Engaging adult learners with mathematics in a flexible-delivery-mode higher certificate in electronic engineering.

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The implementation of a flexible delivery mode Semester 1 Mathematics module is described. The student cohort is diverse, and the following were taken as key points in the development of a mathematics module with the flexibilities required:

- *The provision of a flexible delivery methodology, more suited to the lifestyle, work, and social patterns of potential students, which can impact on the re-engagement of those students with technology based education.*
- *The provision of specific reinforcement and remediation in mathematics for some students so that they can engage successfully.*
- *The structure of the module should enable the learner to control and direct the learning.*
- *The module structure should also provide facilities for the learner to measure their performance in as real time a manner as possible, so that they can make informed decisions as to the necessary steps they must follow during the process.*

In this paper the PRIMER and Semester 1 Mathematics courses designed to meet these key criteria are discussed. Both courses are delivered entirely using the computer based CALMAT learning environment, with learning monitored by the mathematics lecturer. Students also work at home on the CALMAT software and have access to further online notes from home and tutorial support within the college. Learning is assessment driven using the CALMAT software but separate to this software students must also maintain a reflective diary during the Primer course.

Student engagement is compared and contrasted with full time students also studying through CALMAT. Themes coming from the Primer Reflective Diaries are also discussed.

Key words: mathematics; adult learners; motivation; computer-based; CBL.

Section 1 - Introduction

In the last decade sustained economic growth has been experienced in Ireland, leading to almost full employment. The resulting increase in affluence, and growth in part-time

and full employment, along with changes in social behaviour and expectations, has been paralleled with a steady decline in those that are being attracted to full–time third level education in ICT and associated areas such as Electronic Engineering and Computing (see tables 1 and 2 below). For many at second level the opportunity of, and participation in, excessive part-time working has created a scenario that militates strongly against academic achievement. This in turn has led to many young adults in the poorer end of the labour market having low confidence with technology and mathematics. It is noted that the Report of the Royal Irish Academy (RIA 2005) discusses this theme.

This decline is illustrated in Table 1, which shows the number of full-time students entering the Higher Certificate in Electronic Engineering at IT Tallaght in recent years.

Table 1. Full-time students entering The Higher Certificate in Electronic Engineering at IT Tallaght

Year	**Number of students**
2002-3	72
2003-4	83
2004-5	53
2005-6	39
2006-7	44

This significant process of disengagement, which has been occurring over the past three to five years, is reflected in entries to other higher level institutions in Ireland, to the extent that in disciplines such as Electronics and Computing there is a danger of a shortage of suitably skilled people into the future (Enterprise Strategy Group 2004.).

In the Republic of Ireland applications for admission to undergraduate courses in all higher education institutions are processed through one organisation known as the Central Applications Office. Table 2 shows the number of first preference choices through the Central Applications Office for Engineering and Technology Courses from 2000 to 2007 at level 6/7 (two or three year higher education courses not including honours degrees). Also shown are the total number of preferences (1st to 10th) and the total number of students sitting the Leaving Certificate Examinations over the period.

Table 2. The popularity of Engineering amongst Leaving Certificate Students.

Year	1st Preference (1st February Figures)	All Preferences (1st February Figures)	Leaving Cert. Candidates
2000	15055	99607	Not available
2001	14312	89674	59537
2002	11066	66893	58522
2003	10208	58983	59536
2004	9262	50894	58742
2005	9109	48945	57422
2006	9004	45270	54100
2007	8700	40451	Not available

Sources: *Central Applications Office at http://www.cao.ie and the State Examinations Commission at http://www.examinations.ie*

Due to demographic trends the number of candidates available to do Engineering courses has decreased by a twelfth over the years. However, the numbers who really want to do engineering (1st preferences, see column 2 in Table 2) has fallen by over a third, and engineering has fallen hugely out of favour as a secondary option (see column 3 in Table 2).

