Implementing a Key Skills in Mathematics Initiative

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Abstract

The drive towards mass education, and the year-on-year fall in popularity of technical based subjects in Ireland (and other western countries), has created cohorts of students in many technical courses who are ill-equipped to succeed on those courses. Compounding this problem is the fact that most students in Ireland are now on semesterized courses, which seems to encourage students to learn enough for the regular examinations, without necessarily taking time to reflect on what they have learnt.

Whilst addressing the needs of these students is multi-faceted, we would like to describe the construction of a Moodle-based initiative at IT Tallaght called Key Skills Testing in Mathematics, with the aim of helping students bring knowledge with them from one semester to the next. Using the Moodle platform, Key Skills consists of:

1. creating many categories of multi-choice question which we believe our cohorts of students MUST be able to do. Each question comes with feedback and reference to a book chapter and an electronic resource.
2. creating tests which draw randomly from particular categories of questions. These tests may be repeated several times over a semester and only a high mark is rewarded with credit.
3. different tests run for different groups and in different semesters, reflecting the Key Skills of previously taught material required for that semester.

The aim is for students to expect Key Skills in each semester, re-enforcing and repeating their learning.

This project is in its first year, making evaluation premature. However, we would like to describe the development process and to present our material as a “how to do it” kit. Each question category together with upload instructions, additional files like images, and any tools used in the creation of questions, will be presented as learning objects. The whole Moodle course complete with tests will be presented as a learning object, as will detailed documentation on creating and managing such materials in Moodle.

Introduction

The Institute of Technology Tallaght Dublin (ITTD) is located in South County Dublin and was established in 1992. The Institute caters for a student population of approximately 2,300 full-time and 1,200 part-time students and offers a wide range of programmes from Higher Certificate, Ordinary and Honours Degree to Masters Degree and Doctoral level.

This decade has seen a gradual trend of falling numbers applying for Engineering and Technology based courses in Ireland. Compounding this fall has been a fall in the preparedness of students for their course, in terms of ability in mathematics and physics. Table 1 below shows the number of first preference choices through the Central Applications Office (the equivalent of UCCA within the Irish Education System) for Engineering and Technology Courses from 2000 to 2007 at level 6/7 (two or three year courses not including honours Degrees). Also shown is the total number of preferences (1st to 10th) and the total number of students sitting the Leaving Certificate Examinations over the period.
Table 1: Student Course Preferences.
Data available from Central Applications Office at http://www.cao.ie and the State Examinations Commission at http://www.examinations.ie

The number of candidates available to do Engineering courses (Candidates) has only dropped significantly in 2006 and 2007. This is due to demographic changes at school leaving age and due to a higher proportion of students enrolling on level 8 (Honours Degree) courses. The numbers who really want to do engineering (1st preferences) fell by over a third from 2000 to 2005 and has recovered a little in 2006/07 as a proportion of the candidates, but Engineering and Technology based courses at level 6/7 have fallen hugely out of favour as a secondary option (All Preferences).

Table 2 below shows the proportion of engineering students at ITTD with reasonably good maths (B or better in Ordinary Leaving Certificate maths, roughly the equivalent of English O Level and combining B1, B2 and B3) and reasonably poor maths (C or less at OLC, combining C1 to C3 and D1 to D3)

![Proportions of Leaving Certificate grades of students entering ITTD Engineering](image)

Table 2: Mathematics ability on entry at ITTD on Engineering Certificate courses, Robinson et al (2007).
Table 3 below shows the proportion of students who had done a Leaving Certificate physics course before coming to ITTD.

<table>
<thead>
<tr>
<th></th>
<th>Known to have studied LC Physics</th>
<th>Haven't studied LC Physics</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>37.50%</td>
<td>62.50%</td>
</tr>
<tr>
<td>2004</td>
<td>36.00%</td>
<td>64.00%</td>
</tr>
<tr>
<td>2005</td>
<td>36.36%</td>
<td>63.64%</td>
</tr>
<tr>
<td>2006</td>
<td>25.00%</td>
<td>75.00%</td>
</tr>
<tr>
<td>2007</td>
<td>8.00%</td>
<td>92.00%</td>
</tr>
</tbody>
</table>

Table 3: Physics preparedness on entry at ITTD on Engineering Certificate courses, O’Sullivan et al. (2007)

Tables 1, 2 and 3 show that engineering is becoming less popular, and that the mathematical knowledge and facility of those students that do enter our programmes is changing too, at least at ITTD. These trends are well documented elsewhere – see for example Bamforth et al. (2007).

