GP129/abs010

Construction and student feedback of a 'transition to university' online support course in mathematics for STEM students.

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Abstract: *School/college students in the UK usually complete their last Advanced level examinations in June, receive results in mid-August and then enter university in mid to late-September. This means that students have often gone months without having revisited material before entering onto a higher education course. This invariably causes issues in that students could easily have lost fluency in their subject, or even forgotten specific material.*

A collaboration between Mathematics in Education and Industry (MEI), a small, independent, charitable UK curriculum development body, which is committed to improving mathematics education for all, and the Wales spoke of the National HE STEM Programme, sought to create an online support course and study guide for use by students during the period between them obtaining their results and entering university.

This paper details the creation of the mathematics support course within a Moodle Virtual Learning Environment, which was then made available to 750 STEM students at Cardiff and Swansea universities once they had accepted their place at university.

Evaluation of the project, including feedback of survey responses from over 250 students, will be given. This showed that the project was seen to be of benefit by students and that they thought the online materials were so valuable that they wished to have access to the content for the whole of the first semester and not just for the time before they began at university.

The transferability of the project to other universities and departments will also be discussed.

Background

Qualifications

All students aged 14-16 in England are required to study for General Certificate in Secondary Education (GCSE) qualifications, one of which is a mandatory GCSE in Mathematics. They can then continue education post-16 with a variety of qualifications, with by far the most popular being Advanced levels (A levels), which are studied for two years. The majority of students taking A levels use them as entry-level qualifications for university. A level Mathematics is studied by students wanting to study mathematics and mathematics-related, i.e. STEM courses, at university.

There is a second A level in Mathematics: A level Further Mathematics. This both broadens and strengthens students' knowledge of mathematics and is aimed at the more able A level Mathematics students. Approximately 15% of A level Mathematics students currently study this second A level. Further information about the content of the mathematics A levels can be found in *'Understanding the UK Mathematics Curriculum Pre-Higher Education – A guide for Academic Members of Staff'*, Lee et al (2010).

Over the last decade MEI has created, maintained and developed extensive mathematics resources, which are focussed on the content of GCSE and A level Mathematics, see Button et al (2008). It is this expertise which meant that MEI was an ideal industry partner for universities to work with on this project.

Transition from school/college to university

Hicks (2007) at a conference on *Attracting the best students of mathematics into engineering* stated that 'The mathematical preparation of students entering university to read engineering is increasingly critical.' This viewpoint of the importance of mathematics prior to entry to university is widespread.

In the last decade there has been a lot of literature on the subject of the transition from school/college to university, and specifically with regards to Engineering and other STEM subjects. See for example:

- Measuring the mathematics problem, Hawkes and Savage (2000)
- Mathematics in the university education of engineers, Kent and Noss (2003)
- More Mathematically competent undergraduates, Porkess (2007)
- Newton's Mechanics: Who needs it?, Savage and Stripp (2008)
- Mind the Gap - Mathematics and the transition from A-levels to physics and engineering degrees, Institute of Physics (2011)
- 'State of the nation' - preparing for the transfer from school and college science and mathematics education to UK STEM higher education, Royal Society (2011)

Indeed, concerns are still on going in 2012 – *Solving the maths problem: international perspectives on mathematics education*, Norris (2012) found that many students do not realise that mathematics is necessary for success in a range of higher education subjects. This follows the Mathematics Taskforce (2011) report *A world-class mathematics education for all our young people*, which stated that:

> *'…in this country most new undergraduates arrive at university having taken no mathematics since GCSE two or more years previously. Even if they remembered all the mathematics they once knew, it would be inadequate but, in practice, much of it has often been forgotten anyway.'*

It is this concern, about forgetting, not having seen, or not being fluent in the relevant mathematical topics for their degrees, which this project sought to address.

Virtual Learning Environments

In the publication *'The undergraduate experience of blended e-learning: a review of UK literature and practice'*, Sharpe et al (2006) detailed the expansion of VLEs:

> '*The uptake of VLEs by Higher Education Institutions (HEIs) has been undertaken in a short period from 7% of HEIs in 1997, 81% in 2001, 86% in 2003 and 95% in 2005.*'

With VLEs now in almost all Higher Education Institutions in the UK, the focus has changed from simply having them available to students, to thinking how their functionality could be best developed. In this project we carefully considered how best to construct the resources to assist in the learning process.

Collaboration and project development

The rationale for this project was to help new undergraduates meet the mathematical demands of their degree courses. The project enabled students to use tailored online materials to reinforce and extend their mathematical skills over the period from confirmation of their university places, at the end of August, to the start of their degree course. At the development stage of the project it was decided that students should have access to the materials until the end of their first semester, but that as the project was focussing on the transition to university, students would not be advised of this until they arrived. This would therefore try and get students engaged in the material prior to their arrival, rather than waiting until they had arrived.