The influence of Ireland's sustained economic growth has also changed the opportunities available to students at the end of the secondary school cycle. The availability of 'low grade' but relatively well-paid employment to almost all those having completed the end of second level Leaving Certificate has resulted in many young adults who historically might have engaged in further studies not doing so. This trend, and the resulting need to modify the traditional views of participation in higher level education, has been recognized at a national level and has accentuated the importance of lifelong learning provision to society and the economy (Irish Government White Paper 2000), (Forfás 2004), (Enterprise Strategy Group 2004).

1.1 Introduction to Engineering at ITT Dublin

The Institute of Technology Tallaght (known as ITT Dublin) is located in South Dublin County and was established in 1992. The Institute caters for a student population of approximately 2,300 full-time and 1,200 part-time students and offers a wide range of programmes from Higher Certificate, Ordinary Degree and Honours Degree to Masters Degree and Doctoral level.

The School of Engineering at ITT Dublin has always facilitated lifelong learning by allowing for and encouraging a continuing process of skill acquisition through the modular provision of programmes in ACCS (Accumulated of Credits and Certification of Subjects Scheme) mode. In particular in the School of Engineering very good

contact exists between the departments and relevant employers situated in the South Dublin County.
In the years after 2000 it was expected that there would be an increased demand for the courses in engineering delivered in part-time ACCS mode from young adults in the age bracket 20 - 25 who had gone into low grade employment, but who had now reached a ceiling in terms of promotion and career progression due to lack of third level qualifications. However, instead of the increase in part-time applicants expected, a decrease occurred to the point where running the Higher Certificate in the traditional part-time mode was no longer economically viable (see Table 3).

Table 3. Applications to the Part-time National Certificate Awards in Engineering.

Year	Number of Applicants
1998-9	32
1999-0	37
2000-1	17
2001-2	9
2002-3	14
2003-4	0
2004-5	7

(Note that applicants may not have started the course or sat examinations, but did register for the course)

To try to gain insight into this apparent contraction the Head of the Department of Electronics (the third named author) consulted with employers and young people working in related industries to gain some insight into possible factors inhibiting potential students from undertaking studies. This consultation was carried out on an informal basis with companies whose employees had in the past availed of the part-time access to courses in the department. The following factors were identified:

- Employers and prospective students wanted a flexible delivery methodology, more suited to the lifestyle, work, and social patterns of potential students, which can impact on the re-engagement of those students with technology based education.
- In the greater Dublin area the difficulty with travel and transport around the city had become a significant factor inhibiting re-engagement. This factor was not unexpected as concerns regarding the impact of increased traffic congestion on economic activity in general had been highlighted in a survey of companies conducted by Irish Business and Employers Confederation in 2002. For example 91% of businesses in the Dublin area who took part in the Irish Business and Employers Confederation survey reported traffic congestion as having an adverse impact on business whilst in the same survey across the national sample, 87% of companies surveyed indicated congestion as having an adverse impact on delivery scheduling and 71% of companies saw some adverse impact in terms of staff punctuality. (IBEC 2002).

- Prospective students wanted to be able to complete their studies in a timeframe roughly equivalent to the current full time delivery for a Higher Certificate (i.e. 2 years), but with significantly higher levels of participative flexibility to match their work-life expectations.
- For many of those in the age bracket 20 - 25 who had entered employment directly on completion of second level education the opportunity of, and participation in, excessive part-time working at second level had created a scenario which had militated strongly against academic achievement especially in mathematics. As a result these people expressed concerns that they could not engage with any form of technical/technology based education because of poor second level performance in this area. It should be noted that these type of concerns were expected given the research in the area of attitudes to mathematics such as that by Singh (Singh, 1993) and the work regarding negative attitudes to mathematics and math-anxiety such as that by Klinger (Klinger 2004) , (Klinger 2006).

Section 2 - The FLASHE Program

In 2004 the School of Engineering at ITT Dublin won significant funding from the Higher Education Authority of Ireland for the design and delivery of a flexible Higher Certificate in Electronic Engineering aimed at meeting the requirements of our part time students.

