TRANSITIONING TO E-ASSESSMENT IN MATHEMATICS EDUCATION

IMPLEMENTATION GUIDE FOR POLICY MAKERS AND PRACTITIONERS

Project funded by The National Forum for the Enhancement of Teaching and Learning

PREFACE

This implementation guide has been created as part of the project "Transitioning to E-assessment in Mathematics Education", funded by the NATIONAL FORUM FOR THE ENHANCEMENT OF TEACHING AND LEARNING IN HIGHER EDUCATION through the Teaching and Learning Enhancement Fund 2014. Deirdre Casey (CIT) is the lead author of this document with input from the project team in Cork.

The project is a joint initiative between University College Cork and Cork Institute of Technology. The main project aim is to leverage the potential of Numbas (an online assessment tool developed at Newcastle University) to construct localized formative e-assessment for first year service Mathematics and Statistics courses at UCC and CIT. The project focuses on the implementation and evaluation of this Mathematics e-assessment tool. The project team would like to acknowledge the cooperation of colleagues in University College Cork and Cork Institute of Technology.

The project website is www.teame.ie (**T**ransitioning to **E**-**A**ssessment in **M**athematics **E**ducation).

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WHY INTRODUCE E-ASSESSMENT IN MATHEMATICS AT THIRD LEVEL?

BENEFITS OF E-ASSESSMENT

E-assessment is a valuable tool for higher education for many reasons. It has huge potential benefits for students in terms of learning and retention of content as well as improving their engagement with their chosen topic. E-assessment offers many advantages over traditional pen and paper exams. See (Biggs 2011) and (Maier 1998).

When e-assessment is at its best, students receive instant and individual feedback on their work allowing them to form an accurate picture of their progress through the relevant module and build their confidence. It was highlighted in the Provisional Digital Roadmap (National Forum for the Enhancement of Teaching and Learning in Higher Education 2014) that

"students often say they don't get enough feedback on their performance, and that when they do receive feedback, it is often inadequate, difficult to interpret, or too late".

The use of e-assessment makes it much more realistic for students to obtain this timely and appropriate feedback given the workload already experienced by lecturers in an Irish context. The feedback given can also be further enhanced by technology as it may contain links to interactive content, further reading, videos etc., so that students can be directed to engage in self-directed learning tailored for their particular difficulties.

E- assessment can

- supply immediate and focused feedback on students' work
- guide students to further reading or resources if they are having difficulty
- allow students more than one attempt at an answer
- be used for diagnostic, formative or summative assessment
- present questions in a predetermined or random order
- record highly detailed student learning analytics and present them to the lecturer in real time
- improve student engagement
- manage lecturer workload and corrections
- improve students' digital literacy

Best practice and recommendations in Ireland are clearly aligned in the direction of increasing the use of innovative approaches to teaching, learning and assessment. The Hunt Report (Hunt 2010) recognizes that, due to our changing society and demographics, traditional large group teaching will increasingly be complemented by e-learning. The Digital Roadmap Recommendation 4 (National Forum for the

Enhancement of Teaching and Learning in Higher Education 2015) outlines "the imperative to embrace technological innovation in higher education and learning in meeting the challenges of a modernized and expanded Higher Education."

The Digital Roadmap also highlights the need to maximize the potential of data analytics to inform teaching and learning in Higher Education. The use of e-assessment makes this task manageable as most systems automatically track many learning analytics as students use the system.

E-assessment can also be effectively used to develop greater opportunities for part-time, flexible learning, including lifelong learning.

E-ASSESSMENT IN MATHEMATICS

Since Mathematics is a stepping stone subject, where a gap in understanding in one area can affect many other areas, it seems essential not only to keep the student continually engaged but also to give students the tools to identify any areas causing difficulty. The opportunities for improved engagement and timely and high quality feedback that e-assessment can offer make it an ideal tool to meet these needs.

The national consensus is that skills in the STEM areas (Science, Technology, Engineering, and Mathematics) are of particular importance for Ireland at the present time. The Hunt Report (Hunt 2010) places a particular emphasis on the fact that business and enterprise in Ireland needs our Higher Education Institutions to produce graduates with a high level of literacy in Mathematics and core digital skills. The majority of students studying for a science, engineering, business or commerce degree at an Irish University or Institute of Technology take Mathematics as a compulsory first year module. It is clear from student feedback that many students regard this as a continuation of the irritation that was Mathematics as a compulsory subject at Leaving Certificate. One way to break the vicious circle of poor student performance and poor student engagement is to present students with a more positive learning experience. Formative e-assessment, in particular the instant reward for correct work that it provides, can improve students' experience of Mathematics once the correct balance between online and face-to-face has been achieved (Paechter 2010).

WHY CHOOSE NUMBAS?

Numbas is a freely-available e-assessment tool for Mathematics that has been developed at Newcastle University. It allows students to input mathematical formulae easily and creates a similar but different question for each student. It gives students instant feedback and also interacts with Learning Management Systems such as Blackboard and Moodle. Since Numbas is an open source tool with a global community of users, expertise and experience can be shared nationally and internationally. It is actively maintained at Newcastle University and is easy for students to work with straight away. The potential for feedback on student performance to influence lecture content and online content can be exploited by the lecturer to dynamically tailor the lectures to the needs of students.

