has embraced technology as a powerful learning and teaching strategy. Utilising Tablet PCs to create resources for Electronic Study Guides and electronic marking has facilitated the active learning, engagement and subsequent success of bridging mathematics students [5].

What is a Tablet PC?

The Tablet PC is essentially a laptop computer that enables the user, through pen technology, to annotate (write) on the screen. There was much excitement surrounding the technology in the late 1980s, reaching a peak by 1991 [9]. It was envisaged that this technology would eventually replace the mouse and keyboard, but they were difficult to use and the handwriting recognition was inadequate [9]. Fortunately, improved computer technology has resulted in greater functionality with the newer versions. Tablet PCs are now lighter, more efficient and more affordable; processors are faster; resolution is finer; and the handwriting recognition software has been vastly improved [10]. Additionally, no attempt has been made to replace the mouse and keyboard in the current Tablet PCs and although handwriting recognition is still a feature, “digital inking” (allowing the user to annotate on the computer using a stylus or pen) proves to be its strength.

Electronic Study Guide (ESG)

Hargreaves and Jarvis [11] explain learning as “a planned process to modify attitude, knowledge or skill behaviour through learning experience to achieve performance in an activity or range of activities”. The ESG contains the entire set of course resources and can be accessed by the learning management system and/or a CD/DVD. The ESG enables students to easily navigate their way through the course, all

with the click of a mouse. It is designed to provide students with weekly directions to keep them on track with their studies. As the student works through the week's instructions they are able to read the relevant sections of the textbook; watch instructional videos; complete and check textbook examples; and when they finish a module they can easily access the corresponding sample test (with worked solutions) before accessing and completing the module test required for submission. This is facilitated by hyperlinks within the week's instructions (see Figure 1).

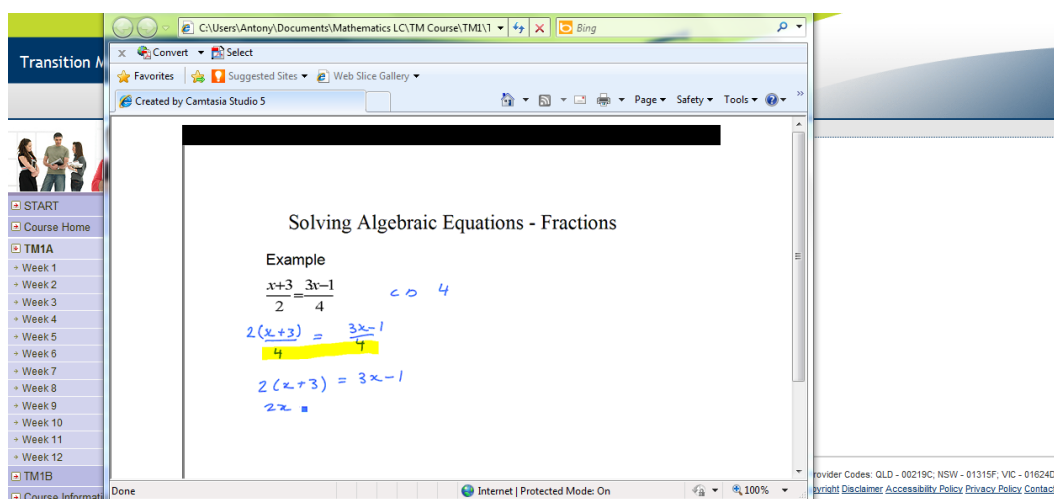


Figure 1. Electronic Study Guide.

Making external materials stimulating and meaningful is an on-going challenge and one in which the MLC has a particular interest. In the online environment, we have incorporated a number of innovations designed to provide the same kind of scaffolding that is available to students in the face-to-face situation, including PowerPoints® or slides, discussion boards, readings and instructional videos. Students greatly appreciate the ease afforded by the ESG, as witnessed for example in one student's response, who notes:

I'm really enjoying maths - the program explains concepts really well (TM1 external student, 2011).

Instructional Videos

“Rote computation and tedious algebraic manipulations have historically turned many students away from mathematics” [8]. Mathematics has been associated with the memorisation of number facts and formulas, algorithms and number substitutions in equations, drill and consolidation exercises and performing long, monotonous computations. Individuals whose motivation and application are frustrated by the tediousness and repetitiveness of this process are able to be actively engaged via instructional videos developed by the MLC. The instructional videos, developed using a Tablet PC in conjunction Camtasia®, that record the screen and sound, are embedded into the ESG, thus making it a very powerful tool. The videos enable the student to hear and see the mathematics unfold as if they were in a class situation. The lecturer not only explains the concepts and ideas but also the mental processes involved in problem solving. Robson, Abell & Boustead [12] highlight the importance of students being able to mentally plan a sequence of strategic decisions when forming a strategy for solving

equations.