In an attempt to respond to the concerns outlined above the FLASHE (FLexible AccesS to Higher Education) Higher Certificate in Electronic Engineering was developed. The FLASHE programme is an attempt to provide a flexible course which allows the learner to control and direct the learning process to a greater extent than traditional day or part-time models. It makes use of the internet to deliver some materials and support, reducing the duration of the programme and the amount of class time for which students must attend the Institute. It also provides more than one session per week that students may attend in each module, on top of full time classes that may be attended. There are also tutorial supports available. The normal ACCS rules also apply in that students may choose the number of modules they do each semester.

Requiring only eight hours per week attendance at the Institute during each semester, the course is designed to provide flexibility in attendance times and progression rates for individual learners. As part of the programme the student is provided with learning material for home study and is supported and assessed by college tutors. The programme provides for the learner to measure their performance in as real time a manner as possible, so that they can make informed decisions as to the necessary steps they must follow during the process. In particular the course structure allows for a gradual process of re-engagement particularly in the area of mathematics in which the students may lack confidence.

Students may enrol on the programme in June, September or January. From its inception the FLASHE programme has proven to be very popular. In the academic year 2005-2006 8 students registered in June 2005 (after only a few weeks of advertising)

and a further 35 in September 2005. It therefore had the largest enrolment of any first year part-time programme in Electronics in the country with 43 students enrolled in 2005-6. In the academic year 2006-2007 a further 34 students started the FLASHE programme in September 2006.

Interestingly, most of these students are not in the 20-25 year of age group, and the age profile leans more towards 35-50. Those under 30 are also mainly non-nationals. The structuring of the initial Mathematics modules to engage with the philosophy of access, progression and flexibility is now described.

Section 3 - Mathematics for FLASHE.

Taking cognizance of the influence of the confidence of learners in their mathematical abilities and attitudes, beliefs, and feelings regarding mathematics can have on their learning of mathematics (Coben, 2003) and the feedback from the informal consultations with companies undertaken by the Head of Department of Electronic Engineering described previously, the department felt it was likely that people considering returning to a technical education will have a lack of confidence in mathematics, which may prove a significant psychological barrier to embarking on a technical course.

With this in mind, two mathematics courses are offered to the incoming FLASHE students; a pre-entrance PRIMER enabling mathematics course and the normal Semester 1 Mathematics course. In the PRIMER, in addition to the mathematical material being covered, the students are asked to complete a reflective diary entry after each session. Both courses use the CALMAT computer based learning environment (http://www.calmat.gcal.ac.uk) to enable the delivery and assessment of the mathematical material on the courses.

CALMAT was chosen as it contains three basic components which would suit the proposed structure of the courses. The first component is MoLS (Monitored Learning System) currently containing 140 lessons, starting at basic fractions percentages and decimals moving on through more involved material such as that covered in school and reaching a level covering material in the early years of higher education. The MoLs section presents theory, examples and lots of opportunities for student practice in a way that the student gets immediate feedback on their practice. The second component TAS (Tutorial and Assessment System) is a system containing a bank of almost 800 questions which the student can attempt (receiving hints from the system if required), input an answer and receive instant feedback and the full correct answer. Finally the CALMAT software has a Player component which allows the lessons and assessments to be assembled in a customised way for a module and allows the student to monitor their progress on the module in a structured way in real time.

After a session introducing them to the basics of calculator manipulation, the students take a short CALMAT generated diagnostic test which benchmarks where they are

mathematically. The test covers the very basics of number, basic algebra and properties of linear data. If the students achieve a high threshold on this diagnostic test they can (if they want) proceed directly to the Semester 1 Mathematics course, as this has been set up to be delivered using CALMAT also.

3.1 The PRIMER Mathematics Course

The primary objective of the pre-registration enabling PRIMER mathematics course is to bring prospective students back in contact with mathematics in a way which will boost their confidence in their mathematical ability. The secondary objective of the enabling course is to provide a basic foundation for their subsequent course. This is achieved through a combination of topics as outlined below and a strategy of creating a learning environment which is different to the 'chalk/talk/ get left behind' environment which the prospective students may have experienced last in their mathematical education. For this reason the PRIMER course uses the CALMAT mathematical learning environment to set up an assessment driven (and hopefully success driven) course which is tailored to the needs of the students.

