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Forum Insights**ASSESSMENT FOR LEARNING:
Resources for First Year Undergraduate Mathematics Modules
Interim Report****Overview of the project:**

This project concerns the development of formative assessment techniques in order to improve the teaching and learning experience of first year undergraduate mathematics modules. Black and Wiliam (1998) defined formative assessment as 'encompassing all those activities undertaken by teachers, and/or by their students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged' (p7-8). The work in our project has two main components: firstly we are creating formative assessment tools for use in the classroom; secondly, we are developing interactive tasks which can be used by students to monitor their own progress and we will further support this progress with the provision of online resources.

A fundamental pillar in the work on classroom formative assessment tools, is the development of an audience response system which will allow lecturers to ask questions in lectures and gather responses from students through their smart-phones or tablets. Students will be able to submit graphs, drawings, text and calculations, and lecturers will be able to view the responses instantly.

In this project we also aim to identify mathematical topics and concepts that are problematic for first year undergraduate students in Higher Education in Ireland, and to use this information to inform the creation of online activities and tasks to promote understanding of these concepts. We will then evaluate the effectiveness of these resources. We have conducted a survey of lecturers in Mathematics and Engineering Departments in all Higher Education Institutions (HEIs) in Ireland to ascertain the main topics and concepts that students find difficult in first year courses, the types of resources that are already in use in relation to these topics, and how they are disseminated. We have also conducted a survey of students mainly at the end of their first year in the partner institutions to see with which topics the students themselves would like more help.

We are currently reviewing existing resources both nationally and internationally. Now that we have identified some of the problematic topics for first year students we have begun to design formative assessment activities and online resources with the intention of affording students the opportunity to monitor and develop their understanding of the concepts involved. We envisage the formative assessment resources being used in modules and in Mathematics Support Centres to allow students to develop their conceptual understanding and we aim to support this development using screencasts and activities designed by the project team.

We will conduct trials of all resources developed in this project over the next 18 months in appropriate mathematics modules at the partner institutions. The resources will be modified as necessary based on the results of these trials and consultations

with staff members and students. The final versions will be made available on the web for all institutions in Ireland to use.

Partners:**Maynooth University (Lead Institution) –**

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Dr Fiona Lawless, Department of Computing and Mathematics.

Key Outcomes of the project

(Please note that this is an interim report as we are less than one quarter of the way through the project.)

By the end of the project (in December 2016) we will have:

1. An audience response system which will consist of lecturer and student apps for both android and ios systems.
2. Survey data on the topics which students and lecturers feel are problematic for first year undergraduates.
3. A range of resources on the topics identified above, to include:
 - a. An inventory of useful existing resources;
 - b. Moodle Course using Khan Academy materials;
 - c. Online 'lessons' designed in Moodle;
 - d. Student screencast projects;
 - e. A suite of interactive tasks.
4. Evidence of the effectiveness of these resources.

Our progress to date on these outcomes:

1. We have hired a programmer to start working on the audience response system from June 29th 2015, with the intention of having a beta version ready for testing during the first semester of the 2015-2016 academic year. In addition, we have identified some key requirements for this system that includes embedding a means of recording its usage and, in

particular, student usage, in hope of being able to ascertain the effect of this system on the overall student learning experience.

2. We have administered the staff and student surveys. As the lecturer survey has just closed we have not had time to conduct a full analysis. However 32 lecturers completed the online survey (16 from IoTs and 16 from Universities). The questions were open and asked lecturers to indicate which topics were difficult for their first year students, which resources they recommended, and what kinds of resources they would like us to develop. Lecturers reported that students have problems with basic algebraic skills, functions and graphs, and limits and Calculus.

Summary of results from the student survey: The survey consisted of both Likert scale questions and open response questions. The questions sought to identify areas where students felt they had problems and also to gather information on the types of resources that students commonly use. In all, 460 students at the end of their first year were surveyed across the 4 institutes; AIT, DCU, DKIT and MU. The analysis of the data is ongoing.