Several initiatives to improve basic mathematics ability have been tried at ITTD, Robinson et al. (2007) and Marjoram et al. (2004). These initiatives have targeted first-year students with the aim of improving first-year retention. Unfortunately, while these initiatives appear to have been moderately successful in the fight to retain students, there is still a worrying lack of mathematical ability and knowledge amongst most second and third year students. The semesterized examination system does not help, leaving students with little time to reflect on their learning. Typically, the weak student does not bring key mathematical knowledge with him/her from one semester to the next. How can we help them to do that, and continuously refresh key skills?

In October 2006 we applied for an internal seed fund grant of €3,000 to implement a project which we call Key Skills. The idea is to continuously test key mathematical skills over a semester until a high mark is achieved (a high threshold competency based test). Such tests need to be randomized so that adjacent students do not see the same questions. They need to be repeatable, automatically marked, and provide immediate feedback on learning resources that students might go to in order to do better next time.

The tests must be reasonably difficult to cheat on and marks gained must go towards the continual assessment for their maths module – a currency all students understand.

The Moodle Quiz Platform (http://www.moodle.org) was chosen to implement the Key Skills initiative. This platform has proved to be extremely stable, with no performance issues or corrupted data to date. It possesses all the features we require, as well as keeping excellent student record data that can be further processed in Excel, for instance. It is also open source and has a very active Quiz component user group (http://moodle.org/mod/forum/view.php?id=737).
Implementation of Key Skills

Implementation was done in two phases. The longer-term goal was to carry out frequent Key Skills testing for all groups in years 1, 2 and 3 in Mechanical, Electromechanical and Electronic Engineering (9 groups comprising 316 registered students). Phase 1 was a pilot process involving just one group in semester 2, 2006 intake (Jan to June) and 3 groups in semester 1, 2007 intake (Sep to Dec). Phase 2, involving all groups in years 1 to 3, is ongoing for the semester 2 2007 intake (Jan to June).

Our Key Skills initiative has been set up as one Moodle course that all students enrol on. This cuts down on explanatory material for students and also gives lecturing staff a single location and log-on process to describe. The idea is that students will do Key Skills tests in all semesters, so that this single location is valuable for continuity of student access. All student records are also kept in the same location, which will allow us to do a longitudinal analysis of student performance over several semesters. This in turn will provide insight into something that we really want to know;

*does frequent Key Skills testing promote deeper learning and lasting knowledge retention in students?*

To create a moodle quiz, one first creates categories of question. Each quiz is then built from questions chosen from categories. Most categories were created in Phase 1, with others created as we needed them. At the time of writing there are some 50 categories comprising about 600 questions. Each question is mult choice with 3 distractors, and each answer option comes with feedback to a CALMAT lesson (Computer Assisted Learning in Mathematics) and a book chapter. Tests of 15 questions each are then built from questions in categories. Each question is randomly selected from each category required, with its answer options randomized and questions in random order in the quiz. Together with lecturer set password, duration and start and stop time we are confident that cheating can be minimized in the medium term. As students become more familiar, we can provide further security in terms of restricted IP addresses and secure browser windows.

Tests for different groups are, in general, made up of questions from different categories. This is to reflect the different Key Skills that students need for this semester’s work. All questions test material from previous semesters, and the first Key Skills test is in semester 2, testing semester 1 material. There is an overlap of material between semesters and we want the student to appreciate that, semester after semester, they will be required to know certain things. Each test also has a partner Practice Test. This test is always available and comprises 15 fixed questions similar to the ones in the real test. Students can review or repeat this test anywhere they have a web browser. When students complete a real test they can also review it later and see question feedback. All real tests are supervised and students may not repeat a test for at least 24 hours, preferably longer.
We want students to be active learners. The delay between tests is there to allow students to review their test attempts and question feedback. We would like them to have a little time to reflect and seek out information. During tests, no formula sheets are allowed and between tests we supply no supplementary notes to help with particular topics. We do not want frequent tests to be so frequent that students simply attempt to learn the form of each question and its distractors.