Numbas allows the integration of innovative and interactive content including geogebra and video.

Recommendation 2 from the Digital Roadmap (National Forum for the Enhancement of Teaching and Learning in Higher Education 2015) states that higher education institutions should strive to work collaboratively. Numbas is an ideal tool to facilitate collaboration as resources are open source and free to use. It is even possible to create collaborative projects where members can work together on creating shared content. Recommendation 3 foresees that institutions will work together on such open educational resources in the future to develop shared repositories of resources.

The Numbas system has a proven track record and a strong reputation (B. Foster 2012) and (Perfect 2015). It has been used in Cork Institute of Technology and University College Cork as well as at Newcastle University (B. Foster 2012) , University of Leicester, and Kingston University, London (Denholm-Price 2014) among others.

Numbas can

- supply immediate and quality feedback on students' work
- provide hints to students on how to solve each problem, including in video format
- guide students to further reading or resources if they are having difficulty
- allow lecturer to set the number of attempts a student can make on a question
- be used as a diagnostic tool
- be used for formative or summative assessment.
- present questions in a predetermined order or shuffle questions.
- improve student engagement
- manage lecturer workload and corrections
- improve students' digital literacy, in particular in relation to standard forms of mathematical input

WHY USE WWW.TEAME.IE?

Using www.teame.ie to transition to e-assessment will allow an institution to "hit the ground running" and make the introduction of Numbas as pain free and straightforward as possible.

All the exams that are on the website have been extensively road tested with our third level students and aim to guide students through the process of assessment for learning. The exams cover the key topics usually taught on first year business, science and engineering maths modules as well as some more advanced topics.

Examples of some of the topics are:

Pre-Algebra	Algebra	Calculus
Arithmetic	Fundamentals of Algebra	Limits
Conversions and Scientific Notation	Simple and Simultaneous Equations	Differentiation Rules
Error and Approximation	Transposition of Formulae	Curve Sketching
Income Tax	Indices	Introduction to Integration
Mensuration	Logarithms	Integration by Substitution
Percentages	Partial Fractions	
Ratio and Proportion		

Probability and Statistics	Advanced Engineering Mathematics	Other
Summary Statistics	Introduction to Laplace Transforms	Binary Numbers
Descriptive Statistics	Differential Equations	Financial Maths
Introduction to Probability		Trigonometry
		Vectors

The www.teame.ie website is developed and updated by Irish lecturers who have experience of implementing e-assessment using Numbas in their classes and tutorials. These experienced professionals can be easily contacted through the website for any further information or advice. The realities of the student are taken into account in the design of all resources with particular attention being paid to areas in which students have been found to be weak in the first year of Mathematics at third level.

The process of implementation is deconstructed from one potentially daunting project into manageable steps. It is designed around four levels of engagement with e-assessment that can be chosen to match the requirements and resources of each particular institution.

HOW TO GET STARTED

Outlined below are four possible levels of engagement with e-assessment using Numbas. The levels become progressively more involved, thus requiring more resources but also offering more potential reward.

The four levels of engagement are

Level 1: Click and play

Level 2: Use a test

Level 3: Customise a test

Level 4: Develop a test

	Level 1: Click and play	**Level 2: Use a test**	**Level 3: Customise a test**	**Level 4: Develop a test**
Try a test	Y	Y	Y	Y
Imbed test in LMS		Y	Y	Y
Delete a question			Y	Y
Add a question			Y	Y
Re order questions			Y	Y
Shuffle questions			Y	Y
Set a time limit			Y	Y
Control attempts allowed			Y	Y
Set a pass threshold			Y	Y
Control if user is allowed to regenerate the question			Y	Y
Control if user can reveal answers			Y	Y
Create questions from scratch				Y

Figure 1

LEVEL 1: CLICK AND PLAY

At level one a student or lecturer can select an exam and just try it out. This would be an excellent first introduction to the system for many people. It allows the user to try one of the premade click and play exams from www.teame.ie. These exams cover a wide range of topics that would be standard in most first or second year courses at third level institutions.

ADVANTAGES OF LEVEL 1

- no programming knowledge required
- no special training, cost, or resources required
- very user-friendly
- allows students and tutors to 'play' with the software
- students can use at home for revision
- lecturers/tutors can use this level for formative assessment
- can be used in Maths Learning Support Centres

LIMITATIONS OF LEVEL 1

- no learner analytics or grades are recorded
- restricted to the exact format of the current exam
- no opportunity to change any settings or questions

RESOURCES REQUIRED

- only technology required is a standard web browser to run the tests
- no financial cost associated with this level of engagement
- no training of staff is needed

INSTRUCTIONS FOR LEVEL 1

Go to www.teame.ie

Click on RESOURCES menu. Listed here are topics which have premade and tested exams to click and play.

Pick the topic of interest to you and click on the link.

Click on start. See Figure 2

Work your way through the exams. Note the special features, show steps, advice section when answers are revealed. If extra practice is needed on a particular question you can generate another question like this. See Figure 3.