MEI worked with representatives from Cardiff University (Mathematics), University of Glamorgan (Engineering) and Swansea University (Engineering, Mathematics) to produce bespoke courses within a VLE. This VLE used the Moodle course management system.

In addition to the mathematical materials, a 13-page 'Student Guide' was also produced. The first chapter was specific to each university department and allowed the different departments to indicate

their expectations of students accessing the materials. The second chapter gave advice on how students need to take more responsibility for their own learning at university and how to develop their independent learning skills in mathematics. The third gave guidance on using the resources site itself.

Table 1 details an outline of the work undertaken for the project.

April 2011	Initial meeting between all partners, in Cardiff, to determine outline schedule and discuss technical aspects of the project
May to June 2011	MEI worked with Department contacts (DCs) to determine what material was appropriate Once content was agreed, MEI created the bespoke courses within their VLE, which is called Integral. MEI produced the 'Student guide'.
July 2011	Once the courses were finalised student accounts were created and details sent to DCs DCs coordinated with their admissions to enable the information to reach their incoming students by A level results day (in August)
August to September 2011	Incoming students accessed the materials from mid-August, before entering university in late-September
October 2011	MEI created an online survey, which students completed by 31st October
November 2011	MEI analysed the replies to the online student survey and created an outline evaluation.
December 2011	Final meeting of all parties to discuss the project and schedule for completion, including feedback from staff/DCs involved in the project

Table 1: Outline dates and actions undertaken for project

Materials and pedagogy

Here the materials and pedagogy of the VLE will be described, with the focus on its construction rather than the mathematics that was contained within the materials.

Users, once logged into the VLE, were able to see just one 'course', which included all relevant materials. Figure 1 depicts the VLE and shows the top menu section, which includes links to a user's profile, their tests, external links and a way to contact us should there have been any issues. It also shows the mechanism for navigating between the different sections of material.

Figure 1: Screenshot of VLE, with section drop-down option

As detailed in the opening section, over the last decade MEI has created, maintained and developed extensive mathematics resources, which are primarily focussed on the content of A level Mathematics. Their initial development was for a project to enable more students to study the second A level in mathematics, A level Further Mathematics. Details of this and how the resources were incorporated can be seen in Stripp (2007) and Stripp (2010).

The pedagogy underlying the site is that students should be able to engage and develop the learning of a topic themselves as a direct consequence of the construction and content of the VLE. This formed the basis of the way in which the site was used for this project.

Considering the specific detail of a course, then this is made up of a number of individual sections, which include a common format:

- 'This section covers…' text
- Section test (multiple choice automatically marked)
- Notes and Examples document
- Crucial points document
- Exercise questions and solutions
- Interactive/active learning and other resources

The title of each of these elements gives a clear indication into what their purpose is. This way of constructing and directing the learning has been well-developed and has been evaluated in several different contexts, from use in schools/colleges, i.e. Button et al (2008), Lee (2011), to use in universities, i.e. Golden et al (2007).

For this project learning resources were all selected from those that were already held within MEI's VLE. Though the materials did not form an exhaustive list of mathematics, Departmental Contacts still needed to carefully select the material for topics that were relevant to their students/course. This turned out to be a key aspect of the development of the bespoke courses and needed an

understanding of what underlying topics were the right ones to have, i.e. being selective rather than just taking a huge set of materials was the correct approach.

In this project there was some overlap of materials chosen for the different universities courses, e.g. algebra, polynomials, calculus, trigonometry, but some materials were required by one department but not another, e.g. proof for mathematics and vectors for engineering. More specifically, the Swansea University Engineering department had 35 sections, which included an introduction section along with: 4 on Algebra, 4 on polynomials, 2 on differentiation, 3 on integration, 5 on trigonometry, 3 on functions, 3 on logs and exponentials, 5 on techniques for differentiation, 3 on techniques for integration and 2 on vectors.

The introduction section suggested that students attempt the section test to find out if they knew the work in a given section. If they didn't score too highly, or didn't feel confident with the work, then they should review the other resources in the section, such as the Notes and Examples, Additional Exercises and Interactive Resources.

Figure 2 shows what a section from the site looks like, though note that each of the resources sections contained more than the indicated links, which have been truncated in the image to allow for an overall impression of a section to be seen.

