NUI MAYNOOTH
Ollscoil na hÉireann Má Nuad

NUI MAYNOOTH
CENTRE FOR TEACHING
AND LEARNING

TEACHING FELLOWSHIPS 2011 – 2012

PROJECT REPORTS AND OUTCOMES

CTL

HEA
Higher Education Authority
An tÚdarás um Ard-Oideachas

DUBLIN REGION

FOREWORD PROFESSOR PHILIP NOLAN, PRESIDENT

I am very pleased to introduce this publication, which presents the reports of completed Teaching Fellowship projects for 2011-2012.

The reports document and underline the profound commitment of each of the Fellows to teaching and learning, and the exceptional work they have done in the course of their Fellowship. We should, as a university community, be very proud of their achievements and contributions to the enhancement of student learning. It is heartening to see the range of disciplines in which Fellowship projects have been undertaken, and the impressive outcomes from each.

While each project is situated within its context and its discipline, the outcomes are relevant to colleagues across the Faculties, and the initiatives undertaken are clearly transferable to other subject areas and beyond NUI Maynooth. We also see significant collaborative activity between disciplines.

The impact of these Fellowships will be felt across the institution in the years to come, to the benefit of all our students. I encourage colleagues across the institution to engage with this publication, browse the reports, and pick up ideas for their own teaching. Resolve now to do something different in your teaching next year.

I would like to congratulate all staff involved on the successful completion of their Fellowships, and thank them for their exceptional commitment and hard work as demonstrated in the reports presented in this volume.

Professor Philip Nolan
President

INTRODUCTION
DR ÚNA CROWLEY

With the launch of the Teaching and Learning Fellowships initiative in 2011, the Centre for Teaching and Learning marked the beginning of an exciting new phase of work in the enhancement of students' learning at NUI Maynooth.

The 2011 Teaching Fellowships offered the opportunity for colleagues to put into practice ideas that they had been considering over time, but which needed seed funding and time to take forward. Fellows could try new equipment or technology not previously available to them to determine its effectiveness for teaching. The Fellowships additionally opened possibilities to work with colleagues in other departments and draw on the strengths of each other's disciplines.

One year since the launch of the 2011-2012 Teaching Fellowships, the fruits of those endeavours are now presented here. This publication represents the culmination of more than a year's work by Teaching Fellows from the presentation of their proposals at the application stage, through the implementation of their projects, and their completion. It is very encouraging to see the range of projects presented here, the discussion of how they were implemented (including the challenges encountered along the way), and the positive outcomes for students.

It is also very heartening to see the tangible outputs of these projects, and the clear potential for these to be used and re-used in teaching across the University. The design of software including Biochemicalc and the App for Geography fieldwork are some of the highlights here. The complexity of student group work, and choosing appropriate methodologies for groups are discussed by Fellows in Computer Science and Biology. Authentic data-gathering activities and analysis were the focus of the Fellowship in Education. The work of Fellows in Anthropology highlights the range of issues in evaluating the effectiveness of teaching, and is timely in informing the ongoing discussions across the University on this issue. The importance of involving students in their learning is demonstrated clearly in the peer-tutoring programme undertaken in English, and active learning methods also come to the fore in the Fellowship project undertaken in Chemistry. The range of activities, technologies, methods and feedback mechanisms adopted by the Fellows in their work is clearly evident, and augurs well for the development of teaching and learning in their subjects and across the University as a whole.

I encourage colleagues across the University to use this publication as a reference point throughout the coming academic year. On a practical level, it can provide you with information about how the projects were implemented and evaluated. On a wider level, it provides opportunities to network with those Fellows who led the projects and the chance perhaps to adopt some of the successful outcomes of their work in your lecture theatre, laboratory or tutorial settings.

Finally, I would like to acknowledge the work of the Fellows here and to thank them for their close collaboration with the Centre for Teaching and Learning in the course of the year. Our interactions with Fellows have been very valuable to us as a team and we too have learned from their work.

I would like to congratulate the Fellows warmly on the successful completion of their projects, and wish them well in the continuation of their work.

Dr Úna Crowley
Director of the Centre for Teaching and Learning

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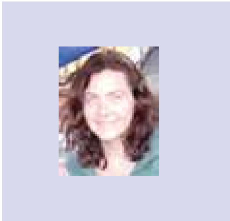

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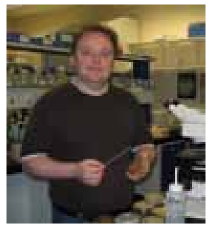

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DEPARTMENT OF ANTHROPOLOGY

Reflexive Large-Group Evaluation for Anthropology

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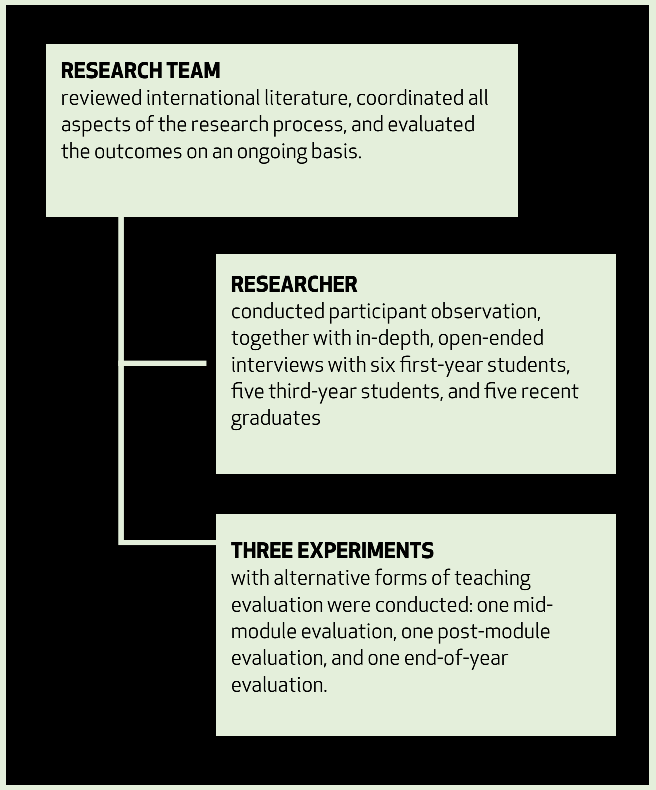
Traditionally, anthropology has been configured as a craft, passed down from teacher to students. Yet at NUI Maynooth, anthropology is delivered to very large and diverse classes. What are the implications of this for the learning the principles of anthropology? This project sought answers to this question by bringing together staff in the Department of Anthropology as a team that also included a graduate student researcher. We set out with the ambition of using the tools of anthropology itself to investigate the teaching and learning of anthropological principles. But we were also concerned to understand the ways in which students understood 'evaluations', the extant systems of module evaluation of the Department, and possible ways to introduce improved methods of two-way evaluation.

We built up a collection of resources, designed appropriate research protocols and widely advertised the project among students and colleagues. A qualified anthropologist-ethnographer was hired to conduct participant observation of pedagogical processes and contexts, including lectures, tutorials, seminars, and other more informal settings. The researcher conducted in-depth open-ended interviews with six first-year students, five third-year students, and five recent graduates. Three experiments with alternative forms of teaching evaluation were conducted: one mid-module evaluation, one post-module evaluation, and one end-of-year evaluation. The research team analysed transcripts, evaluation results and fieldnotes, generating areas for further analysis and investigation. There were, therefore, a number of imbricated strands to the research as illustrated in the table below.



RESEARCH STRANDS

The project was hugely successful in generating data useful for ongoing reflection on the undergraduate learning experience, the curriculum, evaluation methods and understandings of how students learn at subject level.

CONTEXT

As elsewhere in the world, Irish universities are responding to the challenges presented by increasing student numbers, declining staff numbers, new education technologies, and increasing demands for staff accountability. In anthropology at NUIM, these structural changes in third level education are perhaps most acutely felt in the first year of instruction, where large lectures predominate. We wished to attend to these dynamics by researching and taking steps towards developing a reflexive assessment of anthropological learning at subject-level.

There are 250 first-year students of anthropology and over 500 students throughout the Department's programmes. We understood that a system that increases students' opportunities to communicate with staff and to have their voices heard, combined with a system that allows them to track their learning progress at subject level, will have an invaluable effect on student success in learning.

Moreover, no international anthropology departments that we are aware of have considered the question of how students learn the subject in large groups. How students experience reflexive education – the absorption of epistemology, the appreciation of the subtleties of theoretical and ethnographic decisions, framing and articulations – is an important scholarly question with a variety of important implications for the discipline. We understood the benefits to our department and to the university as a whole, but we also appreciated the internationally applicable scholarly challenge in this project.

REVIEW OF RELATED LITERATURE

In our efforts to consider the most appropriate ways to elicit students' voices, while also evaluating module teaching and students' performances, we quickly came to the understanding that one-size-fits–all institution/sector-wide approaches to evaluations are not optimal for eliciting feedback of good quality from students and often serve to disenfranchise all those involved. Moreover, the timing and intent of such an approach tends, according to international scholarly literature (see Hamermesh and Parker 2005; Titus 2008; Lodewijks 2011), to suit sectoral management aims rather than sound pedagogical practice supported by evidence. Indeed, there is a growing body of scholarship that argues that top-down and uniform approaches to evaluations may lead to the fetishization of feedback as a proxy for 'quality' in ways that are often entirely divorced from the actual quality of teaching and learning. We analysed this critical social-scientific literature in order to understand practices being used in international institutions recognized for the sophistication of their approaches, as well as to understand highly disparaged practices.

We studied 'Peer Evaluation of Effectiveness in Teaching' as it obtains in the University of Alaska Fairbanks; Stanford University's 'Mid-Quarter' and 'Small-group Evaluations' and the University of Bielefeld's 'Bielefeld.GERM'. We were struck forcibly by a plain issue – though an often overlooked issue – that the design of actual feedback forms or systems has taken on a technocratic solidity in thinking about teaching and learning; by contrast, the best international practices that we observed seem to pay as much if not more attention to the timing of evaluations, the style of participatory implementations, clarity of purpose and the density and quality of the information elicited.

Following this literature review, and a review of international practices, we embarked on an open-ended research process together with testing evaluation methods and experimenting with them.

KEY OUTCOMES

– OPEN ENDED, QUALITATIVE FORMS OF FEEDBACK BETWEEN STUDENTS AND STAFF ARE HIGHLY VALUED AND MORE MEANINGFUL THAN RATING SCALES.
  In the modules in the first semester of First Year, students were provided with details of our project and they were asked via Moodle to provide course evaluation by filling in a short feedback survey on SurveyMonkey. This proved to be relatively successful. However, we also passed out a hardcopy, standard institutional module evaluation form which elicited fewer responses and a quality of information that could only be described as derisory. Our qualitative research with interview participants revealed that open-ended forms of feedback between students and staff are highly valued and more meaningful than rating scales. We also experimented with an evaluation of subject-level learning at the end of the first academic year – again the quality of information and student satisfaction with the evaluation methods were greater where qualitative approaches were taken.

