Blending on-line and traditional classroom-based teaching

By Kevin Golden* and Charlie Stripp**

* *University of the West of England, Bristol, UK*
** *Mathematics in Education and Industry, Exeter, UK*

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Abstract

With the considerable effort that has recently been put into developing high quality on-line teaching resources for engineering mathematics, questions arise as to how to incorporate on-line materials into a university education that still uses the traditional lecture and tutorial as the normal method for delivering course material. Over time, delivery styles may change as academics make use of the new resources that are being made available. However, any new pattern of delivery must recognise the different needs of what has now become a diverse student population. In this paper we describe and evaluate the use of a web-based student support resource for a first engineering mathematics module taken by about 150 students. We show that a web-based resource that is closely integrated with the week by week delivery of the module is well received by students and can play an effective role in supporting a diverse student intake.

1. Introduction

The work described in this paper is concerned with the use of a web-based learning resource to support a course delivery that is based on lectures and tutorials. A two year project was set up between UWE and MEI, funded by the Gatsby Foundation, to look into the use of web-based learning support on a first year engineering mathematics module. In this paper we report on observations arising from the first year of the project. Like many other modules of this type in the UK, a single module is used to teach mathematics to students on different engineering awards, with mechanical, electrical and electronic, aerospace, music systems, motor sport and civil engineering being the main awards supported in this case.

The most common entry route for students wishing to study engineering at university is still through the traditional route of A-level entry points, which should include A-level or some cases AS-level Mathematics. However, for a number of years, recruitment to engineering awards of students with A-level Mathematics has been difficult and institutions have had to look elsewhere for potential recruits. For some institutions, including UWE, the majority of students come with alternative qualifications to the full A-level Mathematics. Recruitment from a particular academic background must carry with it a realistic potential for success and ensuring that this occurs is at the heart of a wide range of teaching and learning development that has taken place in recent years.

Alternative entry routes to AS/A-levels exist through BTEC qualifications, university foundation years, Access to Higher Education programmes and non-UK qualifications. While students from some of these backgrounds can lack confidence with regard to mathematics, they may have strengths in other areas. At UWE it has been observed for a number of years [1], when comparing the relative performance of A-level and foundation year students, that while A-level students are more likely than foundation year students to pass their first year programme without any referrals, it is foundation year students who are more likely to progress to the second year. The explanation behind this surprising statistic may lie in the filtering of students that takes place during the foundation year itself, but it is also evident that students from non A-level backgrounds are often older, have invested a large effort to get to University and are generally mature in their approach to their studies. However, they do tend to be more anxious with regard to subjects such as mathematics, for good reason as their entry qualifications do not necessarily replicate the depth of the A-level experience. Consequently, they require significant support in addition to that provided by the tutorials that follow the weekly lecture session. It is how to provide this support in a manner that increases the confidence of these students that is a challenge to institutions that have significant recruitment from these backgrounds.

To illustrate the diversity of entry qualifications that can be present on a first year engineering mathematics module we present the following table, which provides a breakdown of mathematics entry qualifications for the 2004-05 cohort at UWE. The engineering mathematics module in question supports all accredited engineering programmes within the University, together with non-accredited programmes that have a significant mathematical requirement. There are 124 active students on the module. The module actually had 137 active students, but 13 were repeating the module, and in some cases may have been studying without attendance. In this investigation we concentrate only on those students attempting the module for the first time.

Mathematics entry qualification	% of cohort
A-level	41.5
AS-level	11.5
University Foundation Year	19.5
BTEC Level 3	16.0
Non-UK qualification	11.5

TABLE 1. Entry qualification data for 2004-05 cohort

Overseas students offering non-UK qualifications often have a standard of mathematics that is equivalent to or greater than A-level mathematics. However, given the range of qualifications accepted, we generally have to assume that some students entering the course will have not studied mathematics much beyond AS level. This means that, for example, they may not have met the product or quotient rules for differentiation before beginning the course. It should be noted that the pass-rate for this cohort was 80% for the summer examination, rising to 90% after the referral examination. The overall pass-rate for the 2003-04 cohort was 86%. These data show that we are able obtain good progression rates from the module, despite the variation in mathematical background described in Table 1.