The PRIMER course is of 24 hours duration structured into 2 hour sessions over a 12 week semester. The reasoning for this time structure is to not to try and cram too much into any particular session, which would be overwhelming for students who are under confident in mathematics and hence counter-productive. The structure also allows students the time to practice if they wish between sessions. Students are provided with a student version of CALMAT which they can use off-campus and merge their off-site work back into their files at the next session.

The material has been carefully chosen in 3 basic areas: number, algebra and data presentation. The students start with concrete concepts in number manipulation, are introduced to a simple level of abstract symbol manipulation in the brief introduction to algebra, and finally see a topic that will have easy application to the engineering in the topic of graph manipulation.

The course has 4 tests – one every 3 weeks. This is used both to show the students how they are doing (they get instant feedback from the CALMAT system) and to pace students through the material. Students were also given a student copy of CALMAT on disc to work on at home, and were expected to do 2 further hours per week at home. Records can be merged at home and college providing continuity.

The students are asked to complete a reflective diary entry after each CALMAT session. Suggested entries are to say what they have just covered, what they found difficult and what they feel they need to work on, but also how they feel about the PRIMER course, their work and how things are going. The hope is that students will develop good learning habits by reviewing their learning and perhaps gain insight into how their own mathematics anxiety might inhibit their learning. Themes coming from the diaries will be discussed later.

A mark is awarded to the student for their course based on the four tests, CALMAT assessments and handing in their Reflective Diary. There is no credit awarded for the course and a poor mark does not stop progression to the Semester 1 course. Interestingly in the academic year 2005-2006, no students asked why they should be doing the PRIMER course at all. In the academic year 2006-2007 a small minority of students did express concerns that by having to complete the PRIMER course they might not complete the higher certificate as quickly as the students who could proceed directly to Semester 1 Mathematics .

3.2 The Semester 1 Mathematics Course

The Semester 1 course is also entirely done within CALMAT in the same computer laboratory as the PRIMER course. This means that students need not be split up for their mathematics courses and one mathematics lecturer can be assigned to the whole group. The lecturer then manages the learning of each student and provides tutorial support as each student progresses at their own pace. In fact, in view of the efficiency gain of having all students in one computer laboratory, the Electronic Engineering Department agreed to fund a further support lecturer in the computer laboratory.

There are two assessment modes for the Semester 1 course:

1. Students study the material and do 4 tests. These count for 30% of their total mark and they do the examination in the normal way, counting 70%.
2. Students may complete 70% of all CALMAT tutorials set (148 tutorials comprising 3-4 questions each). They may also get 100% on 24 CALMAT Assessments (which may be retaken and comprise 6-12 questions on a lesson). They may also get more than 70% on each of four tests (15-20 questions on groups of lessons). Completing all these requirements gives them at minimum B+ grade and they need not sit the end of module written examination.

Section 4 - Student Feedback

Student feedback on the PRIMER course was gathered by means of their Reflective Diary entries. Themes coming from the Reflective Diaries from students doing the Primer course were:

1. All students recorded their four test scores over the course, and indicated how they felt about it, even though the diary or lecturer made no mention of recording this. Comments ranged from satisfaction and delight if high, disappointment and reflection on what they might have done in terms of revision if low. This suggests that the students respond to assessment driven learning.

2. All students expressed anxiety at the start of the course, noting how it was a long time since they did mathematics, that they always found mathematics hard, noting early in their diaries that they must do more at home, expressing concern about how hard the

course might be, worrying that other students were further ahead than them. Our assumption that the students might be anxious seems well founded.
3. Many students noted how useful the first two hour class on using the calculator given to them was. Perhaps more time could be spent on calculator skills with such students, especially older ones.