– STUDENTS IN THE FIRST YEAR RESPOND POSITIVELY TO EARLY, "LOW STAKES" FORMS OF ASSESSMENT.
  It is now widely accepted that students in their first weeks in university need to feel engaged and that large class sizes may adversely affect their experiences. Some scholars have even noted a shallowing of course objectives and reduced expectations of in-depth thinking in large classes. However, important progress has been made, especially in the uses of low-stakes feedback to show the progress of students' learning. This project allowed us the opportunity to reflect on early assessments. Our first experiment in evaluation was conducted coterminous with an evaluation of student learning mid way through the first module of the first semester (AN111). The evaluation of student learning was relatively low stakes (15% of module marks) and in the form of a MCQ quiz. Several questions posed in the quiz were posed again in the module evaluation. Feedback was clear: students appreciated this exercise – though they advocated even lower stakes – and better understood the process of two-way evaluation, i.e. that one's evaluation of a module is directly related to one's participation and performance. Therefore, one of the key outcomes will be a move to low-stakes assessments and two-way evaluations for anthropology students in their first weeks in university.

– EXISTING EVALUATIONS MOSTLY FOCUS ON FORM RATHER THAN CONTENT, EXTERNALS RATHER THAN INTERNALS, LIMITING THEIR USEFULNESS.
We critically examined international best practices in the area of evaluations. Our research also showed a tremendous level of approval for extant classroom experiences. The risk with standard, institutional approaches is that they focus on the form of lectures (e.g. the use of slides) and external factors (factors that may range from timetabling to the physical environment) rather than engaging in-depth with the actual classroom experiences.

– STUDENTS SEE THEIR LEARNING AS CUMULATIVE: INDIVIDUAL MODULES MAY BE MORE MEANINGFULLY APPRAISED YEARS AFTER THEY HAVE BEEN COMPLETED, RATHER THAN IMMEDIATELY FOLLOWING THEIR CONCLUSION.
Our research showed clearly that students see their learning as cumulative – texts that they found difficult and may have grumbled about in a first year module prove inspiring years later; questions that they felt were unanswered sometimes resurfaced and were resolved; in short, the student experience is not available in the round in any one module and therefore should not be evaluated within such an artificial frame.

– DIFFERENT DISCIPLINES ARE PROBABLY BETTER OFF GENERATING THEIR OWN FORMS OF STAFF-STUDENT COMMUNICATION AND MUTUAL EVALUATION.
Although module evaluations are widely believed to enable comparisons (across individuals, departments, faculties), the number and type of questions that can be meaningfully asked across all disciplines university-wide is extremely limited – subject-level teaching and learning is simply too diverse. Our experience suggests that using aggregate quantitative feedback data to make comparisons across university departments masks more than it reveals. Such feedback methods also render students passive in the process; we found that the richest feedback was obtained through dynamic collaborative engagement with our students – that is, part of the feedback was our students telling us what was for them the most meaningful method of providing feedback.

IMPACT OF THE PROJECT

This project will impact on-going developments at NUI Maynooth and elsewhere as the University seeks to implement forms of teaching evaluation, and as the University continues to refine and expand its mission in relation to educating undergraduate students. A central finding of the research is that learning is not generic, it is subject-specific. If this is the case, it makes sense for Departments to take greater responsibility for their own modes of teaching evaluation and curriculum development. Where the primary purpose of evaluation, and student-teacher feedback, is improved pedagogy, communication between staff and students is tightly linked to the particular norms and forms through which disciplines are taught and learned. NUIM can lead in avoiding the detrimental 'thinning' of staff-student communication that is widely reported to pertain in contexts where teaching evaluation is only implemented in the form of standardized, quantitative (and rudimentary) evaluations. Because our project will produce an academic publication, the project impact is not limited to NUIM, but will hopefully contribute to discussions elsewhere about reform of universities.

POTENTIAL FUTURE DEVELOPMENTS

ONGOING REFORM OF CURRICULUM.
Our experience will have direct applications in the ongoing reform of curriculum in our department. On the basis of our research results, we have already begun to implement pedagogical means of making connections across modules in the first year, and will work to develop means for doing the same in second and third years.

BA YEAR 'EXIT' FEEDBACK.
Paying heed to the message from our students, we are developing a BA year, content-focused 'exit' feedback survey to obtain students' assessment of their learning through the course as a whole. This will give us constant, layered feedback that will increase our understanding of how students learn anthropology cumulatively, and how we need to adjust the pedagogy from year to year in the programme.

DEVELOPMENT OF MID-MODULE AND POST-MODULE FEEDBACK METHODS.
After presenting the full results of our research to our departmental colleagues, we will begin to work collaboratively to develop methods by which all staff can collect meaningful, open-ended feedback in both formative mid-module evaluations and summative post-module evaluation. This will assure that staff are getting feedback that actually helps them improve the teaching of anthropology at NUIM.

PUBLICATION OF FINDINGS.
The members of the project team will collaborate in writing an article outlining our research and our findings, which will be submitted to the journal Teaching Anthropology, a peer-reviewed, open-access journal of the Royal Anthropological Institute dedicated to the teaching of Anthropology.

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"Hands-on" molecular biology: engaging students with the Central Dogma

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The project involved the development of three new dry practical workshops for 2nd year science students taking the module Introduction to Molecular Biology (BI202) as part of 2nd year Biology. Two workshops dealt with the molecular structures of DNA and proteins while the third addressed the molecular processes of transcription and translation. The main idea of these new workshops was to engage students by providing a 'hands-on' learning experience. Using commercially available DNA and protein modelling kits (purchased with fellowship funds), the students were required to build their own DNA and protein molecules and then to use these to answer a series of questions relating to the most important molecular and biological features of these macromolecules.

CONTEXT

I have taught molecular biology to 2nd year students since 2005. During this time I have accrued an extensive amount of student feedback about the module, both relating to course content and on how the module was taught. It became apparent to me that overall students generally consider the molecular side of biology, as opposed to the organismal side, as being a conceptually difficult subject. A good grounding in appreciation of the structures and biological roles of DNA and protein molecules is fundamental to biology, and particularly important for students taking a variety of advanced 3rd and 4th year biology modules. Through taking the Postgraduate Diploma in Higher Education (PGDHE) at NUIM, I already had a good grounding in understanding how students learn and what may benefit in terms of enhancing their learning experience and engagement with a subject area. Students clearly retain and obtain a better grasp of knowledge through 'doing'- hence I decided to build upon previous innovations I had instigated through the PGDHE course for my second years and establish a 'hands-on' approach, mainly with the aim of enhancing student engagement with a perceived difficult biology topic.

KEY OUTCOMES

Following completion of the BI202 workshops students were requested to fill in a feedback form which asked a variety of questions ranging from how the usage of the molecular models enhanced their general enjoyment of the class, to how the models helped in aiding the student to understand the concepts they were trying to learn. The BI202 workshop classes consisted of two groups, each consisting of approximately 100 students. This size of practical class adds an extra level of complexity for engaging the students with the topic. Of the 200 completed feedback forms I received, there was an overwhelmingly positive response for the usage of the molecular models both in terms of making the class more 'fun' to do and aiding in student learning- hence engagement was clearly significantly increased. To put 'overwhelming' in context, 199/200 agreed or strongly agreed with questions relating to enjoyment of the class and enhanced learning.

Therefore, one of the key outcomes from this project is that clearly a "hands-on" approach to learning about DNA and protein structure has an extremely positive effect on both student engagement and understanding of the topic. The "hands-on" approach would be favourable to adopt in other areas of biology or other subjects.

A key output from this project has been a much improved answering of exam questions relating to these topics (if honest, something I was sceptical would happen). In the final year exam I witnessed an obvious improvement in the answering of two specific questions relating to DNA and protein structure. This improvement was further evident when compared to other questions on the exam where the "hands-on" approach was not applied.

Finally, one personal surprising outcome from this project was the realisation that to actively engage students with a topic does not require the usage of on-line or technology-driven approaches. I have often associated the phrase "innovation in teaching" as applying IT or other modern techniques to the learning environment. This is absolutely not the case. In fact I am sure that transferring some of the developments made as part of this project to an on-line environment would actually detract from student engagement and decrease the learning experience.

IMPACT OF THE PROJECT

- HOW DID THE PROJECT IMPACT ON STUDENTS' LEARNING?
  Very positively. Students enjoyed using the models and actively engaged with the workshops. The students answered a [quite detailed] questionnaire at the end of the workshops and performed significantly better than previous years. Additionally specific exam questions relating to material addressed by this Fellowship, were answered better. Importantly, the students enjoyed the classes!- this is evidenced by student feedback forms but also by verbal exchanges between myself and students during the classes. I had unsolicited 'thank yous' from a number of students at the end of the workshops.
- WHAT DID YOU LEARN FROM UNDERTAKING THIS PROJECT?
  'Hands-on' approaches are a very positive way of enhancing student engagement and with helping to understand "difficult" concepts in molecular biology (an idea that I think is applicable across disciplines). Engaging students does not require the use of IT or perceived 'high-tech' applications. In fact I have formed the opinion that perhaps [innovation in] teaching may have gone too far in this thinking- as long as an engaging and interesting set of classes are available to the students, a pen and paper is all that may be needed to achieve the learning outcomes.
- WHAT COULD OTHERS IN THE UNIVERSITY OR WITHIN THE DISCIPLINE LEARN FROM THIS INNOVATION?
  Where possible, involving students in an active learning process is extremely beneficial at a variety of levels- student engagement, achievement of learning outcomes and also a greater degree of satisfaction for the lecturer! I would recommend the usage of active learning processes within any discipline, wherever possible. This of course may not be doable given the structure of a course. I was lucky in that I had complete control over my module and the workshops were relatively easy to manipulate and adapt to what I wanted to do, which may not be the case for others. I would argue that a case can be made for perhaps modifying courses/ modules to incorporate an active learning element of some kind, where one is currently not part of that course/module.

POTENTIAL FUTURE DEVELOPMENTS

The project has already impacted significantly upon the teaching of molecular biology within the Department of Biology. Following consultation with Biology First Year Lecturers, new practical classes are currently being developed using some of the models purchased through this fellowship (protein models) and also buying in some similar but mechanistically distinct DNA models to link in with the more structurally focused work the students will carry out in their 2nd year. It is clear that this hands-on approach will be carried through and developed within the department of Biology- primarily at 1st and 2nd year levels, but potentially in later years too.

ADDITIONAL INFORMATION

Although not directly relevant to the topic of the Fellowship, I would like to state that the teaching Fellowships are an excellent scheme to both help lecturer morale and also to try and test new teaching innovations. Teaching is the main element in what a university does, yet so often it is seen as secondary in importance to research. Over the past few years NUIM seems to have made moves to try and bridge this gap somewhat, and I warmly welcome such moves. Without this teaching Fellowship there is no way these workshops could have been developed in such a short time frame- which given the success of the approaches taken, would have impacted on the learning experience for this crop of 2nd year biology students.