Many examples of good practice in providing learning support in the context of a first year engineering mathematics module have been developed in recent years and brought to the attention of university tutors through organisations such as the LTSN for Mathematics, Statistics and Operational Research through its various projects and publications [2, 3]. An important component in managing a student cohort that is as diverse as the one considered in this paper is to provide flexibility, both in the style of support offered and the pace at which a student is required to cover the academic content of the module. Most UK university courses still use lectures to the student cohort as a whole to deliver the main concepts contained in a particular topic, together with a rationale, context and examples. Lectures are followed by tutorials, where students are placed in smaller groups and have the opportunity to try examples for themselves or take part in some other activity designed to consolidate their understanding of the material covered by the lectures. This delivery style would not seem to be an appropriate delivery mechanism for the cohort described in Table 1. The weekly lectures set a pace for the delivery of the material that will be too fast for some members of the cohort and possibly too slow for others. This is clearly not an ideal learning environment. At UWE, the course is designed to allow some flexibility in the pace at which students cover the material. The detail of this design is described in section 3. However, additional learning support is also available to each student. As reported in [4, 5, 6], for a number of years, computer based tests have been used to provide regular and instant feedback to students as to their progress. Also, students are able to seek help from a tutor, or may use other resources which could be a text book or web-based materials, such as those available from HELM [7] or the Mathscentre [8]. Hence, while in practice classroom based lectures and tutorials are often used to deliver course content, a blend of different, small group, one-to-one tuition, text and web-based resources are used to support learning.

In evaluating the effectiveness of a learning support resource in the context of a live module delivery, it is often difficult to establish any statistically significant effect that can be attributed to the resource under investigation. To begin with, for very good ethical reasons, it is not permissible to experiment on your student population. All students must have access to the resource, making it difficult to isolate its effect. In addition, as most will have observed, even poor students who make little attempt to engage in a module during its delivery still manage to pass. The popular ‘learning’ strategy of “cramming” just prior to an examination can be successful, even though there may be long term consequences for the student when presented with more complicated problems to

consider at a later date. Other students, who are very confident in the subject, and likely to achieve high grades, may not feel the need to use additional learning resources. Hence, it is difficult to establish the impact of an individual learning resource on the recorded outcomes from a module. The small numbers of students involved in a study such as that discussed here will mean that the statistical evidence for the impact of the learning resource on levels of student achievement is unlikely to be strong. The data presented in this paper will concentrate on showing that the sample cohorts are representative of the module population. To augment the end of module results, a number of interviews were carried out with first and second year students, to obtain their views on the effectiveness of the support they received or were currently receiving during the first year mathematics module.

2. The MEI/UWE Engineering Mathematics Web-site

The role of MEI in this project is to provide a web-based resource specifically designed to support the delivery of the first year engineering mathematics module at UWE and to make this web-resource an attractive feature of the learning support. Use of the web resource by the students was an entirely voluntary feature of the learning support mechanism, alternative learning resources were available to each student. The expertise of MEI in providing this resource arises from their experience of developing structured online resources to support sixth form students studying AS/A-level Mathematics and Further Mathematics. These resources are designed to be used alongside textbooks and have been shown to provide a valuable support to standard teaching and an effective way to encourage students to learn more independently [9]. Many Further Mathematics students have successfully used MEI's resources to help them to complete Further Mathematics qualifications with far less classroom contact than the standard four to five hours per week and the resources form a vital part of the support provided by the 'Further Mathematics Network', which MEI is currently setting up across the country with DfES funding. Resources developed by MEI for Further Mathematics can be easily adapted for use on a first year engineering mathematics module.

Each week, the lecture notes and tutorial questions that had been given to students during lectures were posted on the MEI-UWE Engineering Maths 1 web-site together with references to relevant parts of the course text. After a week's delay the solutions to the tutorial exercises were also posted. Each week's resources also include:

1. Extra notes and examples, tailored directly to the content of the lectures and worksheets.
2. Fully worked solutions to selected questions from the textbook.
3. Where available, interactive resources to help students master concepts and techniques.
4. Mock online tests, modelled on the online assessment tests that count towards students' overall marks for the course.

By tailoring the MEI resources so closely to the UWE course, the aim is to make them as relevant and simple as possible for the students to use. The tailored structure makes referring to the web resources an efficient use of the students' time.

The lecture notes, tutorial questions and solutions were handed out to students during the weekly lecture and were also posted on UWE's own internal web-page for the module. However, the features described in points 1 to 5 above were only available to students through the MEI site. All students had access to the site, and their visits to the site could be tracked providing information about when they logged in, the total time spent on the site and the materials that were accessed. Students were informed that the project was taking place.