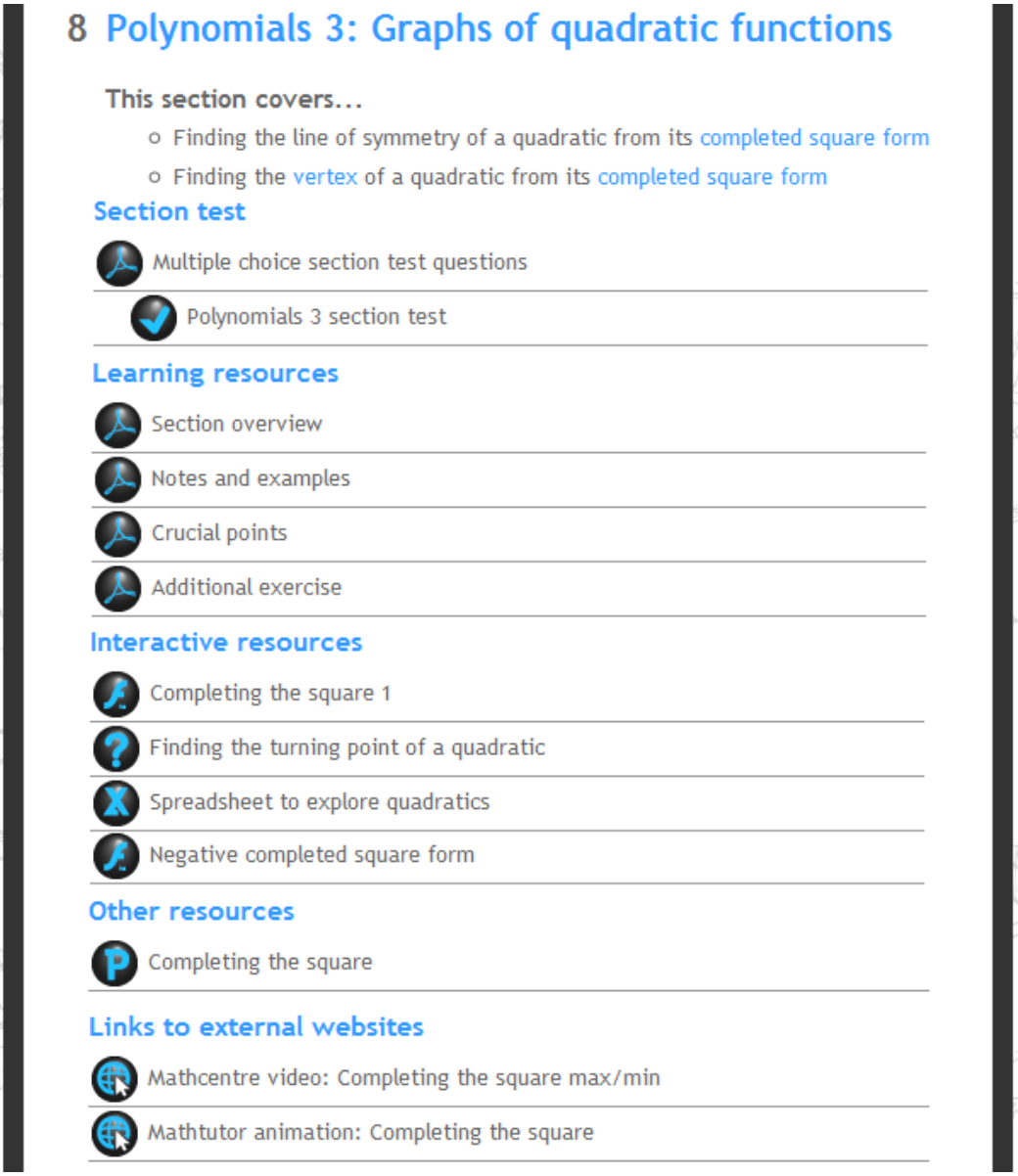

Figure 2: Types of resources available in each section

The small icons next to each resource give indication of its type. Within the VLE there are many different types, which include: PDFs, Word documents, PowerPoints, Spreadsheets, Flash files, Geogebra files, JavaScript interactive questions, videos and hyperlinks to external resources (as appropriate to sites such as mathcentre and mathtutor). This multiple representation, as detailed by Crisan (2004), is one of the main ways in which ICT can be used to aid students' understanding.

Note that the light (blue) text (e.g. 'completed square form' in the first two bullet points) is for expressions which are linked to a glossary, i.e. clicking on these brings up a new internet browser tab/window for the user, which has in it the glossary definition of the terminology used. This is very useful for students who may have any slight misunderstandings about what exactly a certain term means.

As Hoyles (2008) commented 'ICT has the potential to offer visual, dynamic connectivity with real-time interactions' and this is evident through the multitude of interactive and additional resources that are made available within the course.

Project evaluation

Evaluation of the project was primarily via an online student survey, but also through feedback from the university staff involved. It is the case that although the VLE used, Moodle, has functionality that allows individual tracking of which resources students view, the level of funding for the project did not allow for such detailed analysis to be carried out. Such analysis should however be considered whereever possible.