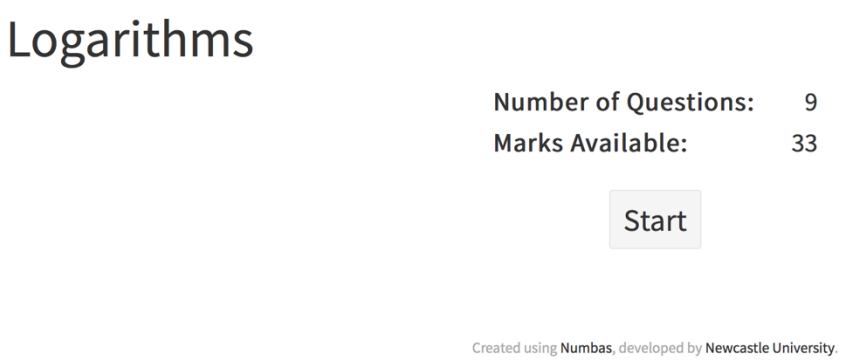


Figure 2

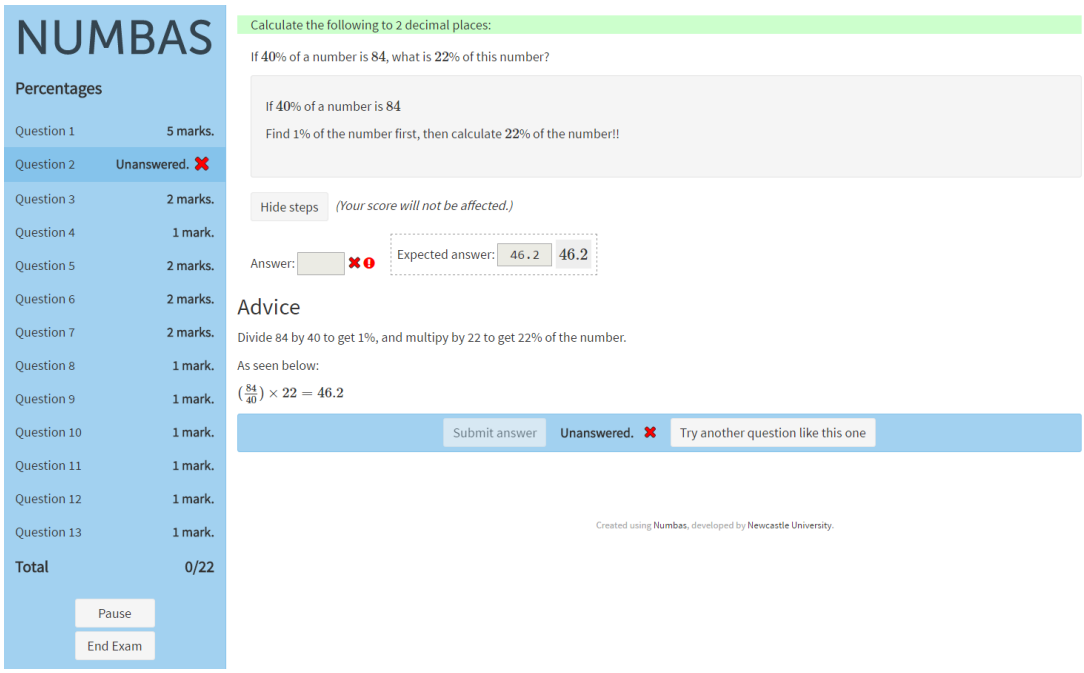


Figure 3

LEVEL 2: USE A TEST

At the second level of engagement, lecturers download the 'rebelmaths' exams as SCORM files. Exams with the 'rebelmaths' tag are quality test questions that have been created or modified by the Cork project team. These files are then uploaded to the lecturers' Blackboard/Moodle page and learner grades are recorded.

ADVANTAGES OF LEVEL 2:

- no programming knowledge required
- very little training or skills required
- learner analytics/grades are recorded
- can be used as formative or summative assessment
- an easy way to try out the system and see how it works in your setting
- students obtain immediate feedback on their work
- students can use it at home for revision
- can be used in Maths Learning Support Centres

LIMITATIONS OF LEVEL 2:

- no opportunity to make changes to the existing exams

RESOURCES REQUIRED

- no financial cost associated with this level of engagement
- some time (minutes) needed to learn how to download the files and upload them to the Learning Management System
- web browser
- Learning Management System (usually either Moodle or Blackboard)

INSTRUCTIONS FOR LEVEL 2

First go through the process of Level 1 and try out the exam you are interested in. If you are satisfied that this exam will suit your purposes, proceed to the Numbas website https://Numbas.mathcentre.ac.uk.