4. Many comments focused on technical problems. Students may merge their CALMAT records with those at home, but this requires they have exactly the same login information at both locations. In the academic year 2005-2006 many (more than half) the students had difficulty with this and took 4 to 5 weeks before successfully merging records, even though they had received simple written instructions. Several students had home machines without floppy drives (which was not anticipated though it should have been!), so that they could not merge records directly. Students also had the usual network login problems.

5. Many students complained in their diaries of losing marks due to "silly" mistakes. The CALMAT system tells students the format of answers required (3 decimal places, simplest form for fractions etc) at the end of the question, and is unforgiving if the format is not met. Students expressed frustration at this technical problem. Many students also expressed similar sentiments about the material on data handling, which asked for visual assessments of Cartesian point locations, but had little tolerance of error! It would be extremely useful, and good for students' confidence, if CALMAT could accept numerical answers within a reasonable tolerance.

6. No students expressed a dislike of the CALMAT class. Most were complimentary about not only the software but the structure of the class, for example:

> "CALMAT tutorials are a better way to learn for me as everything is explained with plenty of worked examples. The tutor is on hand to help when I need – if only school had been like this 20 years ago!"

This last theme is in contrast to some full time groups, who strongly resist learning through CALMAT (Robinson, O'Sullivan, Marjoram & Taylor 2004). This may be due to the full time class of 18 year olds not being willing to change how they learn from what they did at school, or accepting responsibility for their learning.

7. Students commented favourably on being able to go back over material, to being able to come and go in class and miss the odd class, to being able to catch up at home.

Outside of the diaries, some students still expressed a wish to have some traditional taught classes over and above the tutorials. Several students noted in their diaries that they found the CALMAT material on straight lines and linear data difficult to follow, and it was this material they wished to have a taught class on. This may be related to this material being unforgiving on slight calculation errors, and students getting many messages that their answers were wrong. The wrong answers were typically rounding errors or cumulative errors in a sequence of calculations involving fractions.

Section 5 - Student Engagement and Performance

In this section student engagement with the PRIMER and Semester 1 mathematics courses is considered particularly with regard to completion of the courses, as this is a key measure of whether this approach to structuring the initial mathematics courses has been beneficial to the students.

As described previously, after an introductory session the incoming students take a diagnostic test which benchmarks where they are mathematically. If the students achieve a high threshold on this diagnostic test they can (if they want) proceed directly to the Semester 1 Mathematics course. In the academic year 2005-2006 the high threshold on the diagnostic test was set at 90%. With the first intake of 8 students in that academic year one obtained 90% but chose to do the PRIMER course. Three students who completed this PRIMER course started the Semester 1 course in September 2005 (2 did not start in June and 3 left before September). With the second intake of 35 students in that academic year 3 obtained 90% and chose to do the Semester 1 course. The other students who had commenced the PRIMER course in September 2005 could continue onto the Semester 1 course in February 2006. Based on a review of the mathematics course in the academic year 2005-2006 it was decided to modify the high threshold on the diagnostic test to 80%. With the intake of 34 students in September 2006 sixteen students obtained above the 80% threshold on the diagnostic test and chose to start the Semester 1 course. Of the sixteen people who started the Semester 1 course in September 2006 only one person did not complete the course. Of the 18 students who started the PRIMER course in September 2006 three people did not complete the course.

Another measure of whether this approach to structuring the initial mathematics courses has been suitable for these adult students is to look at CALMAT usage by the students in comparison to full-time students taking the Semester 1 mathematics course in a similar way. The Semester 1 course through CALMAT has been used at ITT Dublin with one group of Mechanical or Electromechanical engineering students in each of 2004, 2003 and 2002. In each year only 2 or 3 of each group (12 to 16 students) managed to complete enough material to avoid sitting the examination. Such students typically managed 20 to 25 hours of usage over a semester, even though they nominally had 36 hours (3 hours per week for 12 weeks) of computer laboratory time. Most students achieved less than 20 hours of CALMAT time through poor attendance.