Students attending AIT and DKIT indicated greater difficulty than those attending DCU and MU. These institutes, AIT and DKIT, also had a greater proportion of students who had taken ordinary level mathematics.

The topics that students indicated most difficulty with are:

- Finding limits of functions using graphs
- Finding limits of functions using rules of limits
- Finding and graphing the tangent to the curve
- Deciding whether a function is continuous or not

In the open survey students indicated that integration, differentiation and logs caused most difficulty. This is inconsistent with the data from the Likert analysis, students did not indicate problems with logs and differentiation (integration was not covered in the scale questions).

Generally students indicated that the subjects already encountered in the Leaving Certificate were less difficult.

The most highly rated useful resources for students completing the 1st year modules are handouts, class notes, tutorials and step by step examples. Students in DCU and MU found the prescribed mathematics books very helpful. YouTube videos, the Khan academy and Wolfram-Alpha were also highly rated.

Forty-five of the 225 respondents indicated that there were no gaps in resources. Other students asked for more step by step example and/or solutions, more classes and online resources such as videos, websites and apps.

Students equally selected print based, video and websites as resources they would like to be made available to them. The print based resources requested by students included handouts or notes available in print or from the VLE with step by step examples or solutions. Many students indicated that they wanted the VLE to act as a website of resources.

The results of the data analysis will be presented at an international conference in the UK in September 2015.

3. Here we provide a short description of each of the types of resources and indication of work done.

- (a) A list of useful resources recommended by both students and staff is being compiled. Discussions are underway with the National T&L Forum to create a webpage which will house an extensive list of existing mathematics online resources. This will act as a repository for all academics and students both nationally and internationally.
- (b) Focusing on many of the self-reported problem topics identified in the student survey this moodle module utilises existing resources to provide students with direct access to appropriate materials. It is built around Khan Academy and can be utilised by individual students, module lecturers or Maths Support Services.

By creating a Khan Academy account and following the playlist provided in this module a student is guided to relevant videos and quizzes which will assist in building competence and confidence on problem topics. It will also allow the student to monitor his/ her own progress through the Khan Mastery structure. The monitoring functionality within Khan Academy provides lecturers with the facility to assess student engagement with targeted materials, monitor student progress and identify specific problem tasks which may need to be addressed directly in class or through a Maths Support Service. Of benefit in a Maths Support environment the Khan Recommendations feature facilitates the tailoring of content to meet individual student's needs. This moodle module will provide:

- o An Introduction to Khan Academy including details of playlists & mastery, the class-coach set-up and sign-up instructions.
- o A targeted playlist (links to selected Khan videos and quizzes) relating to each of the following problem topics:
 - i. Equations and transposition of formulae;
 - ii. Log/exponentials;
 - iii. Functions & graphs.

Additional topics will be added to this module. While predominantly built around Khan Academy links to additional resources, materials developed by the project team can also be incorporated. The module is being built in moodle as this is the VLE used by all of the partner institutions, where it will be trialed, however the best way of supporting this module through the project website is also being investigated.

- (c) A Moodle lesson is an interactive learning package. Content can be transmitted as pop-up files (pdf, word, jpeg or screencast) followed by questions to test the learners' understanding of the topic. The lesson can display a progress bar and an on-going score to learners so they can see their grade. Multiple attempts are allowed. A prototype lesson has been designed.

- (d) Screencasts, as used in mathematics education, are defined as video recordings of movement on a computer screen together with audio narration. In face to face teaching of mathematics lecturers often 'walk' through the steps required to solve problems, screencasts can be used to extend this beyond the classroom and into the online environment. Loch (2011). In our project we want the students to create the screencasts for themselves and their peers.