Having the videos embedded into the ESG guides students through the course content in a similar manner to attending lectures or tutorials, with the added benefit of being able to revisit, replay and pause the instruction. Additionally, as well as being embedded into the ESG, there is a separate link to the videos which enables the student to view selected ones again without the need to remember the week of study in which they occurred.

The majority of students find the instructional videos to be extremely beneficial to their understanding of the material:

I found the videos an invaluable resource for me personally and I believe other external students would feel the same. The videos are the reason, I believe, why I have exceeded my personal expectations in the maths component of this course (TM1 external student, 2006).

The Tablet was great. It allowed us to see exactly how to solve the problem, step by step, and allowed the teacher to explain his thinking as he went along. It is always better to see it worked out in front of you than to look at the already made answer and try to decipher it. (TM1 student, 2010)

At all times the aim is to encourage students to take ownership of their own learning. Additional activities are provided for learners experiencing difficulty with concepts, as well as opportunities to access specific resources and individual tutoring. Short personalised videos can also be created by lecturers to further assist external students experiencing difficulties. These videos are quick and easy to develop and can be created in any location, even away from the office. When students are having difficulty with a particular concept or problem in the textbook, they appreciate being able to email their lecturer for help and receive a short video explanation in return:

That is excellent. Thank you so much. (External undergraduate student, 2011).

Thank you, it all makes so much sense when you do it! I certainly didn't expect an answer on a Saturday, boy am I glad you were at work...That did help a lot, thanks again, (External undergraduate student, 2010).

Evaluating the effectiveness of the instructional videos

Skills for Tertiary Education Preparatory Studies (STEPS) is a CQUniACCESS program that commenced in 1986. In 2008, students enrolled in the external STEPS programme were provided with video instructions for the completion of all sample assessment tests via the ESG. Students were not given instructions pertaining to the navigation of the ESG, nor were they specifically directed to the sample assessment test videos. At the end of the course the students were sent a questionnaire. The researchers were not only interested in the students' attitudes toward the videos, but also if they were easy to locate and view, thus enabling the MLC to evaluate the effectiveness of the ESG in assisting students to prepare for assessment.

With a 34% response rate, the results from this study confirmed the MLCs suspicions that students not only found the videos benefited their TM1 studies but, due to the format of the ESG, they were easy to find. The majority of students thought the videos were easy to locate but, although they also regarded the content as clear and easy to understand, they tended to feel more explanation would be beneficial. When asked what aspects of the recordings they found most helpful, 97% of the students said seeing the solutions worked step-by-step and seeing the correct setting out. 77% of the students found being able to hear as well as see the solutions was helpful. Surprisingly only 53% of these students thought the videos added a personal touch, thus adding to their

enjoyment of the course.

Students did comment on the quality of the videos. They found the background noise that was present on some of the videos was distracting. Also the quality of the instructor's voice played a part in their satisfaction. This demonstrates the importance of quiet recording spaces and good quality equipment. For example, microphones need to be strategically placed so that excessive breathing is not recorded. Approximately 50% of students liked the ability to replay sections of the recording until they understood the concept.

The recordings are extremely useful, they deliver explanations and you can replay back until you *understand* (student comment).

In 2010/11, a full suite of instructional videos were created for TM+, and TM1 videos have been enhanced where required. Due to the advancements in recording technology and the subsequent quality of the instructional videos, the MLC are planning to evaluate the effectiveness of the resources again. Judging by the following comments from TM+ students, it is anticipated that the satisfaction level of students will have increased as a result:

I loved having the videos for the first few modules of TM+ and really miss them now I have moved on. The videos really helped me understand some of the more difficult concepts and it was great hearing the explanations and solutions, rather than just reading them from the book (TM+ external student, 2010).

Your course definitely had the support that is required and your videos were very helpful. Hopefully that kind of support will be available for TM2 soon (TM+ external student, 2011).

Formative Assessment

Davis and McGowen [13] found formative assessment was the key to student success in mathematics. At the end of each module of study, the ESG directs students to complete a formative assessment test (End of Module test (EOMT)) covering the content of the module just studied. Hattie [14] insists that in order to gain excellence in education the "teachers need to be aware of what each and every student is thinking and knowing". For external students, formative assessment provides the lecturer with an insight into the students' level of understanding so that they are better able to assist them. Students are invited to submit their tests via email, fax or mail. All tests are stored and marked electronically using a Tablet PC and returned by email. Using a Tablet PC for marking enables the lecturer to annotate the test and provide prompt quality personalised feedback.