DEPARTMENT OF BIOLOGY

Design (2011/12) and Implementation (2012/13) of a Constructively-Aligned First Year Biology Course.

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The challenge is to identify what constitutes a university education in this era of massive quantities of freely available information; to develop strategies that engage our first year Biology students in deep-learning, early in their studies; and to respond to the changing profile of our students and the current advances in cognitive and learning sciences and instructional design.

Four questions may be posed to define the domains of this challenge:

1. **Learning Outcomes: What learning should be targeted in first year Biology?**
2. **Content & learning activities: How is learning best facilitated?**
3. **Assessment: When and how to authentically assess this learning?**
4. **How successfully were the strategies deployed and how did these impact student learning?**
5. **Questions 3 and 4 are beyond the scope of this short project.**

When, 'concept learning' and 'learning for understanding', are the targets, as proposed in this project, an assessment strategy requiring the memorizing of the 'right answer' usually fails to illicit students' misconceptions and 'multiple and layered explanations' of a single concept. While recognising the importance of concurrently designing authentic assessment as an important element in the design of learning outcomes, apart from formative assessment (that is assessment to aid learning which may, or may not, contribute to grades), the design of authentic assessment techniques was considered to be outside the scope of this project. And of course, evaluation of the strategies is a crucially important step in any such project but is beyond the scope and timescale of this project.

Outcomes from meetings with the first year Biology teaching team; semi-structured interviews with student focus groups that were representative of the various degree strands; and finally a wide-ranging review of the literature, were all used to inform the proposed strategies.

Funding was used for the part-time employment of a recent Biology graduate. She was familiar with the first year course as she was engaged in the first year, lab-based teaching programme and concurrently took the Professional Certificate in postgraduate Teaching and Learning.

CONTEXT

A life-long interest in education and my recent studies with the Open University in science education provided the motivation and inspiration for this project. These studies and subsequent reading informed on advances in the area of cognitive learning science and instructional design and were incorporated into this fellowship project. Application to the first year Biology course was an obvious target due to an intimate knowledge of the course from working as senior demonstrator for many years.

With the increasing advance in freely available information, instruction, focus on delivery of information has become much less important, whereas focus on methods of real knowledge acquisition has been developing over recent years. Multi-facilitator delivered modules sometimes lack coherence from the student perspective with a potential, especially in the science domain, to focus on the ever-expanding wealth of information, to the neglect of encompassing concepts.

High intake of Biology student numbers over recent years has put a heavy burden on resources: primarily on lecturer's time in dealing with the challenges that have arisen from different student expectations, profile-intake in recent years, the changing nature of cognitive science and instructional design, and increasing demands from the accountability and transparency agenda.

Due to escalation in demands on an already heavily committed staff, extra resources are necessary to address these challenges and to maintain and re-establish the high reputation in the area of teaching and learning that the NUIM Biology Department have always strived to maintain.

LITERATURE REVIEW

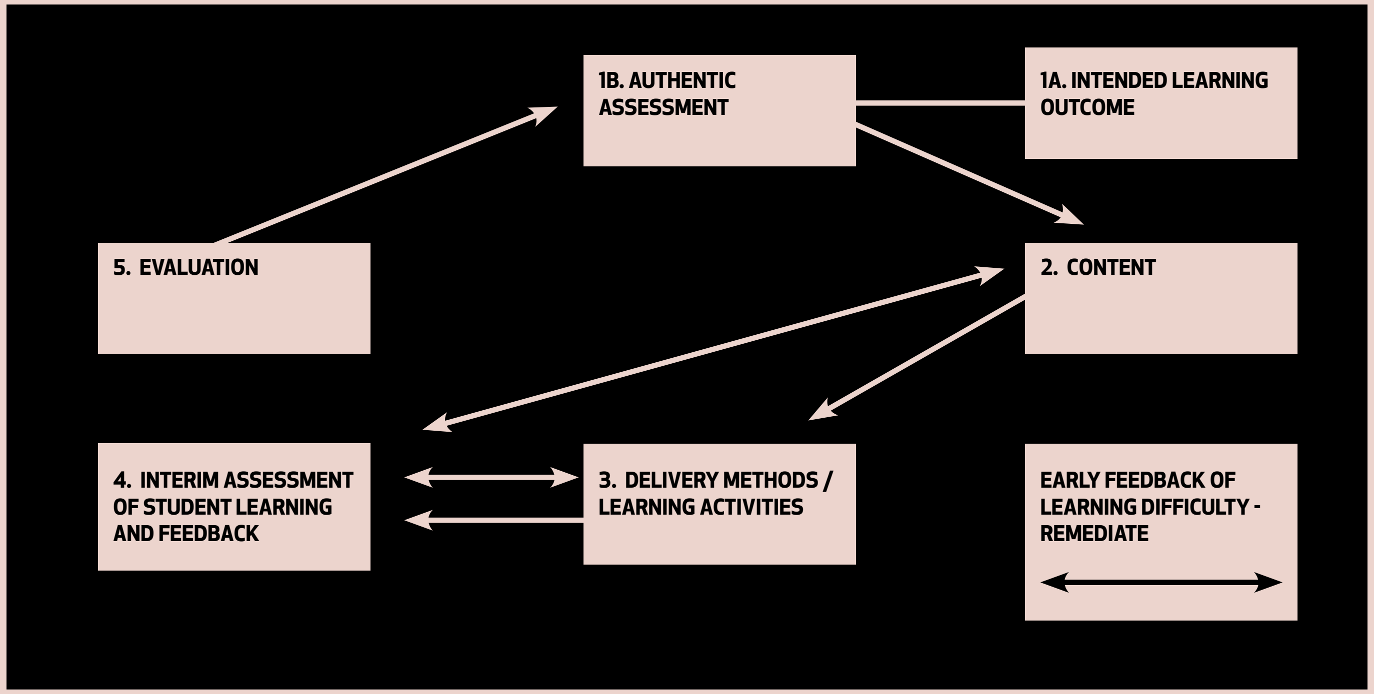
While recognising the enormous complexity in the realm of teaching and learning the following selection of strategies have been targeted. For further detail, Browne provides an excellent guide to the dominant perspectives of behaviourism and cognitive psychology, covering many of the principal learning theories, addressing underpinning tenets, criticisms and implications for instruction (Browne, 2004). Browne provides tremendous insight, for the non-psychologists among us, into the vast array of learning theories and helps bring some understanding of the diversity of approaches.

> **'For a strongly committed behaviourist, learning is the modification of behaviour brought about by experience. For most cognitive psychologists, learning is the study of how information is sensed, stored, elaborated and retrieved. Others would stress the importance of meta-cognition (learning to learn), or reflection on experience as well as experience per se. Humanistic psychologists are more likely to insist that personal growth and development are at the heart of learning, while constructivists argue that learning is primarily concerned with how people develop different conceptions and constructions of reality.**

> **These different views of learning are themselves examples of constructivism at work, of how different people view learning. Each view leads to a different emphasis and consequent neglect of other features of learning. Each view has different implications for course design, the tasks of the teacher, methods of teaching, the construction of learning opportunities and methods of assessment.'**
> **(BROWNE, 2004, P.6).**

But Browne's treatise does not explain how or why students learn.

Much educational research endeavour has focused on producing structural tools, many with similar facets, and Biggs (1996, 2003) presented an elegant framework, termed 'constructive alignment', (see diagram for stages of planning) which may be used to design learning, ranging from that in whole degree programs, right down to individual learning episodes. The sum of the five or six 'learning outcomes' on each lower level of organisation (such as a single class session) satisfies a broader single learning outcome on the higher level (such as one of the course section learning outcomes). While, as Biggs asserts, the constructive alignment model is an essential tool to encourage student ownership and the self-directed nature of learning, as a framework planning-tool for educators it is invaluable. In reality it is assessment that will drive student learning (Boud, 2000) rather than described learning outcomes. Thus well designed, authentic assessment (that which truly assesses the performance) is a crucial component.



DIAGRAMATIC REPRESENTATION OF CONSTRUCTIVE ALIGNMENT (ADAPTED FROM BIGGS, 1996, 2003)

QUESTION 1:
WHAT LEARNING (LEARNING OUTCOMES) SHOULD BE TARGETED IN FIRST YEAR BIOLOGY?

1.1 Identifying a course Storyline or Theme, linking together key course concepts in a framework, supported with skills to filter valuable information from the vast array available. In addition, students should have a strong understanding of key processes and be able to evaluate supporting evidence, rather than simply presenting sets of isolated facts and information.

Information, Knowledge, Wisdom:

> **"Where is the Life we have lost in living?**
>
> **Where is the wisdom we have lost in knowledge?**
>
> **Where is the knowledge we have lost in information?"**
> **T. S. ELIOT**

In this era of vast increase in evermore easily retrievable information, what should constitute an education at advanced level? Professor Perkins, head of the education department at Harvard, in answer to this question, distinguishes between information, knowledge and wisdom as a continuum that may be halted at any stage. Perkins defines 'information' as lists of disconnected facts (Perkins, 2010)

> **'having information is one kind of knowing, and an important one, but**
>
> **knowledge involves added value of depth, breadth and coherence, and wisdom brings**
>
> **a blend of flexible insight, pragmatics, humane values and sensitivity to the human condition'**
> **(PERKINS, 2010, P.10)**

But he comments that while wisdom is aspired to it is seldom being reached by graduate level and perhaps 'knowledge on the way to wisdom' is a more apt target. He therefore identifies the major goal for universities as providing learning environments that assist students in acquiring knowledge 'on the road to wisdom' (Perkins, 2010).

The challenge is to break from the traditional information delivery mode (De Corte & Fenstad, 2010). Development of higher-order learning and knowledge acquisition (as opposed to information acquisition) is facilitated by alerting students to concepts and connections between concepts (Bruner, 1960; Campbell & Reece, 2008; Howitt et al, 2008; Knight, 20010; Michael, 2007; American Association of Advancement of Science, 1986, 89, 2001, 2008, 2011).

The identification of links between concepts, contributes to 'powerful conceptual systems'. 'Storylines carefully crafted according to several principles running throughout' the course material, lead to 'understandings of broad scope'. Perkins recognises these as 'generative topics' that form the basis for teaching for understanding and generating knowledge (Perkins, 2010). Skills in 'filtering and making meaningful use' of information, understanding of processes and most importantly, supporting-evidence, should be presented and given recognition as important in underpinning these concepts (Perkins, 2010) Research supports the view that focus on 'cohesive wholes' (concepts) has lasting educational value and encourages higher quality educational outcomes for students (Prosser, Martin & Trigwell, 2007). It should be noted that it is not implied that recall of information and process understanding (factual knowledge in Krathwohl's framework below) is not important, but rather that it is not enough.