3. Module Delivery and Learning Support

Before we consider evidence relating to the impact of the MEI designed web resource, we summarise the delivery of the module.

- Delivery model

Each week every student receives two one hour lectures [held on the same day] and a one hour tutorial. The module content is organised as shown in Table 2.

Learning Unit
Algebra Refresher
Pre-Calculus
Differentiation
Integration
Differential Equations
Matrices and Vectors

TABLE 2. List of topic areas covered by module

A computer based test is held at the end of each Learning Unit, usually every four weeks. Tests are delivered via the web and are held open for two weeks. Students are allowed three attempts at a version of the test created by randomly selecting questions from a question databank. The highest score is recorded as the mark for that test. A lecturer is also able to provide an additional one hour workshop for any group of students who are struggling with the material. We typically hold two workshops per Learning Unit.

- Assessment Regime

The module is assessed using two components of assessment, one of which must be under controlled conditions. For the module Engineering Mathematics 1, the assessment regime is shown in Table 3.

Component of assessment	Description
Controlled conditions (50%)	End of module examination
Coursework (50%)	6 equally weighted computer based tests

TABLE 3. Module assessment regime

The pass mark for each component of assessment is 40%. To pass the module, students must achieve an aggregate mark of at least 40%. A condonement exists that allows a student to pass the module with a component mark of 35% or above provided the aggregate mark exceeds 40%. If the module is failed, then students are referred in all components with marks less than 40%. If students fail the referred assessment, then they may retake the module in the following year and are required to retake all assessment components.

- Learning Support

We have already described some of the learning support on the module; the full range of support is listed in table 4. Much of what is described is similar to that would be found at most Universities. We have two very distinct types of support. There is that which involves continued tutor-student contact, and that which involves independent study whereby a student refers to an alternative text based explanation of the content and works on this material by themselves. In practice there will be students who use both types of support. The existence of two web resources and the text book, together with the lecture and tutorials mean that there is, in effect, four parallel deliveries of the module taking place. We occasionally have students who make greater use of the web resource or the text book than the class contact on offer, but this is rare. Most students make use of the class contact to find out what they need to study for that week. The trigger for looking at an alternative learning resource is usually the computer based assessment that takes place at the end of each learning unit. The two week testing period and the multiple attempts at each test create a learning cycle. It is during this period that students are able to determine whether their understanding of a particular topic at the necessary standard, or if extra work is required. Surprisingly few students seek additional tutor support during the test period, normally around 5% of the cohort and definitely less than 10%. Students may be

Learning support	Description
Pre-university transition course	Currently only available to part-time students and students from Access to Higher Education pathways [10,11].
Workshops	Organised by lecturer in response to demand identified in tutorials.
One-to-one tuition	Available, either through appointment with module tutor or by attending drop-in sessions held by our Mathematics Resource Centre.
Text book	Mathematics for Engineers (Croft & Davison); students are referred to relevant pages of text each week and the MEI web resources refer very specifically to the text.
UWE-online (Blackboard)	Used to post notices, to store lecture notes, tutorial questions and solutions and provide links to external web pages such as the MEI Engineering Maths 1 site and revision packs on the Mathscentre site.
MEI/UWE engineering maths 1 web-site	As described in section 2.

TABLE 4. Learning support available in maths to first year engineering students

getting this type of support from their weekly tutorial session, or from each other. As we shall see in section 4, a significant number of students do access web-based resources during the testing period and so the computer based tests do generate learning activity, as expected, and this learning activity is largely being managed by the students themselves.

4. Evaluation of web-based learning support

We have used five pieces of evidence to assess the effectiveness and characteristic use of the MEI designed on-line resource; these are an initial student questionnaire at the beginning of the module, the end of module questionnaire that is a standard requirement for all UWE modules, MEI site tracking data, the end of module examination mark and student interviews. As mentioned earlier, given the number of resources available to a student, it is not a reasonable proposition to isolate the effect of the MEI-UWE Engineering Maths 1 site on student attainment.

We have used the examination mark to compare levels of attainment on the module. By design, the computer based tests tend to produce high means which mask the differences between strong and weak students. The mean marks are calculated from the end of year results. Students who were referred in the summer examination are awarded their referral examination mark up to a cap of 40%.

The data below show the mean examination marks for the total population, compared with the sample population of those who used the MEI resources.