In the academic year 2005-2006, of the 6 students starting the Semester 1 course in September 2005, four used the CALMAT system for over 40 hours and passed without sitting the examination. The other two found the computer laboratory times inconvenient (8 to 10pm on a Thursday and/or 4 to 6pm on a Tuesday) and chose mainly to come in for tests and work at home. They both registered only 7 hours of CALMAT time but passed the end of semester examination and claimed to have spent about two hours per week working at home without merging records in the college. In the academic year 2005-2006, for the students who started the PRIMER course in

September 2005, 25 students proceeded to engage in the Semester 1 course in February 2006, and of these more than half spent over 30 hours on the CALMAT system. All the students spent more than 20 hours on the system. This is considerably more usage than the three full time groups of 18 year old students. In the May 2006 examination session, 24 of the 25 students registered for the semester 1 examination; of whom 19 passed, 2 deferred and 3 did not show. Twelve of the 19 passed on the strength of their CALMAT work alone and there was again a high use of CALMAT (40+ hours each) over the semester. This pattern of usage was repeated in the academic year 2006-2007. For the 16 students who started the Semester 1 course in September 2006 and the further 13 students who started the Semester 1 course in January 2007 there was an average usage figure for each student of 39 hours over the semester. In terms of student performance in the academic year 2006-2007, in the January 2007 examination session 15 of the 16 students who started the Semester 1 course in September 2006 registered for the semester 1 examination and all of these passed on the strength of their CALMAT work alone. In the May 2007 examination session all 13 of the students who started the Semester 1 course in February 2007 registered for the semester 1 examination with 12 of these students passing on the strength of their CALMAT work alone (the remaining one student did not attend for the examination in May).

Finally the data regarding the completion of the Semester 1 mathematics module is summarised in Table 4 below. From the total of 60 students who were eligible to take Semester 1 mathematics at the various starting points listed, 52 students successfully completed the module.

Table 4. Completion of the Semester 1 mathematics module.

Eligible to start Semester 1 Mathematics in:	Number of Students	Number of students passing without sitting exam	Number of students passing by sitting exam	Comment on students eligible but not participating
September 2006	6	4	2	
February 2006	25	12	7	2 deferred, 1 didn't register, 3 didn't show for end of semester examination
September 2006	16	15	0	1 didn't show for end of semester examination
February 2006	13	12	0	1 didn't show for end of semester examination

Discussion

From an overall perspective, the continuing numbers of students enrolling for the FLASHE program in contrast to the numbers that had been applying for the Higher Certificate in the traditional part-time ACCS mode would seem to indicate that this flexible blended model of course delivery is addressing some of the factors that had

been inhibiting such students from undertaking studies. One point of interest is that most of these students are not in the 20-25 year of age target group and the age profile leans more towards 35-50, with those under 30 mainly non-nationals. Further investigation will be required to see why the FLASHE model has not been successful with what expected to be the age group of 20-25 years.

Considering the mathematics component of the FLASHE program in particular, student feedback via the reflective diaries taken in conjunction with student completion and progression rates (see Table 4) suggests that the structure which filters the enrolling students via a diagnostic test either to the PRIMER mathematics module or to the Semester 1 mathematics module provides a vehicle through which the students can come back into contact with mathematics in a way which will boost their confidence in their mathematical ability. The use of a computer based environment like CALMAT to structure the learning and assessment in a way in which the mathematics lecturer could move to the role of facilitator of learning has proven to be more successful with the students on the FLASHE program than it was with the full-time students.
The technical issues with using CALMAT in terms of precision and formatting of answers led to some expressions of student frustration, particularly in the assessment elements of the module. To counter this, the lecturer checked all hand written solutions and awarded credit where the problem was simple input error. This intervention by the lecturer resulted in this student frustration being significantly lessened. In conclusion, adult learners seem willing to accept a computer learning environment based, assessment driven course. It has the flexibilities they require and seems to address some of the anxiety issues they face coming back to learning mathematics.

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