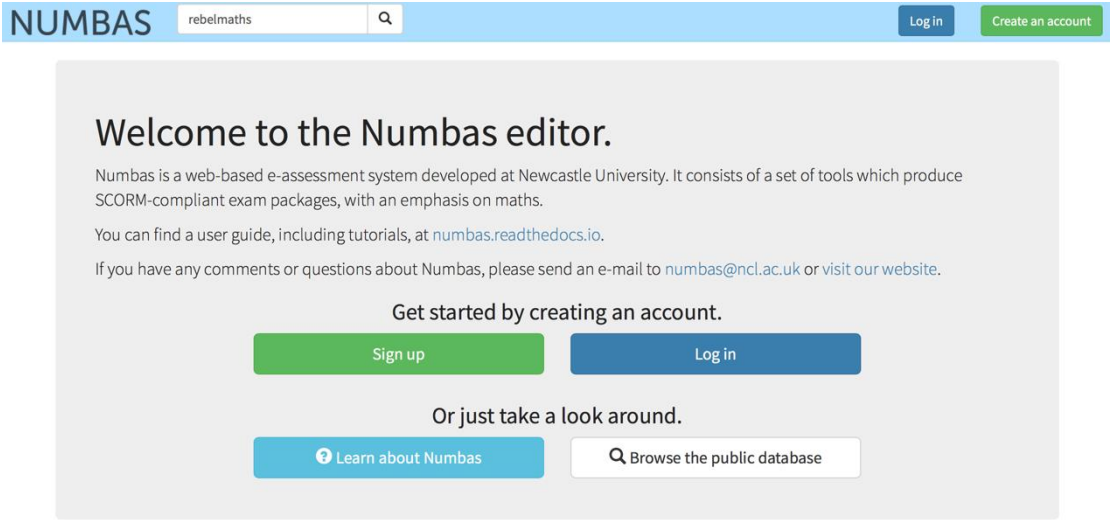


Figure 4

To access our exams, just search for 'rebelmaths'. See Figure 4. All our exams contain this tag. See Figure 5. You will find a list of our exams.

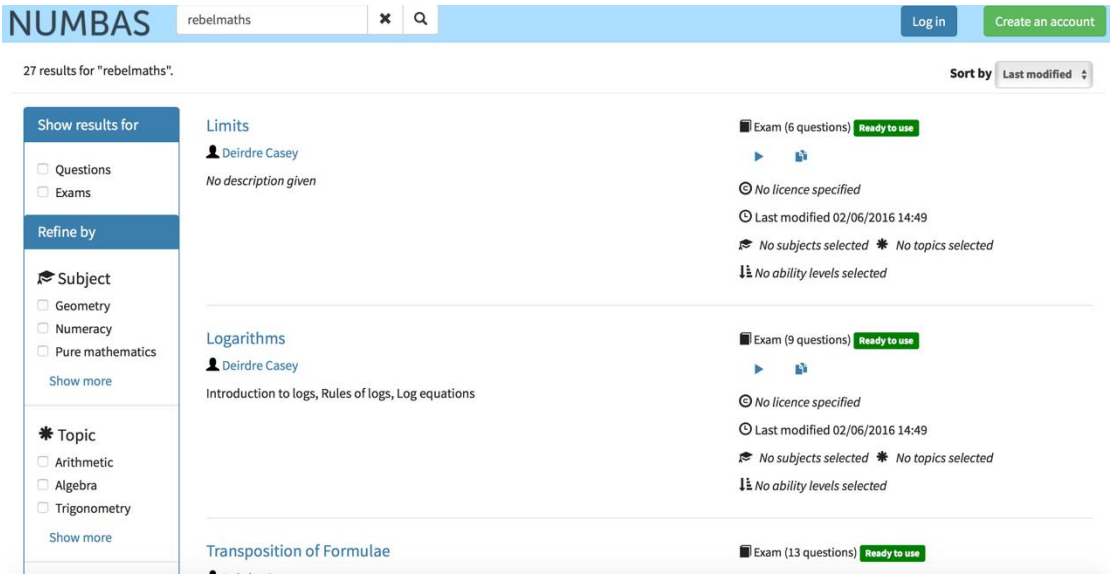


Figure 5

Find the exam you are interested in and click on it.

Click the button saying 'download' and choose SCORM package.The SCORM file has now been downloaded to your computer.

The process for uploading the test to your learning

SCORM stands for "Sharable Content Object Reference Model". It is a set of technical standards for e-learning software products and is the industry standard for e-learning interoperability. The SCORM standard allows Numbas and your virtual learning environment to communicate.

management system depends on which system you are using. Go to http://numbas-editor.readthedocs.io/en/latest/tutorials/upload-vle.html where there are short videos on how to upload an exam to Blackboard and Moodle. See Figure 6.