	All students	MEI users
Number of participants	124	60
Minimum mark	2	15
Maximum mark	100	96
Mean mark	52.73	52.42
Standard deviation	19.24	17.08

TABLE 5. End of year module examination marks (%) 2004-05

Table 5 shows that the examination performance of the MEI users closely matches that of the module population, with just under 50% of the module population making use of the MEI

resource. About 65% of students cited web-based resources as worthy of note in the end of anonymously filled out end of module questionnaire. The discrepancy can be explained by the fact that nearly all students make some use of the UWE-online resource.

We now compare examination performance for each group with entry qualification in mathematics

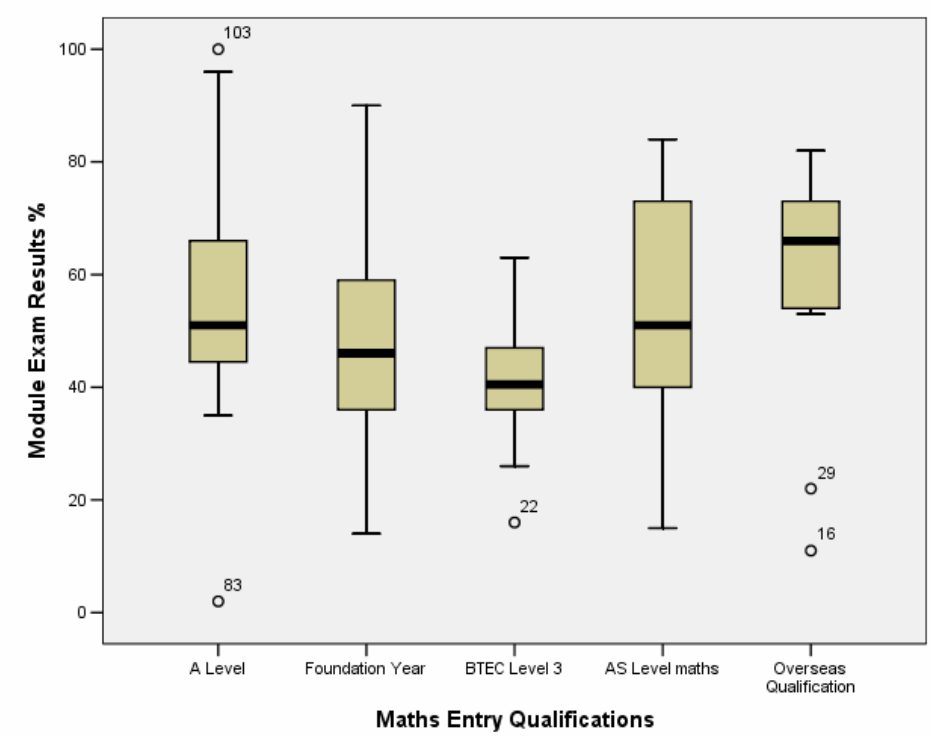

FIGURE 1a. End of year module examination marks (all students)

