Assessment for learning: resources for first year undergraduate mathematics modules

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Abstract
This paper reports on two initiatives designed to address the lack of basic mathematics skills among new entrants to higher education in Ireland, namely, Building Mathematics Competencies using Khan Academy Playlists and The Use of Student-Authored Screencasts as a Formative Assessment Tool. The resulting resources constitute part of the outputs from a multi-institutional project, funded by The National Forum for the Enhancement of Teaching and Learning in Higher Education (NFETL) in Ireland, focused on developing formative assessment resources for use in first year undergraduate mathematics modules.

1. Introduction
The lack of basic mathematics skills among new entrants to higher education has been of concern to the mathematical community in Ireland for some time (Gill et al., 2010). This was re-iterated in a recent national survey of academic staff involved in teaching mathematics at first year undergraduate level in Ireland. This survey conducted in conjunction with a student survey, attempted to identify topics that pose difficulties for new entrants (Ní Shé et al., 2015). Survey responses provided the focus for the subsequent development of formative assessment resources for use on first year undergraduate mathematics modules. Further information on the overall project and resources developed can be accessed through the NFETL website (http://www.teachingandlearning.ie/wp-content/uploads/2015/04/Assessment-for-Learning.pdf) or alternatively see Ní Shé et al (submitted).

We report here on the effectiveness of two of these initiatives as derived from performance data and/or student feedback surveys. Both investigations concerned the use of technology in the creation of learning tasks that produce evidence of learning, allowing students to assess their understanding and encouraging them to take ownership of their learning. The first of these, Building Mathematics Competencies using Khan Academy Playlists involved repackaging existing free online resources to support a diagnostic testing cycle. Its focus was on building core skills. The Use of Student-Authored Screencasts as a Formative Assessment tool involved an investigation of their use as a self-learning tool aimed at providing opportunities for students to develop their conceptual understanding.

2. Literature review
Resource development was guided by Black and Wiliam's (1998) definition of 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*". The emphasis was on providing information as feedback within the assessment process, allowing learner and teacher to

adapt their strategies as required and giving students opportunities to improve both their procedural skills and conceptual understanding. The resources developed within this project achieve this by addressing the five key strategies of formative assessment proposed by Black and Wiliam (2009). The two initiatives being discussed focus on a subset of these, they use technology to assist in the creation of "*questions and learning tasks that elicit evidence of learning, providing feedback that moves learners forward and activating students as owners of their own learning*".

The use of online quizzes in mathematics has been the subject of much discourse. Broughton et al. (2013) surveyed nine lecturers and interviewed six of those regarding the use of Computer Aided Assessments (CAA) in a university in the UK. The lecturers all taught on first-year undergraduate mathematics modules for science and engineering students where CAA was used. Some lecturers maintained that the feedback encouraged students to learn a procedure which they often cannot apply to a new context; overall, lecturers found that such quizzes were a useful tool that allowed students to practise their mathematical skills and obtain immediate feedback. In agreement, Trenholm et al. (2015) also suggested that the use of CAA can promote surface rather than deep learning unless feedback is carefully constructed. Muir (2014) also noted the focus on procedural understanding. In this study Muir surveyed a group of students after they had viewed a self-selected Khan Academy clip on a problem or new topic. Students reported increased understanding of the material covered, they liked the step-by-step nature of the explanations and the fact that clips could be paused and replayed. While the use of online quizzes would appear to be beneficial in building procedural skill, the development of conceptual understanding may be further enhanced through the use of alternative technologies.

"*A screencast is a digital movie in which the setting is partly or wholly a computer screen, and in which audio narration describes the on-screen action*" (Udell, 2005). The creation of student-authored screencasts for use as instructional tools by other students has been investigated in the literature (Shafer, 2010; Croft et al., 2013) and suggests a number of potential benefits. These include the creation of a more active learning environment, deep as opposed to surface learning due to the reflective process required of students in the creation of screencasts, together with the development of transferable skills such as organisation and presentation skills. Focusing on the learning which can be gained from the reflective process involved in the creation of their own screencast we investigated their use as a self-learning tool.

3. Methodology

Building on existing resources and following on from the successful school-level Mathletes (Learnstorm) project (http://mathletes.ie/) the first initiative involves the use of Khan Academy resources to support a diagnostic test-retest cycle and subsequently as an assessment for learning tool. At the onset of the 2015/16 academic year a diagnostic test-retest cycle was implemented with 175 first year undergraduate Computing Students at Dundalk Institute of Technology (DkIT), with a view to assisting students to both identify and address gaps in their basic mathematics skills. Students completed a standard mathematics diagnostic test, were quickly informed of their mathematical weaknesses, as determined by the diagnostic test, and were advised of the mathematical resources and supports available to assist them in addressing these issues and in preparing for a subsequent re-test.

The main resource provided to students was a Khan Academy playlist, specifically designed by members of the project team to support this diagnostic testing initiative. The playlist, provided through Moodle (the virtual learning environment used in DkIT), was designed to guide students to relevant videos and quizzes to assist them in building competence and confidence on problem topics. Playlist topics were derived from preliminary survey feedback and included equations, transposition of formulae, logs and exponentials, functions and graphs. The Khan Academy mastery structure also provided students with a means of monitoring their own progress.

Following the second diagnostic test, students were invited to complete a questionnaire on the effectiveness of the Khan Academy playlist and their confidence in their mathematical ability. A follow-up study designed to address issues raised in questionnaire responses, relating to the level of the material targeted in the playlist and its lack of relevance to module content, was subsequently conducted at DkIT.