The best mark in the semester’s Key Skills test is allocated to half of the continuous assessment for that semester (typically 15% of the module mark). At the moment, for a 15 question test, a student gets 5% for 11 or 12 correct, 10% for 13 correct, 15% for 14 or 15 correct and 0% for 10 or less correct. We will probably drop the requirement for 5% to 10 or 11 correct and change the 10% mark to 12 or 13 correct. We want to avoid students becoming demoralized by repeatedly getting 0%.

The most difficult aspect of implementation in Phase 2 has been to provide sufficient test opportunities, both in terms of time and lab space. There is the added complication of providing testing opportunities for groups that the named authors do not teach. Luckily, the mathematics staff at ITTD are well disposed to this initiative, in part due to the fact that no administrative effort is required from them! We have tried to create two test opportunities for each group within their own class slot and with their own lecturer taking part. The lecturers have found this useful, and we think it is also crucial that students see Key Skills as being embedded within their maths module. Students are emailed about the coming test opportunity and also texted.

After the first two test sessions students will be emailed and texted about further opportunities to do a test outside their normal lecture times. Labs are deliberately overbooked with groups as we found in Phase 1 that attendance is typically less than 30% of each group, often much less. Currently, the first and fourth named authors are coordinating test sessions, contacting available student groups and contacting postgrads to do supervision. This work requires about 2 hours per week each, on top of the initial work in the semester of identifying free lab slots for each group.

**Test Uptake and the testing process**

Table 4 below shows the uptake of tests so far in the 2008 Spring Semester, between the start of teaching on the 19th of Jan and the present 4th Mar.

<table>
<thead>
<tr>
<th>Test</th>
<th>1 Test</th>
<th>2 Test</th>
<th>3 Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elec_Semester 6</td>
<td>9</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Mech_Semester 6</td>
<td>26</td>
<td>19</td>
<td>10</td>
</tr>
<tr>
<td>MechElec_Semester 2</td>
<td>39</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>MechElec_Semester 4</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Numbers of students and their test frequency

This table shows that 120 students have taken 180 tests so far this semester (there were 131 tests in total for the whole of the previous semester’s pilot phase). This is probably
about half the students who are actively on each course. In this table, the Semester 2 and 4 tests are common to electronics and mech/electromech engineering, while the Semester 6 tests are different. The testing process is yet to get in full swing in semester 4, but we would anticipate 600 to 800 tests completed by the end of May 2008.

If the reader wishes to repeat our Key Skills initiative they should keep the following points in mind:

1. As early as possible in the semester identify all free computer lab slots, lab slots that coincide with mathematics classes and all slots that can be used to run a test for each group. Review this frequently as timetables change.
2. Obtain as many student mobile phone numbers as possible and invest in an sms texting facility from your PC. Most students now give their mobile number to student records. Email to students is also useful, but is checked less frequently.
3. Involve each group’s maths lecturer in the test process. Show them how to log into Moodle and change test times and passwords.

The main difficulties with the testing process is providing timely warning that a test is available and coordinating time, group and test supervisor. A further ongoing problem, as our seed funding runs out, will be payment of supervision for tests that run outside a groups normal maths classes.

**Conclusions**

Without a longitudinal study of student performance over several semesters, conclusions are premature as to whether this initiative really does promote lasting knowledge and skills in weaker students. Further investigation of student attitudes to Key Skills, and feedback from them on improving the process, is also required. That said, Key Skills seems to have captured student attention somewhat. The latest Key Skills test session on 4th March had 28 students in a lab from 5pm to 6pm repeating their test. Anecdotally, students appreciate that they should know how to do test questions and like the immediate feedback on test completion.

Readers are welcome to all of the material we have produced. As well as the complete course with its categories and tests, we have detailed documentation on Moodle quiz creation and quiz management. We have also bundled each category as a learning object, together with any files used to help create such questions and upload instructions to Moodle. Please contact the fourth named author if you would like this material.

**References**