As the current first year Biology course is delivered by a series of academics from the first year teaching team, each presenting specific material, it is essential for the development of student-knowledge that the course should have a unifying theme, a storyline.

1.2 DESIGNING LEARNING OUTCOMES

Writing learning outcomes is probably the most challenging and least understood stage of the constructive alignment process and the easiest to get wrong. Bloom's taxonomy of the cognitive domain (Bloom, 1959) has received much warranted attention and, in being still invoked, has stood the test of half a century. Revisiting Browne's continuum of learning approaches 'from behaviourism on one end to radical humanist approaches on the other'; the cognitive taxonomy descriptors have been much utilised for behaviourist learning outcomes (Gronlund, 1998; Kennedy et al, 2007), but few publications have addressed the potential application of the affective domain to the humanist approaches. The affective domain also provides useful learning taxonomies that may be used to describe, and therefore plan for development of 'ways of thinking and practicing' as a biologist (Hounsel et al, 2005), and may also be used by students to provide a spectrum to interrogate one's own development of personal meaning, values and ethics. Krathwohl (2002) revised Bloom's taxonomy to produce four knowledge dimensions and revised the six cognitive processes. His overview in table form (below) provides a tool to interrogate the learning facets of material.

KRATHWOHL'S REVISED TAXONOMY. THE COGNITIVE PROCESS DIMENSION

THE KNOWLEDGE DIMENSION	1. REMEMBER	2. UNDERSTAND	3. APPLY	4. ANALYSE	5. EVALUATE	6. CREATE
A. FACTUAL KNOWLEDGE						
B. CONCEPTUAL KNOWLEDGE						
C. PROCEDURAL KNOWLEDGE						
D. METACOGNITIVE KNOWLEDGE						

Many students reported confusion when presented with laboratory activities that had many, if not all of Krathwohl's knowledge dimensions. Utilising the knowledge dimensions in tandem with the cognitive (affective and/or psychomotor) domains to write clear learning outcomes in all learning sessions will facilitate students' identification of what are the elements of the learning required and the level of performance expected.

With respect to metacognition, three types of knowledge are identified: strategic knowledge (strategies for learning, thinking and problem solving, also planning, monitoring, setting of goals and so forth); knowledge about cognitive tasks ('what', 'how', 'when' and 'why' of using strategies appropriately); and finally self-knowledge (knowing one's strengths and weaknesses). 'Accuracy of this latter dimension of self-knowledge seems to be crucial for learning' and Pintrich draws particular attention to the importance of giving realistic feedback to students in this regard (Pintrich, 2002). In drawing direct attention to metacognitive processes (learning how to learn) in science learning, development of self-directed learning is facilitated. (Entwistle, 2009)

A common error in writing intended learning outcomes is to ascribe the lower levels of learning to early years and the higher orders of learning to final year students. It is highly desirable to design learning sessions for all years that have learning outcomes from across the levels.

1.3 BARRIERS TO LEARNING IN RELATION TO LEARNING OUTCOMES

Attention is drawn to two barriers to learning noted in recent literature: threshold or troublesome, knowledge (Meyer & Land, 2003, 2005, Jordan et al, 2011, Perkins, 2009), and the need to identify student misconceptions (Laurillard, 2002). Threshold knowledge is recognised as fundamental in developing students' understanding, it is recognised as transformative, integrative, and irreversible. Such knowledge is crucial because of its 'gateway' nature (Meyer & Land, 2003, 2005).

The need to provide students with opportunities to identify their misconceptions is informed by research conducted in 1993 by Laurillard. This highlighted students ability to maintain 'primitive concepts that obtrude on their thinking and problem solving', and indeed that it is possible to hold conflicting conceptions simultaneously (Laurillard, 1993). With increased awareness of the importance of gateway knowledge, identification of likely topics and subsequent targeting with specific learning in small group learning environments (particularly interactive learning with models and so forth in laboratory or workshop sessions) will facilitate student crossing of these barriers to learning.

2. CONTENT & LEARNING ACTIVITIES: HOW IS LEARNING BEST FACILITATED?

To abbreviate this section the results of Ken Bain's investigations into 'What the best College Teachers Do' are presented. It was found that almost all strategies compiled from the literature were subsumed in Bain's findings. (Bain is the former director of Centre for Teaching Excellence, New York University, who studied a large number of the best college teachers from a range of academic disciplines in America). The common traits were grouped into three areas in Bain's text: creating a critical learning environment; identifying obstacles to effective teaching; and learner motivation. It is important to note that despite the similar traits described below, teachers varied widely in their approach. Some mostly lectured, some were very active, and some used blended learning approaches and so forth (Harrison, 2007).

2.1 CREATING A 'NATURAL CRITICAL LEARNING ENVIRONMENT':

- They devise activities in which they embed the skills and information students will find fascinating – authentic tasks to arouse curiosity, challenge assumptions and examine mental models of reality.
- 'Teaching' is viewed as anything they might do to stimulate and encourage their students to learn.
- The classroom is considered as an environment designed for learning and meant to engage students.
- Their primary focus is:
  What should my students be able to do? (this is really designing intended learning outcomes)
    * *intellectually (In learning outcome jargon that is defined by the cognitive level of conceptual & informational knowledge);*
    * *physically (procedural knowledge / psychomotor domain) and*
    * *emotionally (metacognitive / affective domain)*
  - *What can I do to best help and encourage the development of these abilities and habits? (Design of content, presentation and / or learning activities).*
  - *How can both my students and I interpret the progress, nature and quality of their learning? (Metacognition and interim assessment of students' learning with feedback facilitating remediation if needed).*
  - *How can I evaluate my efforts to foster that learning? (Evaluation)*

Outstanding teachers are noted for their 'wisdom' – a broad understanding with intimate subject knowledge which facilitates a 'much richer process of inquiry and reflection in their class design'. They also let their students know they expect excellence from them. Students are treated with respect, opinions and observations are valued and feedback is realistic, rather than being designed purely to build self-esteem.

2.2 OBSTACLES TO EFFECTIVE TEACHING:

Bain identifies the need for teachers to adopt a 'learner centred' approach (focus on what you want your students to learn, and try to evaluate the learning that is going on in front of you rather than waiting for the final exam when it is too late). The traditional, comfortable model of didactic teaching with the teacher in charge -'I talk you listen' model, needs to be challenged. He also encourages an examination of whether all that information is actually necessary and examination of the way we teach – as we have been taught? Bain encourages rethinking of teaching activities:

- Teaching, whether it be to large and small groups, extends to a large range of activities – anything that helps build skill and understanding of concepts
- Teaching is 'creating those conditions in which most – if not all – of our students will realise their potential to learn'
- Identify to your students that you too are constantly learning
- To recognise that teaching is an art, a science and an 'intellectual creation'.

2.3 LEARNER MOTIVATION:

Motivating factors may be:

- Competition, being the best
- Mastering a subject for the sheer enjoyment of the knowledge

Entwistle (2009) discusses Marton & Säljö's (1997) research where student approach to learning was a very significant variable in the learning outcome. 'Surface learning' (quickly forgotten, not embedded in conceptual knowledge, not understood or applied, merely rote-learned, attaining the first cognitive level) resulted from a memorisation strategy that was exam oriented. While 'deep learning' resulted from a quest for understanding, for making meaning for oneself , which results in higher order learning, discrimination and critical analysis of the material (Entwistle, 2009). Evidence suggests that perceived heavy work-load encourages surface learning while reflection time, engagement with stimulating, and relevant material is associated with deep learning (Entwistle, 2009). It should be noted that Leaving Certificate preparation is recognised as engendering a surface, exam-oriented approach to learning. Further it was shown by Entwistle and Tait (1990) that students 'with contrasting study orientations are likely to define effective teaching in ways which reflect those orientations' (Entwistle & Tait, 1990).

Finally attention should be drawn to the potential stimulus for deep-learning by using the Socratic method in teaching large groups. The following table reproduced by Tanner & Allen (2005) illustrates quite nicely a range of questions which may be used in the Socratic method.

Six facets of understanding from Understanding by Design (Wiggins and McTighe, 1998)

KEY OUTCOMES

DURING THE PROCESS:

- A series of first year Biology teaching-team round table talks focused on and analysed the first year experience. This resulted in most members engaging in an on-going basis with the first year learning experience

WHEN ONE UNDERSTANDS, THEN ONE…	UNDERSTANDING ENABLES ANSWERING OF QUESTIONS SUCH AS..
CAN EXPLAIN	WHY IS THAT SO? WHAT EXPLAINS SUCH EVENTS? HOW DOES THIS WORK? HOW CAN WE PROVE IT?
CAN INTERPRET	WHAT DOES IT MEAN? WHY DOES IT MATTER? WHAT OF IT? HOW DOES IT RELATE TO ME?
CAN APPLY	HOW AND WHERE CAN WE USE THIS KNOWLEDGE, SKILL, OR PROCESS?
HAS PERSPECTIVE	IS THERE ADEQUATE EVIDENCE? IS IT REASONABLE? WHAT ARE THE STRENGTHS AND WEAKNESSES OF THE IDEA?
CAN EMPATHIZE	HOW DOES IT SEEM TO YOU? WHAT DO THEY SEE THAT I DON'T? WHAT DO I NEED TO EXPERIENCE IF I AM TO UNDERSTAND?
HAS SELF-KNOWLEDGE	WHAT ARE THE LIMITS OF MY UNDERSTANDING? WHAT ARE MY BLIND SPOTS?