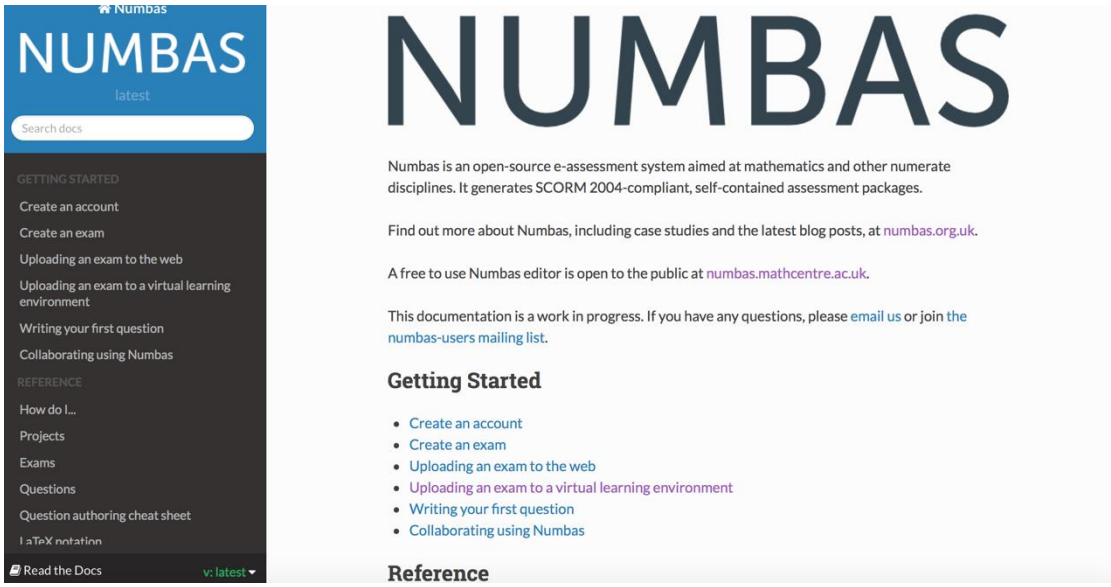


Figure 6

Once this is done the exam is ready for the students. Once the students have completed the exam, the results will appear in the virtual learning environment. In Blackboard, for example, they appear in 'Grade Centre'.

LEVEL 3: CUSTOMISE A TEST

At the third level of engagement a lecturer can make changes to the existing tests or questions in the 'rebelmaths' database.

Examples of changes:

1. Remove a question that is not covered in your module.
2. Add another question from the database.
3. Set a time limit for students to complete the exam.
4. Set the number of attempts allowed.
5. Decide whether you allow the user to regenerate questions.
6. Show current score.
7. Show maximum score.
8. Show answer state (give feedback that the answer is incorrect without telling students the answer).
9. Allow 'reveal answer'.
10. Can shuffle questions.
11. Can pick a subset of questions at random from a set.

Once the modified exam is to the lecturer's satisfaction they can download the SCORM file and upload it to their Blackboard/Moodle Page, as described in Level 2.

ADVANTAGES OF LEVEL 3

- no programming knowledge required
- learner analytics/grades can be tracked on Blackboard/Moodle
- can be used for formative or summative assessment
- exams can be tailored to best fit the lecturer's course and teaching style
- students can use it at home for revision
- can be used in Maths Learning Support Centres

LIMITATIONS OF LEVEL 3

- some training/skills required
- still limited to pre-existing questions, but you can draw on an extensive database of questions on Numbas from other developers.

RESOURCES REQUIRED

- some lecturer time may be needed to learn how to adjust settings for exams
- Web Browser
- Learning management system (Usually either Moodle or Blackboard)

INSTRUCTIONS FOR LEVEL 3

To find our exams on the Numbas website you need to go to https://Numbas.mathcentre.ac.uk

To access our exams just search for 'rebelmaths'. All our exams contain this tag.

You will find a list of our exams. Choose the relevant exam and click on “Make a copy of this exam”. You will need to create a Numbas account in order to do this.

At Level 3 there is a lot of flexibility about what you can change on our tests. To get full information on all the changes you can make you should refer to http://Numbas-editor.readthedocs.io which has information and tutorials on all the available settings.

LEVEL 4: PRODUCE A TEST

At Level 4, a lecturer can make full use of the capabilities of the Numbas software. Lecturers/technicians can use existing questions, modify existing questions, or create questions from scratch and use these to build their own exams. Once the exam is to the lecturer's satisfaction they can download the SCORM file and upload it to their Blackboard/Moodle Page.

ADVANTAGES OF LEVEL 4:

- full control over all aspects of the e-assessment from questions to style of exam
- learner analytics/grades can be tracked on Blackboard/Moodle
- can be used for formative or summative assessment
- exams can be tailored to best fit the lecturer's course and teaching style
- students can use it at home for revision
- can be used in Maths Learning Support Centres

LIMITATIONS OF LEVEL 4:

- Your imagination!

RESOURCES REQUIRED

- A lot of time is required to get to this level of skill. It is recommended to have a programmer/technician trained to this level as creating questions from scratch can be very time consuming for the lecturer

INSTRUCTIONS FOR LEVEL 4

At Level 4 you are learning to use all the flexibility and functionality of the Numbas system. The best source for all this information is http://Numbas-editor.readthedocs.io.

CASE STUDY: CORK INSTITUTE OF TECHNOLOGY

SPARK OF INTEREST

It all started for CIT when Julie Crowley (O'Donovan at that time) went to the CETL-MSOR Conference in Coventry in September 2013. At the conference Julie was introduced to several systems for creating Mathematics e-assessments but decided that Numbas seemed the most user friendly from the test creator's point of view.