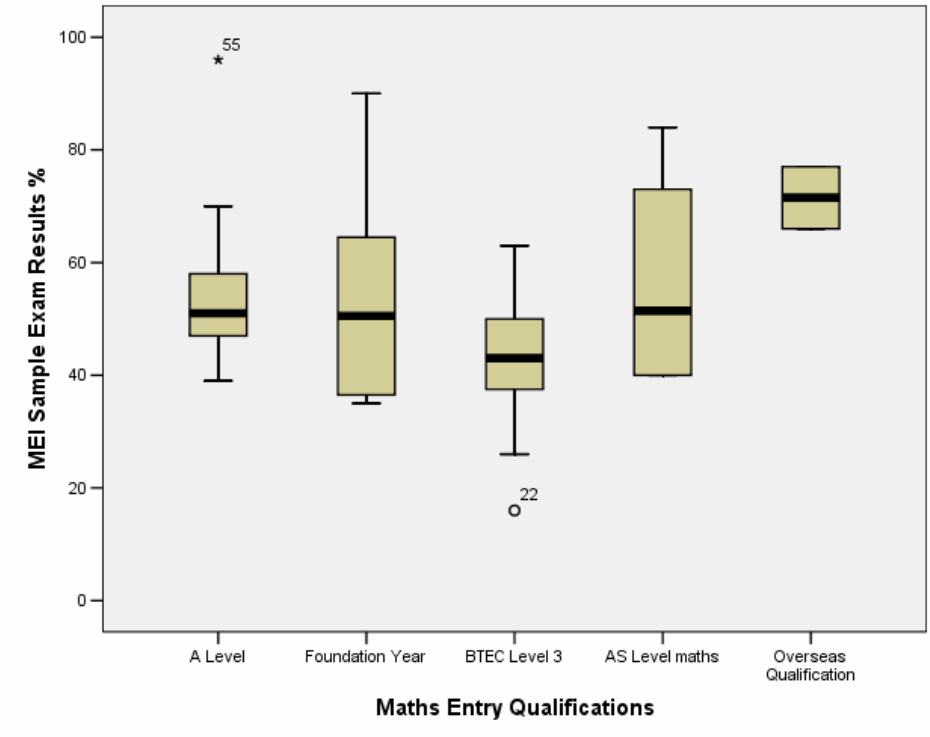

FIGURE 1b. End of year module examination marks (MEI users)

Again, the behaviour of the MEI users is representative of the behaviour of the module population. There is slightly less variation in the MEI sample. The results themselves are as expected. Overseas students often have a level of mathematics that is similar in standard to A-level Further Mathematics on entry to the award and so, generally speaking, do tend to perform better than A-level students on this module. The relative performance of the Foundation Year, BTEC level 3 and AS-level Mathematics students is below that of the A-level students, as would also be expected. The relative performance of these groups to each other does vary from year to year. The AS level performance is slightly surprising in that it is very good, but these students were identified at the beginning year and offered a lot of support. They were a fairly small group and obviously responded well to the support that was given. It is worthy of note that all of the Foundation year and AS-level entry students who used the MEI resources passed the module. Only two overseas students used the MEI resource.

At the beginning of the year students were asked whether they had used online resources before. There were 73 responses, with 41% stating that they had used online resources in previous courses. It was not possible to establish any correlation between previous use of online resources and use of the MEI resource. Neither was it possible to establish a statistically significant effect when looking at use of the MEI resources against other factors such as age and length of absence from study prior to joining the course.

To obtain some direct insight into a student view of the web resource, we conducted a number of interviews. The interviews were conducted in 2005-06, so these students have had time to reflect upon the experience they had in year 1. We also carried out interviews with some of our current first year students. Interviewees were given a short questionnaire to complete, to encourage them to think about the issues involved; the interview itself lasted for about twenty minutes. The table below gives a profile of each interviewee.

Student	Age	Mathematics entry level	Absence from formal education (years)	End of module exam mark 2004-05 (%)	Entry Year
A	25	BTEC Level 3	4		2005-06
B	23	BTEC Level 3	0		2005-06
C	29	AS Level	12		2005-06
D	25	BTEC Level 3	1		2005-06
E	>40	A Level	24	84	2004-05
F	21	A Level	0	61	2004-05
G	33	BTEC Level 3	10	47	2004-05
H	27	Overseas	0	53	2004-05
I	23	Foundation year	0	75	2004-05
J	30	AS Level	8	40(R)	2004-05
K	24	AS Level	1	76	2004-05

TABLE 6. Interviewee profile for MEI web resource study (R indicates passed on referral)

As can be seen from the above table, the interviewees were mostly mature students with some entering higher education after a significant break. A range of awards and entry qualifications are included in the sample. The end of module examination marks show that the interviewees from the 2004-05 cohort are probably not representative of the sample as a whole, but contain some of the more self-motivated and engaged students on the module. It is unfortunate that we were unable to find any students in the 18 to 20 age group to interview. Our hope is that they were too busy studying to participate in the study. While perhaps the interview group is not representative of the module cohort, the characteristics of the group shows that the module delivery and support needs not only to help those students who may struggle with mathematics, but must also appeal to and engage students who have the potential to be high achievers. It is not always possible to identify who these high achievers may be from entry qualifications. It is worth noting the typical profile of students in the interview sample is that of students who would have been anxious about mathematics at the beginning of the course, although went on to achieve good results.

All students were asked to identify which learning resource on the module they used regularly. When asked to identify which resources were particularly effective, nearly all students identified the lectures and tutorial. The availability of one-to-one tuition was identified as important, even by those who did not use this facility. All those who used the MEI resources (seven of the eleven interviewed) rated them as excellent. This group also expressed a wish for the MEI web based resources to be developed into a general resource that could be used later in their course for revision purposes and expressed disappointment that the resource had not been available during the second year of their programme. Most of the students thought the text book was well written and supported their studies. The consistent messages that came across during the interviews were that they liked class based delivery of academic content and they liked web-based learning support.