- A series of semi-structured focus group interviews with a stratified, random selection of first year Biology students
- Revision of the first year genetics course to include many of the targeted interventions
- The first year teaching team were exposed to a wide range of educational research
- Design of a constructively-aligned First year Biology Course
- Design of storylines for each module
- Identification of important introductory topics to enhance the understanding of the process of epistemology in Biology. Topics such as 'what is science?', 'what do we know and not know in science?', 'how do we know it?', 'what is the difference between superstition and science?' and an introduction to the cognitive processes expected at university level
- Design of introductory sessions to each module where the theme or storyline will be outlined, expectations communicated, and some of the epistemology of science introduced
- Design and preparation of resources to be shared across module facilitators
- Student feedback was shared with the first year team
- Potential methods for formative assessment in lab sessions are being reviewed and will be piloted in one section of the course in the first semester
- Both Laboratory manuals are being revised and digitised, with reformatting of material to indicate intended learning outcomes, and their respective knowledge domains. Safety and risk assessment data is also being incorporated
- Despite not being part of this phase of the project, much attention was paid to the collection of appropriate authentic-assessment techniques and evaluation methodologies

RECOMMENDATIONS FOR PRACTICE

PREPARATION

- Work with the course team to design the module theme or storyline
- Decide what is worth knowing for your students? What is it important for them to know; to find out; be able to do and feel, by the end of your course and during and after each learning session
- Familiarise yourself with the programme learning outcomes – be critical, are these adequate or in need of updating?
- Using learning taxonomies design the overall learning outcomes that (exactly) describe your desired learning for your section of the course? Share these with your students in each session

SESSION BY SESSION

- Design session by session learning outcomes which will enable your students to acquire the overall learning outcomes you desire
- Would it aid your students' learning to categorise the learning into Krathwohl's domains: information, conceptual, procedural and metacognitive
- Design the best learning episodes to engage the type of learning you require – traditional or interactive lecture? Workshop? Lab inquiry session? Introduce variety
- Identify of the 'storyline' or 'through-line' (Perkins, 2009?) for each module in the first year course be critical – can we do better?
- Embed the story-line in each course section
- Be familiar with the conceptual framework in other sections of the course
- Identify the major concepts in the material and identify links to other parts of the course
- Is it possible to produce a visual scheme of the concepts in this section of the course and how they link into the overall conceptual framework of the course
- Assist students to identify the connections between concepts within the storyline
- Design learning outcomes for each section of the course, including each lecture, practical and workshop
- Aid metacognition by illustrating how the sum of sub-learning outcomes contributes to higher level learning outcomes. Alert students to different levels of cognitive, affective and psychomotor domains
- Embed relevance and context to bring value to the material and thus motivate our students leading to higher-order learning and student retention
- Identify the principal Threshold Concepts (troublesome, gateway knowledge) in the section of the course and target these through laboratory and workshop sessions
- Investigate interactive learning materials targeting the identified threshold concepts
- Embrace a paradigm shift from didactic teaching to learner focused teaching
- Identify interactive learning methods to encourage the type of learning outcome you have designed
- Embrace variety but remember the art of performance – it has to be right for you and everyone has their own methods
- Examine the current volume of material in light the importance of understanding of concept as opposed to disjointed information. Be aware that information overload encourages surface learning
- Present material in such a way that enhances development of critical thinking skills,
- Teach using evidence from research, (especially that carried out in NUIM) posing research questions, reviewing results, interrogating conclusions, bias and developing generalisations
- Introduce the scientists and social dramas behind the discoveries
- Practice Socratic questioning techniques and their inclusion in large group teaching sessions
- Cultivate an empathetic manner, and realise that many students may not learn in the same manner as the lecturer, and indeed come from very different lives
- Find out what the students know and start from there
- Be alert to students' orientation to surface learning that has been engendered through the Leaving Certificate programme. Devise learning opportunities that would help students to develop cognitive and metacognitive skills
- **Finally and most importantly:**
  - *How will you know what your students are learning to enable you to give constructive feedback and help them develop metacognitive skills?*
  - *Use quick classroom assessment techniques to test the effectiveness of your students learning (Cross & Angelo, 1988)*
  - *Try to incorporate reflection and evaluation on each teaching session*

IMPACT OF THE PROJECT

KEY LEARNING POINTS:

- The first year teaching team critically engaged with the first year Biology learning experience
- The design of a constructively-aligned first year Biology course structure, with embedded themes, and conceptual frameworks, ready for implementation in academic year 2012/13
- A list of recommended teaching interventions, compiled from first year team meetings, student focus group interviews, and an extensive review of education research literature
- Interactive learning materials sourced and trialed to target 'troublesome knowledge'
- Practical manuals currently being revised and restructured
- Assessment and evaluation methodologies sourced
- The process has started!
- When redesigning a curriculum, or, as in this case, when redesigning a component of the degree programme, one should ideally start with the degree-level intended learning outcomes and work back year by year
- First year teaching team should comprise the wisest members of staff who can bring the broadest range of expertise, experience and… wisdom to bear
- Newly graduated staff might start lecturing in fourth year where the detail of their recent studies will bear fruit
- Introducing change is always challenging, with varying enthusiasm levels. Communication of aims and rationale and providing opportunities for discussion is vital

KEY LEARNING POINTS FOR OTHERS:

- Practically all of the project methodologies and findings are directly applicable to any academic discipline within this and other Universities

POTENTIAL FUTURE DEVELOPMENTS

– Design and implementation of authentic, concept-based assessment is vital if the programme is to have any real effect on student learning. Examples of sourced, authentic assessment utilised in other universities were circulated to the first year team.

- *Carry out a full evaluation on the measures implemented and recommended.*

– First year teaching team:

  - Check degree to *which the recommendations were implemented, if not, why not?*
  - *Evaluate* their experience of the project?
  - Request *permission to facilitate the supply of confidential student feedback* on their teaching and learning to individual lecturers

- *Students*
  - *Evaluate the first year experience*
  - *Review exam papers for concept as compared to information assessment*
  - *Review exam scripts when authentic assessment implemented*
  - *Review same with external examiner*
  - *Use Biggs and Entwistle's questionaires for interrogating deep / surface learning*
  - *Compare outputs form semi-structured interviews with current year and previous year*

The methodologies of the whole project could be brought to bear on the whole degree programme, in addition to diversifying to Chemistry (identifying concept links, themes and so forth that encompass Biology and Chemistry).

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DEPARTMENTS OF BIOLOGY AND COMPUTER SCIENCE

Biochemicalc: A Web-Based Environment for Teaching Biochemical Calculations

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The purpose of this interdisciplinary project was to establish a website which will assist Bioscience students, and new researchers in the Chemical Sciences, to acquire laboratory-specific skills for the execution of biochemical calculations. At present, Bioscience students experience considerable difficulty in gaining confidence to undertake the biochemical calculations necessary to work in the laboratory. To circumvent this issue, we proposed to design and establish a web-based environment where students can (i) carry out biochemical calculations using user-friendly software, (ii) undertake problem-based learning to strengthen their skills in this important area and (iii) readily access a range of key biochemical data and information to assist with laboratory write-ups and project theses compilation. It was also a requirement that the site be easily maintainable into the future, allowing for example, the addition of new biochemical compound data or quiz problems. The project required temporary recruitment of a software engineer, to assist in website design, write all necessary code and upload all data required for optimal website functionality. Undergraduate student involvement in alpha-site testing was undertaken. Biochemicalc.com is now online and hosted on the NUIM cpanel server. It has been and will be continuously publicised to NUIM undergraduates and postgraduates, in addition to external publicity.

CONTEXT

Bioscience students experience considerable difficulty in gaining confidence to undertake the biochemical calculations necessary to work in the laboratory. Yet, this skill is required for both 4th year projects, and to carry out laboratory experiments in undergraduate years 1-3. This issue is exacerbated by the high student:staff ratio in the Department of Biology and declining PhD student numbers, as a result of research funding constriction, to supervise students in the laboratory.

Existing best practice for teaching students biochemical calculations and how to prepare solutions in laboratories involves lectures, tutorials and practical classes. These work well but still students seem to be confused about some basic principles and lack the confidence to undertake biochemical calculations. Some commercial websites are available which are similar to BiochemiCalcTM but are not user friendly or designed with learning in mind. In other words, they present ways of doing calculations, without explaining how the calculations are done, moreover, no "problem-solving" questions are presented on similar websites.

KEY OUTCOMES

Overall a brand new online learning environment http://www.biochemicalc.com was established (Figure 1). Firstly, this website informs students as to how to carry out biochemical calculations and how to prepare reagents in the laboratory. Secondly, it provides calculators which students can use to check their own calculations. Thirdly, it presents online problems which students can use to practise their biochemical calculation skills and abilities. The website is open-access and external users also have access to it.

FIGURE 1: BIOCHEMICALC ™

Specifically,

1. In order to make the BiochemiCalcTM site simple to understand and use and minimize the learning curve, common tasks performed in the laboratory were identified and for each task a goal-directed calculator was devised and tested by the Teaching Fellows. These calculators are then integrated on the site with a problem oriented question base to cultivate understanding and confidence in making the calculations in practice at the student's own pace. The quiz section incorporates immediate feedback informing the user of the correctness of calculations and also showing how the calculation is performed. A reference section of the site draws together common laboratory practices, hints and formulae in one place.

2. Peer input and Undergraduate Student assessment of the BiochemiCalcTM utility as a learning tool was solicited during the project using a site survey form as well as an integrated feedback mechanism on the site. Ideas and comments made were used to feed into the incremental design and development process, and again during beta-testing of the site in association with the web developer.

3. BiochemiCalcTM uses Wordpress as its content management system, which operates using PHP server side scripting and a mySQL database configured at the NUIM cpanel hosting service. A custom template or Wordpress theme was created to give an overall consistent clean look and frame to the site pages and to blend well with existing NUIM website styling used on campus. The functional elements of the site are then added as modules to this template and the browser pages seen by the user are generated dynamically through Wordpress PHP scripts from these elements. The PHP mechanism allows user account control to certain parts of the site used for administration of content so an administrator can log in to the site securely online and reconfigure modules or add items to the biochemical compound database or quiz section while the main site can be viewed by the public without login requirements. Calculations and other user interactions are performed within the browser using Javascript once the pages have loaded.

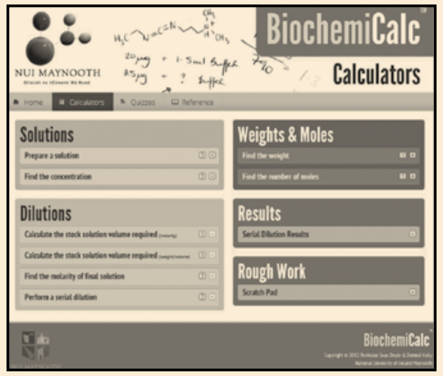
IMPACT OF THE PROJECT

Biochemicalc is now available to both undergraduate and postgraduate students. The portal will be advertised in the Course Manuals, for undergraduates and postgraduates, produced annually by the Department of Biology, and also brought to student attention in Introductory talks, Moodle, and by 4th year and higher degree project supervisors. Students will benefit by being able to either double-check the answers to their own biochemical calculations or carry out calculations using the easy to use Windows-based icons on the portal.

The Department of Biology already provides extensive instruction to students on how to carry out biochemical calculations in the laboratory. However, it is clear that many students find it both challenging and time-consuming to develop the necessary practical confidence. Access to a user-friendly portal, Biochemicalc, will strengthen the educational armamentarium of the Department in its efforts to train a new generation of Experimental Scientists. Moreover, it will partially offset the negative effects of the very high student:staff ratio which currently exists in the Department and which is almost twofold greater than in other FOSE Departments (except Psychology).

PROJECT LEARNING POINTS:

1. A clear initial vision of the format and need for this teaching tool coupled with user involvement and feedback during the incremental development process lead to very positive assessment.
2. Students surveyed expressed satisfaction with content (especially the calculators) at 90%, utility at 90%, ease-of-use at 97%, and 97% of users indicated that they would recommend the site.
3. The cross-disciplinarity of the Fellows and Undergraduate Media Studies Student who developed the site proved to be a useful mix in achieving the final structure, functionality and usability features.
4. Students like online learning spaces.
5. Collaboration between different expertises can yield novel tools.
6. People wish to take on extra unpaid duties to aid student learning.
7. How to use Google Analytics.