In relation to (e), it is hoped to develop and implement a suite of interactive tasks for use on both smart devices and PCs. The hired programmer (to start at the end of June) will work on this task, in parallel with the aforementioned audience response system. It is envisioned that these interactive tasks will be carried out by students in their own time. As such, there is a need to include a suitable mechanism for recording student usage and returning this information to a suitable local database, in order to establish (i) how much students are indeed using the interactive tasks, (ii) which tasks in particular are students focusing on and (iii) if this usage is aiding the students' overall learning experience.

We have designed preliminary versions of interactive tasks involving the topics in first year Calculus courses. While the tasks designed to date focus on a specific mathematical concept, they are of a form which can be adapted to address other concepts.

- 4.** The design of the evaluation of the effectiveness of the resources produced will be completed this summer. The evaluation process will begin in October 2015 and will run through the academic year 2015/16.

A member of the team has attended an international conference on computer aided assessment in June <http://www.matic.no/events/11>, and members of the group helped organise of a conference in Dublin in May which addressed the use of online resources and software in the teaching of mathematics <http://supportcentre.maths.nuim.ie/mathsnetwork/ucd2015>

Benefits to the National Higher Education Sector:

- The data we have gathered on the troublesome concepts in first year will be useful when lecturers are designing first year undergraduate mathematics courses and resources.
- The audience response app will be freely available and will be useful in many situations, especially in STEM classrooms.
- All resources will be made available to the whole higher education community via a dedicated website.
- The research carried out in this project will add to the body of knowledge on education at tertiary level.

Benefits to Students:

- Many of the resources developed from this project are targeted at the problems that students' themselves have identified.
- The resources will be readily available to students and aim to provide opportunities for students to develop their conceptual understanding of 'troublesome' concepts.

- The project is exploring ways of using formative assessment to present students with opportunities to learn in new ways and to maximise student engagement. For example, using the audience response system to allow students and lecturers gain information about levels of understanding in classtime, asking students to create screencasts to explain troublesome topics, using interactive tasks to ask students to experiment and make conjectures.

Other national/international work that complements this project:

- National Forum for the Enhancement of Teaching and Learning funded project 'Transitioning to e-assessment in mathematics education' based in UCC and CIT.
- Improving progress for lower achievers through formative assessment in mathematics and Science (Fasmed) <http://research.ncl.ac.uk/fasmed/>. This an EU FP7 project based at the University of Newcastle. The Irish partner institution is Maynooth University and Ann O'Shea is one of the researchers involved.
- Eabhna Ni Fhloinn and Brien Nolan of DCU have been led a study which mapped resources from Khan Academy to the Irish post-primary mathematics curriculum.
- Screencast projects –
 - o Screencasts have been used in mathematics and statistics education in many countries. Mathscasts (www.mathscasts.org) and Statscasts (<http://statscasts.org/>) have been developed to support 1st year prerequisite mathematics and statistics learning across varying disciplines.
 - o The Open University have produced screencasts for mathematics which are available on <http://www.maths-screencasts.org.uk/index.html>.
 - o Students have generally reacted positively to both the Mathscasts and Statscasts, though it is necessary to promote the screencasts to the target audience. Loch, Gill and Croft (2012), Dunn, McDonald & Loch (2015). Students use the screencasts as part of their overall learning strategy. Loch et al (2014) found that screencasts have a positive effect on student results.
 - o Fiona Lawless has been working on developing student-generated screencasts in DkIT. Her use of screencasts stems from a research project carried out by a colleague, Dr. John Loane, "Using Screen Casting to Improve Assessment, Feedback and Peer-Learning in a Computer-Programming Course: A student perspective" carried out in fulfilment of the requirements of the MA in Teaching & Learning at DkIT.
- Task design projects – most of these projects have been concerned with school-level mathematics. For example, Professor Malcolm Swan and his team at the University of Nottingham have been working on designing tasks for secondary school syllabi for many years. Most recently in the Mathematics Assessment Project they have been funded by the University of California to develop both formative assessment tasks and associated professional development materials for use in US classrooms. See <http://map.mathshell.org/>.