USING TECHNOLOGY TO DEVELOP FORMATIVE ASSESSMENT RESOURCES FOR FIRST YEAR UNDERGRADUATE MODULES

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This project concerns the development of formative assessment techniques which aim to improve the teaching and learning experience of first year undergraduate mathematics modules. 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. This paper reports on the progress to date of each of these aforementioned components.

INTRODUCTION

This paper concerns a project which draws together academics from both mathematics and engineering departments in five university-level institutions in Ireland. The aims of this project are to design and develop formative assessment resources for first year undergraduate mathematics modules and to evaluate the impact of these resources. 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). We see information as being central to our study; the resources that are being created are designed to give lecturers and students information about levels of mathematical proficiency both inside and outside the lecture hall. The use of technology will enable the information to be gathered and processed quickly, so that teachers and learners can act on it immediately to exploit learning opportunities. In order to gather high quality information on student understanding in lectures we have developed an audience response system which will allow lecturers to ask questions and gather responses from students through their smart-phones and/or tablets. Students will be able to submit graphs, drawings and calculations and lecturers will be able to view the responses instantly. Technology also provides opportunities for mathematical tasks and assessments to be presented in different ways, facilitating greater engagement and interaction by students and addressing different styles of learning. Members of the group are also developing a range of new interactive tasks and online assessments, as well as reusing or repackaging existing online resources. In addition, we are investigating the use of student-generated screencasts as an assessment tool. The mathematical topics which are the focus of these resources were chosen based on the results of surveys of staff and students.

There has been a lot of research on the use of online formative assessment in higher education (Gikandi et al. 2011) and in mathematics courses (Trenholm et al., 2015) in recent years. However, the use of technology in assessment (both summative and formative) in Ireland has been limited.

One of the aims of this project is to investigate the possibilities that new technologies offer, and to evaluate the impact on both teaching and learning in the Irish context.

THEORETICAL FRAMEWORK

The National Research Council (NRC) (2001, p116) give a definition of mathematical proficiency as comprising of five interwoven and interdependent strands, these are: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. We will use this description of mathematical proficiency to guide our design of formative assessment resources and will endeavour to address all five strands with our resources with particular emphasis on the first two.

As noted previously, we will use the definition of formative assessment given by Black and Wiliam (1998) and in particular their five key strategies for formative assessment: engineering effective classroom discussion, questions and learning tasks that elicit evidence of learning, providing feedback that moves learners forward, clarifying and sharing learning intentions and criteria for success, activating students as owners of their own learning and as instructional resources for one another, (Black and Wiliam, 2009, p8).

We will use technology to design and deliver the formative assessment in this project. This is not a new idea; according to a report prepared by JISC (p 9, 2010) the benefits of using technology in assessment include allowing a greater range of types of assessments, a greater flexibility on timing and location of assessment; improved student engagement especially with interactive tasks which incorporate instant feedback, timely evidence on the effectiveness of course design and delivery. The report also considers four perspectives on the nature of learning and the assessments associated to each of them; these are associative (learning consists of building competence by making links between concepts and combining existing skills), constructivist, social constructivist, and situative. Our project will have elements which follow the associative and constructivist perspectives.

The interactive tasks will focus on providing opportunities for students to develop ‘mathematical habits of mind’ and mathematical thinking skills by asking students to formulate conjectures, make generalisations, evaluate statements, analyse reasoning etc.; Breen and O’Shea (2011) give a rationale for the types of tasks emphasized with support from mathematics education literature.

TECHNIQUES AND TOOLS

At the beginning of this project we conducted a national survey of staff who teach mathematics to first year undergraduates. 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. Thirty three lecturers from institutions across the island of Ireland completed the online survey. They reported that students have problems with basic algebraic skills, functions and graphs, and limits and calculus.

The student survey consisted of both Likert scale questions and open response questions and was administered in four institutions. The questions sought to identify areas (primarily in algebra, precalculus and calculus) where students felt they had problems and also to gather information on the types of resources that students commonly use. There were 460 responses. The topics that

students indicated most difficulty with when answering the Likert scale questions 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 response to the open questions students indicated that integration, differentiation and logs caused most difficulty.

As noted in the introduction, there are two main strands to our development work. Firstly, we are designing an audience response system which builds on previous work by McLoone at al. (2015). We have hired a programmer to work on this and currently have 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 the hope of being able to ascertain the effect of this system on the overall student learning experience. The software is compatible with both IOS and Android systems; it allows students to use smart-phones and/or tablets to draw graphs or circuits, do calculations etc. and the lecturer can view all responses in real-time. This has a real advantage over clicker systems since questions with open-ended answers can be asked and seems more suitable and adaptable to the needs of a mathematics lecture. We intend that the audience response system will give lecturers opportunities to employ the five strategies of formative assessment outlined by Black and Wiliam (2009). The system is currently undergoing trials in one of the institutions; it will then be modified and will be ready for evaluation in classrooms in the second semester.

Secondly, we are developing a range of formative assessment resources for use in first year undergraduate courses. The results of the staff and student surveys led us to concentrate on four key content areas: basic algebraic skills; logarithms and exponentials; functions and graphs; concept of a limit. Our goal is to improve mathematical proficiency (NRC, 2000) and so we are developing a variety of different resources to help students consolidate both procedural fluency and conceptual understanding. We will expand on three of the resources below.

In order to help students develop their understanding of the concepts of functions, graphs, and limits we have designed some interactive tasks using Geogebra and Numbas. The tasks were developed using the framework advocated by Breen and O'Shea (2011). The use of dynamic geometry technology has allowed us to make it easier for students to explore concepts for themselves and for us to ask them to formulate conjectures or evaluate mathematical statements. Some of these tasks will be used in assignments during the 2015/16 academic year while others will be made available on institutions' virtual learning environments' for students to use to get information about their own levels of understanding. The latter types of tasks have been designed with opportunities for students to receive hints as a means of scaffolding their progression, if necessary, through the tasks as well as receiving immediate feedback on completion.

The basic mathematical skills of new entrants to university level education in Ireland have been a worry for the mathematical community for some time (Gill et al., 2010). This issue was raised again in our survey of staff. Our group is involved in two attempts to tackle aspects of this problem. The first builds on existing resources and follows on from a successful project at school level in Ireland (http://mathletes.ie/). Using Khan Academy resources, we have selected a playlist which covers equations and transposition of formulae, logs and exponentials, and functions and graphs. Using the results of a diagnostic test students are guided to relevant videos and quizzes which will assist in building competence and confidence on problem topics. It is hoped that this process will also allow

the student to monitor his/ her own progress through the Khan Academy 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 mathematics learning support. The second idea on this front is to design Moodle lessons on problematic topics. 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. A series of prototype lessons has been designed and is currently being used.

FUTURE WORK

Between October 2015 and April 2016 we will conduct an evaluation of all the resources developed in this project. The research questions we aim to answer in the Irish context are: What are the benefits of using technology in formative assessment design? How effective are the resources that we have developed in developing mathematical proficiency? We will use assessment and usage data as well as surveys and interviews with staff and students to gather the data we need. We will have preliminary results of our analysis in July 2016.

Acknowledgement

This project was funded by the National Forum for the Enhancement of Teaching and Learning.

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