LEARNING POINTS FOR OTHERS

The Biochemicalc concept is new to NUI Maynooth, and to our knowledge no similar system exists in any other Irish University. We have publicised Biochemicalc at all Irish Universities. It has presented a unique opportunity to NUI Maynooth to adopt a novel approach to training in the Biosciences, and the Chemical Sciences. Indeed, consultation with the Department of Chemistry was integral to the success of the portal and academic staff therein were approached for suitable portal content once the concept had been established for the Biosciences. In the medium term, Biochemicalc has the potential to be added to the Moodle space. In future, Biochemicalc may also be provided as a purchasable 'App' for portable devices.

POTENTIAL FUTURE DEVELOPMENTS

In future, Biochemicalc may also be provided as a purchasable 'App' for portable devices. This would require a redesign of the interface to suit a smaller portable screen device and coding specific to the operating systems of portable devices and so would require additional funding to develop.

We also suggest that NUI Maynooth communications, CTL and Admissions Offices could be proactive in using Biochemicalc to illustrate how progressive NUI Maynooth is in interdisciplinary student learning projects.

http://www.biochemicalc.com

DEPARTMENT OF CHEMISTRY

Applied Teaching Resources in Chemistry: Encouraging Student Engagement and Enhancing the Student Learning Experience.

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During the 2010-11 academic year a Chemistry Department Teaching Sub-Committee was established to investigate chemistry specific initiatives aimed at improving student attendance at lectures and student engagement/motivation during lectures. The Committee worked with the Centre for Teaching and Learning (Ms. Lisa O'Regan and colleagues) with respect to canvassing student opinions - a 1st (large group) and a 3rd (medium sized group) year module were targeted where students were provided with specifically tailored questionnaires. This was followed up with detailed discussions in focus groups involving students, and both academic and CTL staff. In this project the Department has built on these preliminary initiatives by utilising the information already gathered to investigate the use of digital and modelling teaching resources in 1st Year (specifically CH101 and CH102). As chemistry is a practical science subject this will involve both academic (Prof. Lowry, Dr. McManus, Dr. Heaney, Dr. Stephens) and technical staff (Ms. Woods, Ms. Fenelon, Ms. Walsh) addressing the two facets of teaching - lecturing and experimental work. In the former staff investigated the use of mid-course assessments (e.g. MCQs and/or demonstrations using chemical structure modelling) during lecture courses to engage students. In the latter (experimental work), technical staff created digital teaching resources such as videos, screencasts and podcasts for use to supplement lectures and laboratory techniques.

CONTEXT

The primary motivation for undertaking this project was to try and improve student attendance at 1st year lectures. As can be seen from the graphs presented below (see Key Outcomes below) there is a significant drop in attendance by the time the mid-point of semester 1 is reached (284 to 173 students). From our experience with continuous assessment (CA – Laboratory Practicals) it is clear that there is very good engagement and attendance. The primary reason for this we assume is that failing CA means the student fails the year, irrespective of their written/theory mark. Our goal with this project was to strike a balance between encouraging active self-participating engagement and emphasising a compulsory/course requirement mentality. Our aim was to try and achieve this using:

– Course assessments, e.g. MCQs
– Chemical structure modelling, e.g. kits
– Digital teaching resources, e.g. videos, screencasts and podcasts

REVIEW OF RELEVANT LITERATURE

With respect to the use of multiple-choice questions there seems to be a lot of debate in the literature about the positive or negative role of MCQs in the assessment of students. The positives tend to centre around: the facilitation of comprehensive student learning; that well designed multiple-choice tests are an efficient method of assessing knowledge, questioning ability, language proficiency and numerical skills; and the fact that they are open to analysis.

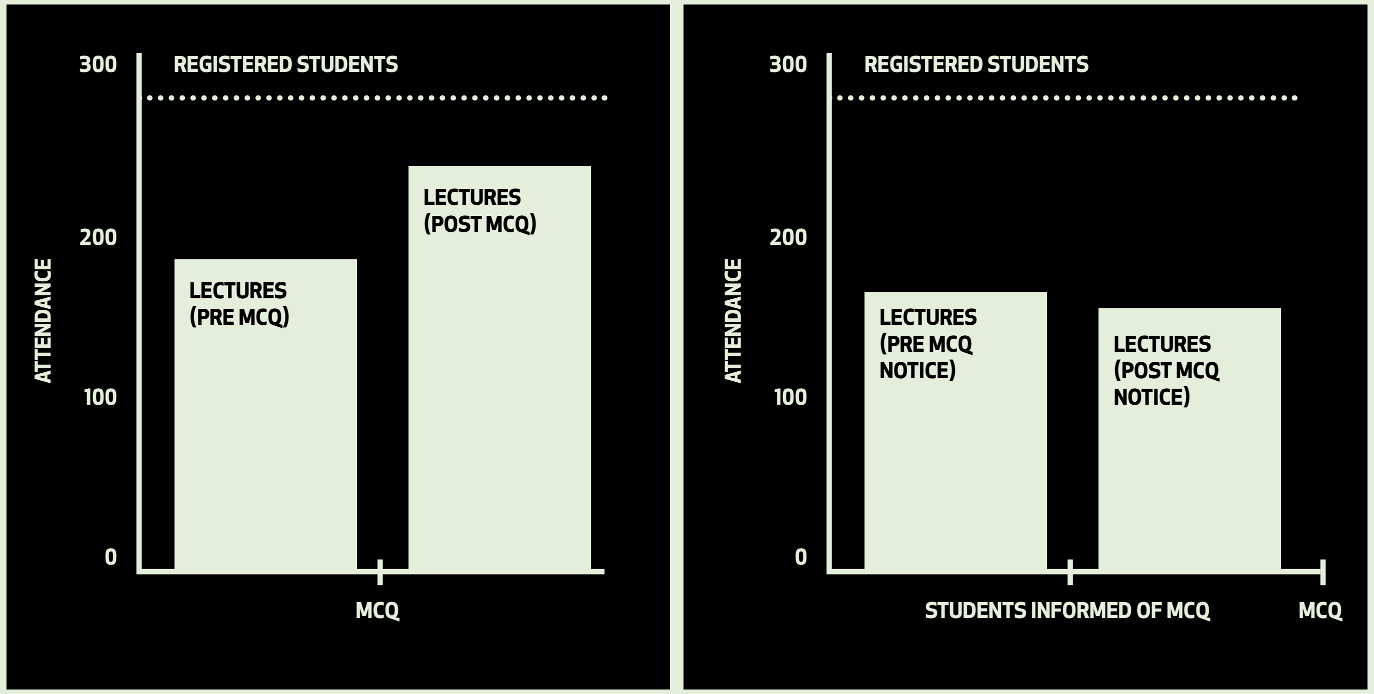
However, the negatives tend to fall into two main categories: general concerns about suitability; and structural issues (e.g. the impact of negative marking). A lot of these issues are highlighted in a recent article by Aidan O'Dwyer (2012) which is directly relevant to this project in both a science and Irish context. In terms of the use of models an excellent resource is the book Model Based Learning and Instruction in Science (2008). This is an edited manuscript with contributions from several authors and it is clear that the underlying premise is that students must engage in their learning to develop a deep understanding of their chosen subject. Models are an ideal tool in this respect. It is widely accepted that videos and screencasts are a valuable tool in reinforcing the learning experience and in showing people that science can be interesting and understandable.

KEY OUTCOMES

The key outcomes and outputs of the project can be summarised as follows:

– ATTENDANCE – MCQs were introduced during the lecturing component of modules CH101 and CH102. There was a significant and positive effect on student attendance when the MCQ was given at the mid-point in the module with the students being informed of the exam in advance (see Figure 1, left). However, when the MCQ was given at the end of the module, with the students informed at the mid-point, there was no effect on the attendance (see Figure 1, right).

FIGURE 1
MCQ AT MIDPOINT OF LECTURE COURSE
MCQ AT END OF LECTURE COURSE



– ENGAGEMENT – A large scale alpha particle demonstration (Rutherford Experiment) was prepared by Dr McManus, (see Figure 2). In addition, a large chemical structure modelling kit was used by academics and all students were given small kits (see Figure 3). Both of these had a very positive effect on both academic and student engagement and the overall learning experience (student feedback – see Student Comments below)

– ENHANCING THE LEARNING EXPERIENCE – Short videos/podcasts were prepared covering laboratory techniques and health and safety issues. These were used to supplement teaching in the 1st year practicals and helped to reinforce experimental concepts and techniques. This is particularly important with increased student numbers and the consequent necessity to teach in groups.

PROJECT IMPACT

In taking attendance over the years we have noticed that there is a strong correlation between lecture attendance and passing exams. This is true for all years and not just 1st year. It is also, in general, supported by external evidence (Cleary-Holdforth, 2007). While we make the students aware of this at the start of each academic year it seems to quickly dissipate into the recesses of their minds.

The MCQs seem to be a simple way of addressing this issue but clearly thought needs to be given to how and when they are introduced. We feel that the models and videos were a great success and had a very positive experience for both the lecturer and students – both welcomed the interaction and engagement and in some respects it help to establish a communication bond between teacher and student.

KEY LEARNING POINTS
The bottom line here is that we as educators (both academics and technicians) need to make more effort in engage with our students. While there is no doubt that this is going to be a more challenging task with larger student numbers, simple things such as the use of models in lectures can significantly enhance the student experience.

LEARNING POINTS FOR OTHERS
There are several practically orientated subjects (e.g. Biology and Experimental Physics) in the Faculty of Science and Engineering which could potentially benefit from the outputs of this project. As outlined above, our goal was improved student engagement through constructive interaction and assessment with the view to providing a better student learning experience. While the use of MCQs may not be easily implemented across the University (see Potential Future Developments below), the use of models and videos is certainly widely applicable across disciplines and indeed Faculties.

POTENTIAL FUTURE DEVELOPMENT

- MCQs – *although there are pros and cons associated with MCQs these are widely used throughout the University sector. However, in other Universities their successful use is facilitated by their provision as a central University resource. Thus, long-term further acceptance and extension may require a once-off investment by the University - if one takes a look across the Irish University sector it is clear that a lot of the resources and supports for initiatives such as those contained in this project (particularly with respect to the digital teaching resources) come from a centralised University facility. For example, an active and highly resourced Audio Visual Centre (e.g. www.tcd.ie/iss/facilities/omr.php).*
- Models – *our plan was to ask students to pay a refundable deposit at the start of the year and that the kits could be reused every year for 1st year students. If students decide to take chemistry in second year we will encourage them to purchase a kit so that the learning experience gained in 1st year is continued. We plan to pursue this in the coming academic year.*
- Videos, Screencasts and Podcasts – *the purchased resources (see below) will be used to create more videos on chemistry laboratory techniques, etc. This will enable the establishment of is a data bank of valuable resources which will extend across all undergraduate years.*

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APPENDIX: STUDENT FEEDBACK ON CH101 MODULE, ATOMS MOLECULES AND THE PERIODIC TABLE, 2011-11-30

STUDENT A:
"Excellent notes and explanation. One best modules yet due to explanation and lecturer."