Electronic submission, storage and the ability of markers to immediately access and mark tests through a shared drive, regardless of location, has reduced the turnaround time to process assessment from 1 to 2 weeks to 2 to 3 days. External students are the main beneficiaries of this efficiency, as they do not have to wait for their assessment to be submitted and/or returned to them via the traditional postal system. This process has an added advantage of allowing the lecturer to keep a permanent record of the student's exact submission as well as an exact copy of the feedback returned to the students. As students need to be involved in the learning process, they are given the opportunity to discuss their progress and formative assessments with the lecture and other students. It is recognised by Darkenwald and Merriam [15] that "Learning is more effective if the adult learner is actively rather than passively involved in the learning activity". Involving the student in their on-going formative assessment not only encourages engagement and collaboration between students and lecturers but also prepares students

for their summative assessment, which students greatly appreciate:

The quick turnaround of students' submitted work is also one of the key contributors to their success – being able to e-mail in their scanned work and then having it returned so promptly is a great initiative. Our WIST students have had a very successful year and we thank you for your contribution to their success, Regards Robyn Donovan (Coordinator, Women in Science and Technology, CQU, 2007).

Many thanks Sherie for the quick turnaround (TM+ external student, 2010).

Feedback

As the Tablet PC allows the lecturer to write on the student's test, personalised handwritten feedback (Figure 2) can be provided promptly, ensuring students receive feedback whilst the concepts covered are still fresh.

1. Solve each of the following for 'a'.

i) $-2a > -8$
 $a > 4$ ✓
 Lecturer: $2a < 8$, $a < 4$. Check $a=1$: $2(1) = 2 < 8$ ✓. $a > 1$, $2 < 8$ ✓.

ii) $4a-1 > a+8$
 $3a > 9$
 $a > 3$ ✓
 Lecturer: $a+5 > 12$ (check $a=7$: $7+5=12$ ✓). $a > 7$, $7+5=12$ ✓. $a < 17$.

iii) $4-2a < 3a < a+8$
 $4 < 3a+2a$, $3a < a+8$
 Lecturer: $a < 7$ ✓. Only half of the solution.

Figure 2. Extract of an annotated TM+ test.

The importance of feedback provided through formative assessment is not only an important part of the learning process but is also reciprocal. Through the submission of the assessment, the student provides feedback to the lecturer, who in turn provides feedback to the student through marking and annotation. If the student makes a mistake, the lecturer highlights the mistake and reworks the problem. This allows the student to see where they made their mistake and the correct working. Providing handwritten feedback is not only more authentic, but also provides guidance as to the correct setting out for a solution [16].

Submission of EOMTs therefore enables the lecturer to monitor the student's progress and provide extra assistance if required. This feedback is not only beneficial to the individual student but the entire external cohort. Through the submission of EOMTs from multiple students, the lecturer gleans an indication of the general understanding of the mathematical content. This identifies shortcomings in the course content such that future modifications are able to be made to the course, including additional instructional videos, as required. Through careful scaffolding of ideas and on-going constructive feedback, many students over the years have been able to achieve levels of competency in mathematics that they would not have previously imagined possible.

Thanks for all your help and support Sherie, I couldn't have done it without you...and by the way you have made my day :) actually quite a few days...lol (TM1 student, 2009).

Conclusion

As universities aim to increase student enrolments, especially LSES and mature-aged students, efforts must be made to ensure students are adequately prepared and supported. It is not acceptable to increase enrolments if the result is to either have students fail or have the quality of degrees decrease in order to maintain retention. With the aid of technology, the MLC has been consistently creating and improving resources in order to enhance the success of all students.

The Tablet PC has enabled the MLC to provide extensive resources that actively engage external students and comprehensive and informative feedback in a timely manner. The ESG is both an innovative and adaptive form of technology which supports the teaching and learning process. The potential of this tool is evident and significant in terms of its application within the learning context. As well as positively influencing the students' attitudes towards mathematics and their work habits, it also affords them an understanding of the relevancy and application of mathematics. The ESG provides external students with a structured learning environment similar to that provided to internal students. Additionally, the inclusion of electronic and paper based study materials in learning packages provide students with multi-sensory mediums, thus catering for a variety of learning styles.

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