Six of the interviewees were part-time students. Five from this group used the MEI resources and were asked if they would like these resources to be used to modify the actual delivery of academic content. The proposal was that we keep their contact hours the same, but use these hours to build upon and consolidate web-based study they had already carried out. There might be good reasons for part-time students agreeing to this as their day at the University is heavily time-tabled, with little time available to them for consolidating their knowledge with the help of a tutor. They all rejected this suggestion, stating that the current arrangement allowed them to manage the work load pressures that they had more effectively than would be the case under the proposed change. In essence they do fall behind in their studies and they feel that the current delivery model allows them to catch up. This is quite possibly simply a conservative response from a group that prefers to learn using mechanisms they understand and have used in the past. Perhaps, they would respond positively to a different regime where the delivery of content was initiated through web-based materials and then expanded upon and consolidated through class contact. However, while these students have expressed a high degree of satisfaction with the quality and usefulness of web-based learning resources, there does appear to be limits on how they would like these resources to be used.

5. Comments

It would appear, from the albeit small-scale investigation carried out in this study, that students are willing to use and show enthusiasm for web-based materials used to support lecture/tutorial-based learning. The students interviewed in this study felt that the large lecture, supported by tutorials is an appropriate delivery method that provides a sound structure for their studies. The students reported that they used the on-line resources, such as computer based assessments, to stimulate learning activity that is managed by themselves, with many choosing to use the MEI resources. For the first year engineering mathematics module considered in this investigation, web-based learning resources have clearly offered choice, convenience and flexibility in the way that learning support has been offered to a student cohort that has a diverse range of characteristics in terms of academic background and maturity. It was not possible establish a statistical significance for the effect of the MEI resource on the learning outcomes of the module as assessed by the module examination. However, we were able to establish student enthusiasm for the use of these resources and an important role for this type of resource in promoting independent study and learning strategies that are managed by the students themselves. In 2004/5 about half of the students used the MEI resources. During the current year the proportion of the student cohort using the MEI resource has risen just over 60%. Participation in using the web learning resource is an entirely voluntary feature of the module delivery.

In terms of developing the learning strategy for the module, we have shown that web-based materials in the form of learning resources and computer based tests can stimulate the development of learning cycles during the delivery of the module. For subjects, such as mathematics, where there is a strong linear development of concepts and techniques, it can be difficult to create a learning environment where students are able to reflect on what they have been taught and effectively assess their own development. Tutorials are used to give detailed feedback to students, but time constraints limit the number of students who receive the support. The marking of coursework by hand is extremely resource intensive if it is to be carried out quickly enough and with sufficient frequency to provide an effective feedback mechanism. The computer based tests offer the opportunity for frequent assessment to take place and allow students to retake the assessments. The feedback from a computer based test may, in some cases, be very different in quality to that which is provided by a hand marked assessment, but it will be sufficient to indicate any problems and it is immediate. Students then have the option of seeking out individual support from their tutor or referring to specifically tailored web-based materials for help.

We have seen in this study that many are willing to use web-based resources to support their own learning.

In recent years, we have developed pre-University transition courses in mathematics for certain groups of students entering engineering awards at UWE. In addition to the mathematical content, the transition courses introduce applicants to the use of web-based learning resources used in higher education, such as the Mathscentre site. The early exposure of students to web-based support through the transition programme clearly supports the continued use of this approach on the module itself and will hopefully contribute to developing a proactive approach to learning by students. The transition course will be extended to cover the whole cohort of students on these awards.

In this investigation, we have limited the way in which the web-based support was used in the support of students on the first year engineering mathematics module. Students have indicated that they would like access to web-based materials in future years of their programmes. The materials used in the first year module can be used for revision purposes, and the materials recently developed by HELM also includes support at this level and for many higher level topics.

In 2006/7, the web-based materials developed during this investigation will be used to provide a remote delivery of the first year engineering mathematics module to a cohort of mature part-time students. These students have chosen to study in this way as part of a degree programme in River and Coastal Engineering. A detailed analysis of the use of the resources by these students will be carried out together with a comparison of their performance on the module with similar types of student on the classroom based delivery. This investigation may provide useful insights into how we can continue to deliver mathematical education, that is both effective and efficient in its use of staff resources,to students from diverse academic backgrounds in future years.

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