PILOT WITH ONE COURSE

When Julie returned to Cork, she decided to use Numbas tests for a short intensive bridging course on Calculus. She created exams using existing questions from the database of questions on the Numbas website. The assessments carried no stakes and the students were a small motivated group so it was an ideal testing ground for the new system. Using Numbas as formative assessment made it possible to give the students a daily assessment with immediate feedback without the extra workload of correcting.

As expected Numbas worked very well as an assessment tool, however there was also an unexpected discovery; the students seemed to enjoy the Numbas work and it appeared to enhance student engagement.

> **"My initial motivation for using Numbas was to reduce my workload in terms of corrections. However, I discovered that Numbas was a highly effective learning tool. In tutorials students could help each other, but only with the method as they all had slightly different questions. I found students were much more determined to get the right answer, and that powerful green tick, than in pen and paper tutorials. I was also surprised that the group had no problem with the computer side of things."**
>
> **Julie Crowley**

GENERATE ENTHUSIASM

In May 2014, encouraged by the success of the Calculus course and supported by Áine Ní Shé, Head of the Department of Mathematics and Marese Bermingham, Head of the Teaching and Learning Unit, CIT hosted a workshop on Numbas. The workshop was given by Bill Foster and Christian Perfect of Newcastle University, the original developers of the system. This workshop was funded by the National

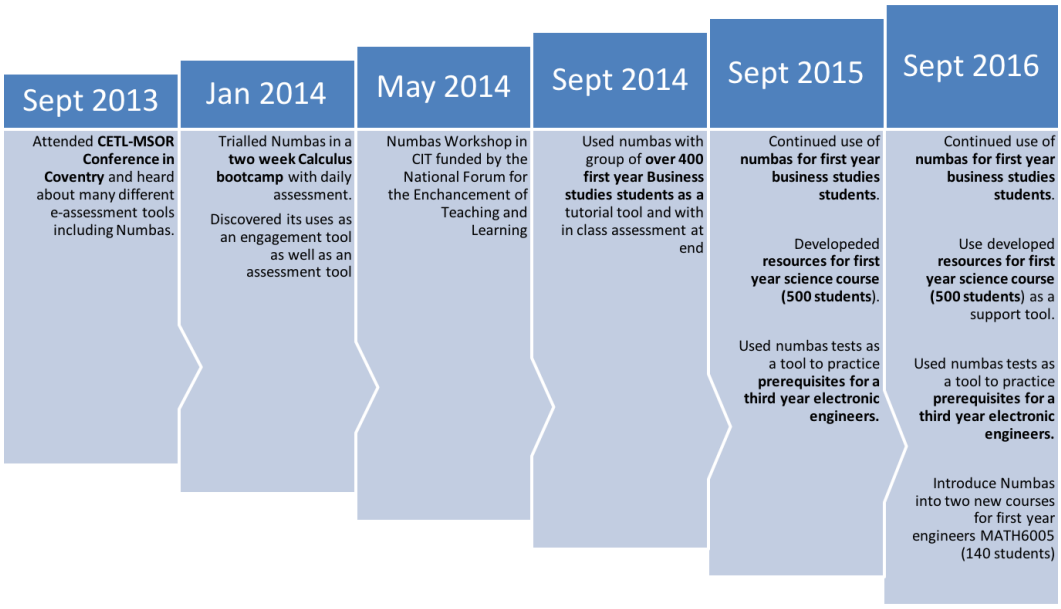
Forum for the Enhancement of Teaching and Learning in Higher Education and was attended by delegates from nine national institutes including peers from UCC. Enthused by the workshop and the positive feedback from the first trial other lecturers in CIT bought into the idea of e-assessment.

ROLL OUT

In the academic year 2014/2015, Numbas tests were used across two large modules *'Essential Maths and Stats for Business'* and *'Statistics and Financial Maths for Business'*. Altogether these modules had approximately 500 students and 10 lecturers/tutors were involved. Numbas tests were used both in tutorials and as in class assessment.

GROWTH

In the academic year 2015/2016, Numbas was used not only in the courses described above but also in three more courses. At this stage approximately 1000 students are using Numbas assessments; it is really gaining ground as this figure continues to grow.



LESSONS LEARNED

Over the course of the three years, lessons were learned about what works best when using e-assessment and what difficulties might be encountered.

- It is very important to have at least one lecturer leading the changeover. This lecturer should be very involved in the teaching of the first trial courses.
- If other lecturers are a little nervous of trying out this new method of assessment do offer them a backup plan for the unlikely event that anything goes wrong. For example, printed versions of the first

assessments, which Numbas can easily generate. This gives the lecturer a feeling that they have a safety net.

- The Numbas test works best in a supervised tutorial type environment where the students can ask for help with any technical issues they may have.
- Students should have one tutorial at the beginning dedicated to learning how to use Numbas and become comfortable with it. The test 'Getting Started with Numbas' on www.teame.ie would be ideal for this purpose.
- It is also a good idea for both tutor and student to have a practice test in this introductory class (worth no marks).
- Numbas tests work very well as a support tool in a Maths Learning Support Centre eg. The Academic Learning Centre in CIT.