Khan Academy masteries were incorporated as a Continuous Assessment component on a Linear Algebra module taken by a subset of the DkIT cohort. The class/coach functionality in Khan Academy was utilised by the lecturer to make recommendations, assess student engagement with targeted material, monitor student progress and identify specific problem tasks to be addressed directly in class or through mathematics learning support.

The second initiative involved an investigation of the use of student-authored screencasts as a formative assessment activity with a view to creating a more active learning environment, as reported by Croft et al. (2013). 69 Computing and Games Development students taking a Geometry module were set an assignment to complete a sequence of tasks that demonstrate the relation between parametric equations and motion, a construct they typically struggle with. Students were required to create a screencast walk-through of their solution. Clear guidance was given in respect of the questions they needed to address in their screencast and they were advised that marks would be awarded on the demonstration of their conceptual understanding and achievement of desired learning outcomes as opposed to their completion of the procedural tasks. The aim was to facilitate deep learning by encouraging students to actively engage with the material.

4. Results

4.1. Building Mathematics Competencies using Khan Academy Playlists

Preliminary analysis found that overall 65% of the students who sat both diagnostic tests (n=104) improved their score on the second diagnostic test, with a higher percentage 83% of students who used the Khan Academy playlist (n=18) showing an improvement. The uptake of the Khan Academy playlist was low, usage was reported by just 20% of the 115 students who completed the questionnaire, however the majority of those students considered Khan Academy a useful resource and indicated that they would use it again. A related study was carried out in Dublin City University (DCU); the data from that study are currently being analysed but initial findings are similar. For example one student said that using the Khan Academy playlist "Helped me to judge what areas I needed help in". (DCU Student1).

Issues reported ranged from technical difficulties, in moving between the playlist in Moodle and the Khan Academy website, to the level of the material and its perceived lack of relevance to their modules: "I feel that this system should be re-done with maths more relevant to our modules", (DkIT Student1) and "It was very basic, maybe too much at times". (DCU Student2)

As expected engagement on the second phase of this study, in which the use of Khan Academy resources was linked to CA, was considerably higher, "from our students point of view, assessment always defines the actual curriculum" (Ramsden, 1992). The mean number of masteries achieved by the group was 9.5 (out of 23) with 35% of students scoring 75% or more on this CA component. Notably those students who used the Khan Academy resources (Time spent in Khan Academy > 120 minutes) had a mean score on the final examination that was more than double the mean mark achieved by those who did not engage with the resource (t-test, $n=75$, $p<0.001$). There was also significant correlation between scores on the Khan Academy mastery CA component and the Final Examination ($r=0.59$ (Spearman), $n=75$, $p<0.001$).

While it could be argued that these results relate more to the nature of the higher achieving students who are more likely to engage with all assessment components than to any impact of the Khan Academy resources on their learning, student feedback may provide a counter argument. An exit survey ($n=39$) was conducted to assess student opinion on their learning from Khan Academy resources: 74% felt that "Using Khan Academy enhanced their learning of Matrices", 55% agreed that it is "a useful resource which I will use when I encounter problem topics in future mathematics modules" and 65% recommended "including relevant Khan Academy Masteries as part of the Continuous Assessment on other Mathematics modules". However not all students felt this way with one student commenting that "Khan Academy ruined my life."

4.2. The Use of Student-Authored Screencasts as a Formative Assessment Tool

57 of the students enrolled ($n=69$) on the Linear Algebra module, completed the screencast assignment and their average mark on the assignment was 64%. After submission, students were invited to complete an online questionnaire on their views of the assignment. Participation in the survey was low at 28% of the cohort.

While no general conclusions can be drawn from the survey data, three themes arose in student responses to open questions relating to their learning from creating a screencast. Eight students pointed to the increased engagement required in planning and producing their screencast leading to a deeper understanding of parametric equations; some sample quotes are: "Felt like I needed to be able to explain every line that I wrote which is good for learning" and "A screen-cast assignment was new to me and a very beneficial project that helped me learn a topic more in-depth than other projects have previously". The benefit of providing the student with a voice in the assessment process was also mentioned by three students, for example "It allowed me to talk through my maths work". Finally three students compared screencasts and presentations with differences in their preferences; one student said "It helps me to explain the concept that I had understood, but may not be able to express in front of many people" as opposed to one of their peers' statement "It's a bit awkward to talk to the computer, I would prefer to talk to people."

These responses together with the high completion rates of the assignment seem to suggest that student-authored screencasts are an effective tool in promoting deeper learning. However, not all students saw the benefit of creating a screencast with seven students who completed the assignment not submitting a screencast and six students disagreeing that creating a screencast was a worthwhile exercise, with one adding "No, it just puts stress on you".

5. Conclusions

The aim of these initiatives was to attempt to address the lack of basic mathematics skills among new entrants to higher education. While both are still only in their first or second iterations, certainly at a local level in DkIT both initiatives appear to have been successful, with high levels of engagement. In addition, while student feedback levels were low, a common problem particularly with online surveys, those who responded were largely positive.

These projects are ongoing. Survey results on the Khan Academy project will be presented to students and further investigated through semi-structured focus groups.

The use of student-author screencasts as a self-learning tool will be pursued, in particular their use in providing students with a voice in the assessment process will be investigated (Trenholm et al., 2012).

Analysis of these developments will be disseminated once completed.

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