STUDENT B:
"I found the lectures interesting which will help me with my further study in chemistry as I was given the building blocks for general chemistry. I found the activities that were carried out in lectures most beneficial. They helped keep interest in parts of the course which became tedious. I found some of the lecture notes verbose. But, overall the lectures were excellently presented and interesting

STUDENT C
"Alpha particle experiment was great"

"Molecular structure ball and stick equipment very helpful"

"The "experiments" like throwing the ping pong balls were both enjoyable and informative. They should definitely remain in your lecture"

STUDENT D
"Practical experiments were helpful and fun"

"I don't believe Callan Hall is the best place for the chemistry lectures. "

STUDENT E
"I found that some of the questions in the second tutorial wer more difficult and in some cases the question varied from the way we were shown in lectures. However, in general, excellent"

STUDENT F
"I liked how the lecturer actually participate in lectures – using alpha particles (balls) and making models of compounds"

"Thought the alpha structure experiment was very good way to understand"

STUDENT G
"The molecule sets for demonstrating VSEPR Theory were very helpful"

"Great lectures, I especially enjoyed the way the Rutherfold gold foil was demonstrated. I also think the models of the shapes of molecules helped me to understand the shapes easier. Great lectures."

STUDENT H
"Lectures were clear and concise and easy to understand. Very good at explaining material. Enjoyable lectures. Took time to explain. Great."

"The chemistry lego and ping pong experiment was epic craic"

"The real life experiments (i.e. compound kit and gold foil) were very useful and easy to understand."

"Practical activities during lecture helped to encourage attendance in lectures and encouraged practical learning"

STUDENT I
"I liked the interactive things, i.e. the table tennis ball experiment and the "build it yourself" atom compound set as they helped remember the material.

"Molecular models and tennis ball experiment was good".

"Loved the Rutherford experiment demo – only lecture so far that actually interacted with the class! Also found the ball and stick models useful – very helpful to see 3D shape of molecules".

An Investigation into the Use of Clickers in Groups for Teaching Data Structures and Algorithms

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In this project I investigated the use of clickers in a second year data structures and algorithms module. In recent years instructors in higher education have begun introducing classroom technology that allows students to respond to questions during lectures. Studies have shown considerable benefits in terms of attendance, classroom engagement and allowing instructors to gain instant feedback (Caldwell, 2007; Kay & LeSage, 2009). In the study students were assigned to self-selected groups of three. 20% of the final module grade was earned by answering questions during lectures in competition with other teams. We found that the use of clickers had a dramatic effect on both attendance and engagement in the class. Students were far more likely to ask questions and defend their points of view, both before and after lectures. At the end of the semester the majority of students rated the clickers positively. However, the final module grade was lower than previous years. An anonymous survey suggested that although students enjoyed working in groups, they were less likely to take personal responsibility for their own learning when there were others on the team that could do the work. In light of this, we recommend allowing students to discuss questions together during lectures, but awarding marks individually.

CONTEXT

Many students taking introductory computer science (CS) find programming very challenging, with the result that up to a quarter of students drop out and many others perform poorly (Williams & Upchurch, 2001). One problem is that introductory CS modules often involve large classes with minimal interaction between lecturer and students. Textbooks and lecture material are often heavy on declarative knowledge, with particular emphasis on the features of a programming language (Robins, Rountree & Rountree, 2003). However, given that the skill of programming requires procedural knowledge, it is best learned through practice, experience and engagement with peers and instructors (Traynor & Gibson, 2004).

Research has shown that students must be active participants in the learning process in order for deep learning to occur (Mayer et al., 2009). While large lectures can be effective in presenting new material, passive transmission fails to engage students in application, analysis, synthesis or problem-solving, all of which are essential for any CS graduate. What is required for teaching large CS classes is an instructional method that can motivate learners to process conceptual knowledge deeply, as well as supporting interaction with the instructor and other students.

REVIEW OF RELEVANT LITERATURE

The last decade has seen the introduction of classroom technology that allows students to respond to questions via a small hand-held device. These devices, often known as 'clickers', typically have several buttons which allow students to reply to a multiple choice question, in the style of game shows such as "Who Wants to be A Millionaire". The answers can be immediately aggregated, analysed, displayed and subsequently discussed in the lecture. Clickers were first introduced at Stanford and Cornell in the 1960s, but only became commercially available in 1992 (Abrahamson, 2006). In 1999 a new generation of more affordable clickers was launched, with widespread use emerging in 2003 (Kay & LeSage, 2009). The most recent models have a 10-digit numeric keypad and keys for permitting text entry (Caldwell, 2007).

Students in larger classes are often reluctant to respond to questions because of fear of embarrassment, public speaking or peer disapproval (Caldwell, 2007). Solutions such as calling on student volunteers, or selecting students randomly from a list are not popular strategies, and typically only elicit responses from a small fraction of the class. This small vocal minority can give the false impression that the larger silent majority understands a topic (Caldwell, 2007). These issues are directly addressed by clicker systems, which allow students to respond anonymously, and provide lecturers with instant feedback which can be used to clarify misunderstandings. Clickers can also change the atmosphere of lectures, with students more likely to become visibly active participants (Beekes, 2006). The act of committing to an answer causes students to become emotionally invested in the question, focusing their attention on the discussion that follows, and motivating them to defend their viewpoint (Beatty, 2004).

Studies have shown that the longest an uninterrupted lecture can be comfortably endured is only 20 minutes (MacManaway, 1970). Clicker questions serve to break up a lecture, allowing students to refocus their attention and improve their concentration. Students generally report a positive attitude towards the use of clickers, citing the benefits of anonymous contribution, and the possibility of comparing answers immediately with the rest of the class as positive aspects (Bunce et al., 2006). Martyn (2007) investigated whether students' appreciation of clickers was due to the technology itself or due to the active learning pedagogy. In a direct comparison of clickers with class discussion, clickers were consistently rated more positively, suggesting that it is the dynamics of clicker use per se that students enjoy.

The use of clickers has also been found to lead to dramatic increases in attendance. For example, Burnstein and Lederman (2001) found that when clickers scores accounted for 15% or more of the course grade, attendance levels rose to 80-90%, with students noticeably more alert during lectures. Caldwell (2007) reports that attendance can be increased by assigning only 10% of the overall grade to clicker participation, though when this is reduced below 5%, the effect on attendance remains negligible. Clickers also appear to reduce student attrition, more than halving the number of students dropping out in some studies (Caldwell, 2007).

Another advantage of clickers is that they can be used to facilitate peer learning by encouraging students to discuss questions (Levesque, 2011). For example, one strategy is to ask students for an initial individual response, display the results, and then get them to discuss the question among themselves before voting again (Caldwell, 2007). When students make a mistake and see that many others voted for it, there is less stigma discussing what made that answer seem plausible (Simon et al., 2010). Previous studies have shown that peer learning can result in superior learning gains and exam scores than the more traditional content based approaches to course material (MacManaway, 1970; Pollock, 2006). In surveys on peer learning, Nichol and Boyle (2003) found that 92% of students felt that discussing with others helped them to learn, with 82% agreeing that hearing other students' explanations helped them to develop their own understanding. Because of their common ages, language and mastery of the subject, students can be better than the lecturer at clarifying each other's mistakes and misconceptions (Caldwell, 2007). Communication can occur on an equal level, and information can be presented in a format which more closely matches the learner's immediate experience, leading to deeper processing (Assiter, 1995). In addition, when a student explains a concept to other students, it serves to reinforce their own understanding (Coleman, 1998).

In our study, we expand on this idea, by examining how clickers can be used in a team-based scenario. Several studies have noted positive effects of team competition in a classroom setting. Lasserre (2009) found that team-based learning resulted in a significant change of ambiance in the class, with increased participation leading to enhanced student confidence and lower dropping rates. Jones et al. (2001) also noted that students became more involved with clickers when they were used in groups as opposed to individually. We hypothesised that using clickers competitively in teams would enhance both engagement and peer learning in the class.

KEY OUTCOMES

This study was carried out involving 120 students from a wide range of disciplines taking two consecutive modules in data structures and algorithms in NUI Maynooth. Clickers were used in the first semester module but not the second semester module. In previous years teaching the same module interaction during lectures was minimal, with few questions posed and few students responding.

Each student was provided with a clicker which they were told they would have to hand back at the end of the semester. Students marked down the code on the back of their clicker so that their responses could be identified in lectures. A total of 20% of the module grade was awarded for participation. Given the large portion of marks going towards clicker questions, we were concerned about lectures becoming too much like exams, raising the possibility of student anxiety and also cheating. As a result, it was decided to assign students to groups and have all of the groups compete against each other for marks. We hypothesised that dividing marks among teams in a zero sum game would eliminate the motivation for broadcasting answers between teams, while promoting constructive collaboration within teams. Teams of three were awarded marks based on their ranking of correct answers relative to the rest of the class.

There are many guidelines in the literature about designing good clicker questions. Beatty et al. (2006) state that the critical challenge is creating questions that cultivate productive classroom interaction and discourse. Kay and LeSage (2009) recommend that questions should be ill-defined and vague so that students are required to think and debate to find the correct answer. They also recommend that questions should focus on deep reasoning rather than on the memorisation of factual content and that they should identify and help to resolve misconceptions. Designing a batch of questions to match these criteria each week was challenging. Several forms of questioning were employed. One type involved a series of five statements about data structures and algorithms, one of which was false. Another type of question involved a piece of code with some calculations and options for possible outputs. Other questions presented students with a piece of code and challenged them to count the number of errors within it. This was particularly conducive to discussion because different students would spot different errors, and the question could only be answered successfully by pooling all of the information. Another type of question would present a real-world problem (e.g. a set of items to be sorted by height) and a range of options for how this would be processed using a particular algorithm. All of the questions were based around deep conceptual issues so that answers could only be identified with confidence given a comprehensive understanding of the concept. We also aimed to highlight common misperceptions by deliberately creating 'trap' responses and then discussing them afterwards.

IMPACT OF THE PROJECT

The use of clickers produced a clear increase in attendance. Figure 1 shows that the lecture attendances in the first semester, when clickers were used, exceeded all of the lecture attendances in the second semester, when clickers were not used.