CASE STUDY: UNIVERSITY COLLEGE CORK

SPARK OF INTEREST

Tom Carroll, Mathematics, UCC and Kieran Mulchrone, Applied Mathematics, UCC have a long standing interest in Mathematics Education at university having collaborated on a project entitled "Development of an online mathematical learning application for first year science, engineering, food science and commerce students" funded by the President's Strategic Fund in 2005. Kieran Mulchrone established an online M.Sc. in Mathematical Modelling and Scientific Computing in 2014 and is completing an MA in Open and Distance Learning with The Open University in 2016. It is no surprise that when a call came for a CIT-hosted workshop on Numbas our interest was piqued and we attended. Numbas was a positive revelation which opened up many possibilities. Our key motivation at this time was helping science students who take a compulsory course in Mathematics in first year at UCC. This is a large cohort of 500 students of mixed abilities, experiences with and attitudes to Mathematics. Efficient management of resources was also to the forefront during a time of government cutbacks.

EXPERIENCE WITH ONLINE MATHEMATICS

Our previous experience of online Mathematics was challenging. Development of resources is typically time consuming and then often provides little variation for students. Prototypes were interesting but upscaling proved almost impossible. We had experimented with using Mathematica as a background workhorse and using some of its innate abilities to break down solutions into steps; however, this typically did not provide useful feedback to students. Kieran has used the virtual learning environment (VLE) Blackboard for many years and experienced the limitations of its built-in assessment capabilities (i.e. multiple choice questions, comparison of exact numeric answers, no symbolic abilities).

NUMBAS AT UCC

Although Numbas is not a panacea for online Mathematics, it does solve many of the obstacles we had encountered earlier. It provides a platform for problem development; it allows for assessment of symbolic answers; it can provide intelligent random parameter generation for variation; it can incorporate graphical (both static and dynamic) material into questions; it automatically grades answers and integrates with VLE's; it can provide feedback. Numbas appeared to have huge potential for helping with not only moderately sized classes but also with large service classes for budding scientists.

ROLL OUT

With the help of funding from the National Forum, Numbas was used in MA1001 (Calculus for Science Part I) in Semester 1 2015. There were approximately 500 students and Numbas was used to provide practice exercises where students could test their understanding with immediate feedback and also it was used for continuous assessment online examinations. Unlike CIT it was not possible to

supervise examinations in small group sessions and we decided to use an allocated time slot where students could take the exam either on university computers or their own laptops. Students were given instruction on Numbas in tutorials and a video was produced which stepped them through the process. This ultimately led to difficulties due to failure of the VLE to transfer results from Numbas SCORM packages into Blackboard (it turns out that this is a known issue with Blackboard). This problem undermined the usage of Numbas as a continuous assessment tool. However, its use as a practice tool was unaffected.

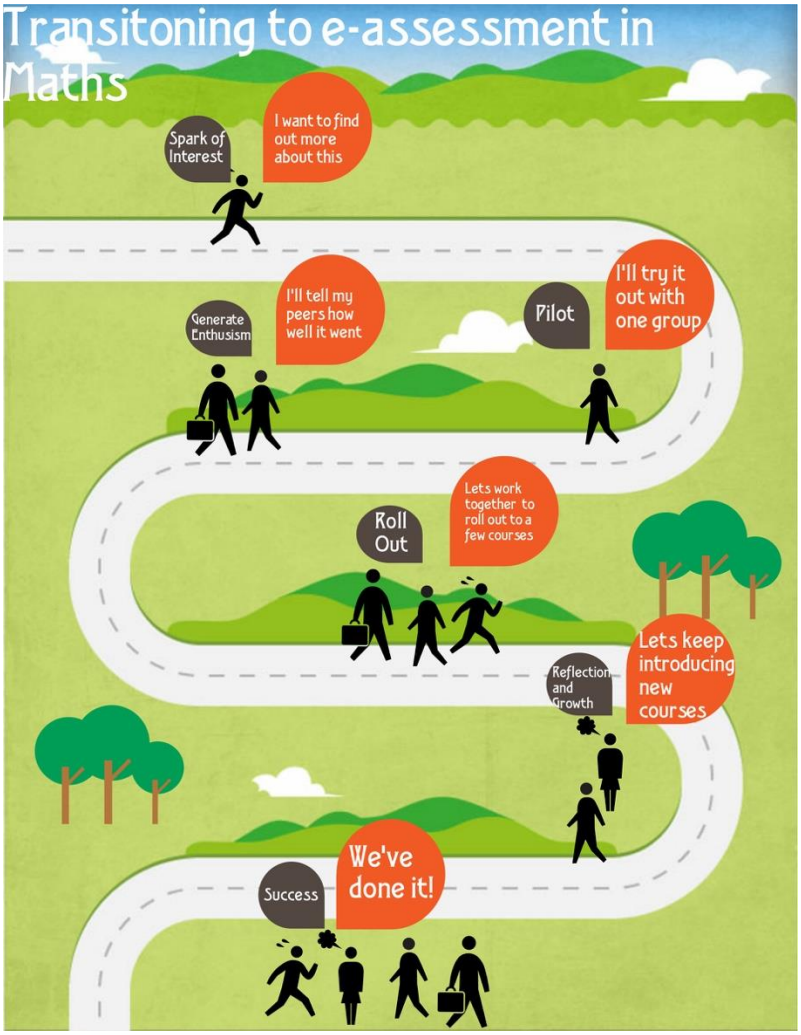
GROWTH

Numbas will once again be used in Semester 1 in MA1001 at UCC except that we have changed VLE from Blackboard to Moodle which does not have the same issues with SCORM. Additionally, Numbas will be extended to provide exercises in other service courses for second year engineering students and will be used by other lecturers in our group.