285 survey replies were received from students. One of the first questions in the survey asked students to rate the different resources in helping with their knowledge/revision of the mathematics, (on a scale of Very Useful, Useful, Adequate or Not Useful). Table 2 shows the percentage of students who choose the Useful/Very Useful option.

	Useful or Very Useful
Notes/Study Plans/Glossaries	73%
Additional Exercises	79%
Interactive/Active Learning Resources	70%
Muliple Choice Tests/Topics Assessments	88%

Table 2: Students rating of different aspects of the resources site

With 88% of students thinking the *multiple choice tests and topic assessments* were useful or very useful, they were clearly a key part of this online structure. This makes good sense as students used these to determine if further effort on a topic was needed or not.

This aligns well with the work of Broughton (2012) in the paper *Using focus groups to investigate the presence of formative feedback in CAA*, where they stated that 'The students in this group believe CAA helped them to identify learning gaps.', which is what the students were doing here. The additional exercises also proved popular, as a means for students to attempt more questions having identified where they may have had gaps.

Students were also asked about the amount and level of the materials. Here 73% thought the *amount* of material was sufficient, 21% too much and 6% too little, and 86% thought the *level* of material was at the right level, 5% thought it was too difficult and 9% thought it was too easy. Overall, this indicates that the right balance was achieved in terms of the amount and level of difficulty of the resources.

The Study Guide was well received with 80% of students rating it as good or excellent.Individual student feedback included:

- Having not done any Maths since the summer examinations, the website allowed me to read over concepts and test myself, which refreshed my memory.
- I refreshed my mind of all the A level content so I was as prepared as I could be for starting University.
- It was useful to have a range of questions to attempt to once again focus my mind on mathematics after such a long break.

- Allowed you to review your knowledge and also gave content on what you would need to know prior to University so everyone would have an appropriate base level
- The jump from A level to degree has been somewhat lessened due to the Integral maths site.
- I think it helped to give me confidence before starting university and it also helped me to revise maths topics that I may have forgotten.
- It helped to reinforce A level material which I am now using as building blocks for the material I am studying in lectures.

Also for those that didn't come straight from their A levels:

- Having had a year between finishing Maths at A level, and starting university, it was exactly what I needed to refresh my brain on everything I'd lost.

Finally, 84% selected 'Yes' to '*Overall, do you think you have benefited from having access to the support material and study guide within Integral?*', and 85% selected 'Yes' to '*Do you feel it will be useful for you to have access to Integral through your first semester at University?'*.

This feedback heavily supports the objectives of the project in enabling students to reinforce and extend their mathematical skills over the period from confirmation of their university places, at the end of August, to the start of their degree course and then onto the end of their first university term.

Departmental feedback from staff involved in the project was also very positive. One comment given was with respect to the performance on students in an entry diagnostic test:

> *'In terms of direct impact, simple comparisons were made with diagnostic scores for the 2011 intake with previous cohorts of students. This indicated a very small increase in the average percentage score i.e. 09/10~74%, 10/11~73%, 11/12~75%,and a small decrease in the percentage number of students scoring less than 60% (the minimum level noted as "expected"), i.e. 09/10~17%, 10/11~20%, 11/12~15%.'*

The departmental contact went on to say:

> *'It was not expected that the resources would significantly improve the diagnostic results, but rather complement the range of induction and support material already available to students making the transition to university.'*

It would be interesting to be able to review how students perform in the examinations at the end of the academic year, but at the time of publication this is not possible to know.

Overall, the project looks to have been well received by both the students and staff involved. Key to this was:

- managing the coordination between the different members of the consortia
- having a firm schedule of the work and who was to undertake it and by when
- the online material being of the right level, right amount and right content
- department contacts being able to contact students who have not arrived at the university to give them access

Extending the project

This project has enabled a suitable methodology to be developed which could be used to facilitate a similar project with other universities. As detailed in Table 1, the process of a university working with an expert industry partner like MEI, allows for a bespoke set of online mathematical materials to be produced quickly and efficiently.

This tailoring to the needs of an individual university, and even more so to an individual department is a key reason for success. This was highlighted in Lee et al (2011), *'This makes it clear that, at this level, generic resources are not as effective in encouraging users to engage with them as are tailored resources'.* It is important to be able to effectively match-up the requirements of a given university department with the MEI materials. However, due to the breadth of mathematical materials and topics covered in the MEI materials, it means that university departments outside of the UK could undertake a project such as described here.

Ultimately, extending this project to other universities and departments will enable many more students to access and potentially benefit from such materials and support.

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Acknowledgements

This project was possible due to funding received from the Wales spoke of the National HE STEM Programme.

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