LESSONS LEARNED

- Numbas is a framework for constructing flexible Mathematics questions.
- Providing meaningful feedback in Numbas is time consuming – this takes the place of our previous difficulties in making flexible questions.
- VLE's can be temperamental and need careful evaluation before integrating Numbas.
- Never over-estimate the technical capabilities of students – not all are members of the Net-Generation. Provide clear instructions about how to use unfamiliar technologies.

TIMELINE FOR IMPLEMENTATION IN YOUR INSTITUTION



INITIAL INTEREST

To get started just one person needs to get that spark of initial interest. Let's presume that person is you. Using Level 1 on www.teame.ie you can try out some tests and get a feel for the system. You could recommend the tests to a small group of students and trial them in a tutorial setting or use them as a review exercise at the end of a lecture. Whatever it takes for you to start to feel the benefits in student engagement and decide that the next step is worth the effort.

PILOT WITH ONE COURSE

The next step is to pick one course to trial Numbas with. The simplest way to do this would be to work on a module that is similar to one of the first year courses in CIT or UCC so that you can simply download the tests from www.teame.ie

and upload them to your learning management system. You will immediately feel the benefit of being able to give plenty of assessments without the worry of the time burden required in correcting these assessments.

GENERATE ENTHUSIASM

For Numbas e-assessment to really make an impact in your organisation you need to generate enthusiasm in the organisation for the transition to e-assessment and enlist some support from other lecturers. The best way to do this is to present your colleagues with some data and feedback about how the initial trial went.

ROLL OUT

Once you have garnered some support and generated some interest among your peers, it is time to roll out the Numbas assessment to one or two larger courses and involve more lecturers/tutors. At this stage it might be necessary to have one or two of the lecturers trained up to level 3 or 4 depending on the content needed for the courses involved. It would certainly be a good idea to have at least one person who is comfortable creating original questions and manipulating existing questions and exams.

GROWTH

Once your organisation becomes comfortable with the idea of e-assessment in Mathematics it is time to grow the project into other courses. It is probably best to roll out to one new course per semester. The real benefits really start to shine through when a course is on its second cycle as all the resources are already created, any small glitches have been ironed out and lecturer workload of correcting is dramatically reduced.

HOW TO JOIN AND CONTRIBUTE TO OUR PROJECT

To get involved with this project contact any of the team or contact us through our website www.teame.ie.

APPENDICES

ABOUT OUR TESTS: DEFAULT SETTINGS

In the interests of consistency, we have aimed to have the same default settings for all our tests. Please find here a list of the defaults options we have chosen. At Level 3 the user can change any or all of these settings.

- Interface Theme: Standard
- Interface Language: English
- Shuffle Questions: OFF
- Pass Threshold: 0%
- Allow user to regenerate questions: ON
- Allow move to previous question: ON
- Allow jump to any question: ON
- Show front page: ON
- Show results page: ON
- Confirm before leaving the exam while it's running: ON
- Leaving a question action: None
- Exam duration (minutes): 0
- Allow pausing: ON
- On timeout action: None
- 5 minutes before timeout action: None
- Show current score: ON
- Show maximum score: ON
- Show answer state: ON
- Allow reveal answer: ON
- Advice threshold: 0%

IDEAS FOR USE

IN TUTORIALS

Numbas tests are an ideal tool to use in tutorials. Students can work at their own pace and get immediate feedback on the answers they have submitted. Our premade tests contain lots of hints and tips for the student as they work through the tests so they can learn as they go. The tutor can easily see how a student is doing with a quick look at their screen as the running total of marks is visible. In this way a tutor can find the students that need help and work with them individually while allowing the others to keep moving on.

IN LECTURES

Numbas questions can be used in many ways in lectures. Some examples might be:

- They could be used to quickly generate some extra practice questions on an area that students are struggling with
- Students can work in small groups on a test with one student in control of the computer
- Small groups could race to get full marks on a test
- Can be used for a quick recap of the previous week
- Can be used as a short filler at the end of a lecture

BRING YOUR OWN DEVICE (BYOD)

Almost all students now have a smart phone or another mobile device that could be used to do a Numbas test. Numbas works well in mobile format and so is suitable for this type of usage. Students could work through questions alone or in small groups using their own devices.

FLIPPING THE LECTURE

Numbas questions could be used in conjunction with a flipped classroom model. The lecturer could record brief instructional videos or set reading assignments for homework. Then the students could use the lecture time to work through the questions, which would traditionally have been the homework element of courses.

ONLINE COURSES

Numbas tests would be an ideal assessment mechanism for online courses.

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