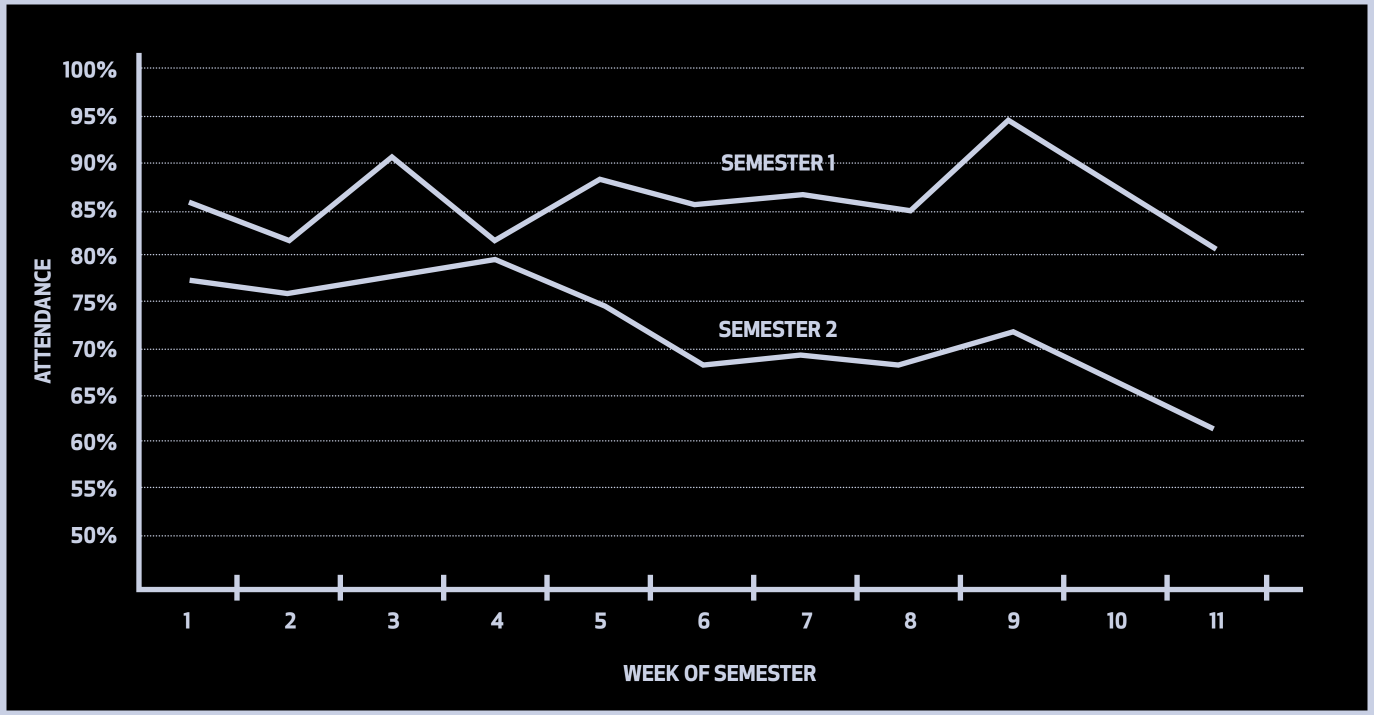
The use of clickers also had a dramatic effect on the dynamics of the class. Students were very vocal in defending their choices and would argue extensively to communicate their opinions, spurred on by other students who shared the same view. The presence of ambiguities or mistakes in the questions themselves also created a significant amount of debate. In line with Beatty (2004), through the act of selecting a particular answer, students developed an emotional involvement in the question. They would raise their hands to reveal errors in the code. They would type the code into a laptop to check if it worked, or surf the web to find information supporting a point. Students would email the lecturer corrections to the lecture slides which at times had gone unnoticed, or unmentioned, for years.

In the final week students were asked whether they felt that the use of clickers would have a positive effect on their exam performance. The average response on a 5-point Likert scale was 3.03, indicating that students overall did not feel clickers would have any impact. Indeed, the marks achieved in the exam were lower than previous years, dropping from an average of 52.8% to only 43.8%. The exam failure rate, which averaged 21.7% in previous years, more than doubled to 44.4%.

Questionnaires were handed out at the beginning of the subsequent semester to investigate what had led to the poor performance. Students were invited to provide anonymous feedback on their experience of clickers. The general feedback was that working in prescribed teams had disincentivised many students from trying to understand the concepts for themselves. Many teams featured one strong programmer who would end up making most of the decisions. Rather than benefitting from the opportunity to engage in peer learning, students were instead availing of the opportunity to take a back seat, as opposed to taking responsibility for their learning. Students also reported that the marks awarded for clicker participation were too high, with many ending up doing less study for the exam because fewer marks were needed to achieve a pass grade overall.

On the whole students reported enjoying clickers and the majority were in favour of using them again in other modules. Many were of the opinion that clickers had improved their attention in class and they enjoyed the competitive element. The following quote is representative of the feedback received: "I liked the clickers. They made me focus during lectures, and gave me motivation to turn up…I learned better by myself. Having groups helped me out, but I think I relied on my group too much."

FIGURE 1. CLASS ATTENDANCE IN SEMESTER 1 (CLICKERS USED) AND SEMESTER 2 (NO CLICKERS)



POTENTIAL FUTURE DEVELOPMENTS

The feedback suggests that it was the group-based paradigm that was responsible for the decrease in exam performance, rather than the use of clickers per se. It appears that imposing complex structures for motivating participation, such as competitive group-based questions, actually encourages students to delegate responsibility rather than enhancing peer learning. Learning how to work in a team is an important skill, especially in computer science where large scale software projects are necessarily collaborative. Nevertheless, the current study suggests that, for modules where the learning outcomes are centred on the development of individual skills, the advantages of group work are outweighed by the reduction in students' levels of engagement.

Group work aside, the introduction of clickers was certainly successful as regards enhancing attendance, attention and engagement. In light of this, we intend to continue using clickers to teach data structures and algorithms in future years, albeit without the group-based element. The use of clickers may be particularly useful with first year classes where enhancing attendance and promoting interaction between students may help to limit early drop-out.

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EDUCATION DEPARTMENT

Developing a Technological Pedagogical Content Knowledge using sensor technology with BSc Science Education students

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This project aimed to promote the development of Technological Pedagogical Content Knowledge (TPCK) among student teachers on the BSc in Science Education programme through the introduction of sensor technology for teaching and learning curricular content. In line with recent developments in science education and the review of the Leaving Certificate Biology, Physics, Chemistry and Maths syllabuses, this initiative proposed to develop teaching and learning activities using sensor technology to provide student teachers with learning opportunities that would integrate their knowledge of subject matter with the development of skills using technology and of knowledge for teaching and learning in specific content areas.

The project involved the use of a range of sensors purchased with the support of university funding. Handheld digital sensors designed to take readings of light, temperature, motion, heart rate, force, gas pressure, dissolved oxygen, pH, carbon dioxide and oxygen were given to student teachers in the context of their university classes. Once they became familiar with the hardware they set about planning the ways to use these to teach junior science topics in their teaching practice schools.

Information and Communication Technology (ICT) has begun to play an increasingly dominant role in teaching and learning in schools (Underwood, 2009) and the teacher's toolkit has been lavishly refitted with online resources, hardware in schools and the emergence of cloud computing. However, convincing evidence that the use of technology in schools has led to transformed practice remains elusive (Livingstone, 2012). For technology to be really powerful it must move beyond that of efficiency aids and extension devices to being transformative (Harris, Mishra and Koehler, 2009 Sensors offer the potential to conduct experiments and observations easily and in real time, with an accuracy which could not have been achieved in Junior Science before. This offers the potential for a great deal more experimental work, in keeping with a constructivist approaches to teaching and learning. In this project student teachers moved from being mere consumers of technology, simply learning how to use the sensors and their associated graphing software, to being active collaborative partners who planned ways to teach using the technology and anticipated challenges these might present in their teaching practice classrooms. Consequently, they were challenged to develop lesson ideas to teach specific content to their classes using technology as a support for the pedagogies employed and to discuss and evaluate the outcomes from the process both in the university class and in the school classroom.

Teaching is a complex endeavour; therefore, initial teacher education is highly complex and needs to be firmly rooted in learning in, from and for practice (Darling-Hammond, 2006). Changing teachers' practice in science teaching is a difficult process especially in a system where external summative assessment has such an influence on teaching and learning. Research on students' experience of junior cycle education in Ireland has highlighted the dominance of the Junior Certificate state exam on teaching and learning practice. It has described the experience of an inflexible, overcrowded curriculum, with a narrow range of assessment activity and without adequate time for engagement with deeper learning (ESRI, 2007). Commentators on science teaching in Ireland have concerns that students are taught to compete well in examinations rather than being taught to understand subjects (Conway and Sloan, 2005). Hyland contends that the discussions on the backwash effect of the Leaving Certificate and the points system on teaching and learning have been happening with 'monotonous regularity over the past 50 years' with most commentators agreeing that there is an over emphasis on rote-learning and not enough emphasis on the application of knowledge (2011, p6). Within this context and coupled with an increased emphasis on literacy and numeracy (DES, 2011), this project was timely in the field of initial teacher education in Ireland.

REVIEW OF RELEVANT LITERATURE

Using technology to assist students learning is being promoted in education worldwide (OECD, 2008, 2010). The use of ICT in teaching and learning is one of the mandatory elements of programmes of Initial Teacher Education (Teaching Council, 2011). The use of technology is integrated across the BSc in Science Education. It is used in so-called 'micro-teaching', where students record and edit role-plays of lessons and develop their presentation skills using a range of presentation software tools, it is found in teaching methodologies where students are exposed to a range of ICT tools and again in modules on teaching, learning and assessment where students develop teaching artefacts using ICT. In an evaluation of strategies used to incorporate technology into pre-service education, Kay (2006) concluded that access to good software, hardware and support in the university classroom and in the field placement was essential and that regardless of the strategy used the need to model and construct authentic teaching activities was central to the successful integration of technology. Sensor technology is embedded in the proposed changes in Leaving Certificate science and maths syllabuses for the realisation of the learning outcomes for the learner. Gilbert advises that the quality of teaching, the curriculum and assessment are all highly influential in the formation of student attitudes towards science (2006). While using technology in science teaching and learning is to be recommended, if it is to be used in a transformative way then learning to do this as a student teacher is highly complex. Learning subject matter with technology is different to learning to teach subject matter with technology (Niess, 2005). This project aimed to enhance this engagement with technology and to use it to connect the students' learning of content and pedagogy with their engagement with technology and in doing so develop their technological expertise.

This project adopted the framework of Technological Pedagogical Content Knowledge (TPCK). Taking Shulman's (1986) concept of Pedagogical Content Knowledge (PCK), which he described as the transformation of subject matter knowledge in the context of facilitating student understanding, the overlap between content and pedagogy, adding the technological dimension, Drawing on the framework originally developed by Shulman (1986) Misra and Keohler (2006) describe TPCK as the overlap of content, pedagogy and technology, or later as the complex set of interrelationships between artifacts, users, tools and practices (Koehler, Mishra & Yahya, 2007, p742).

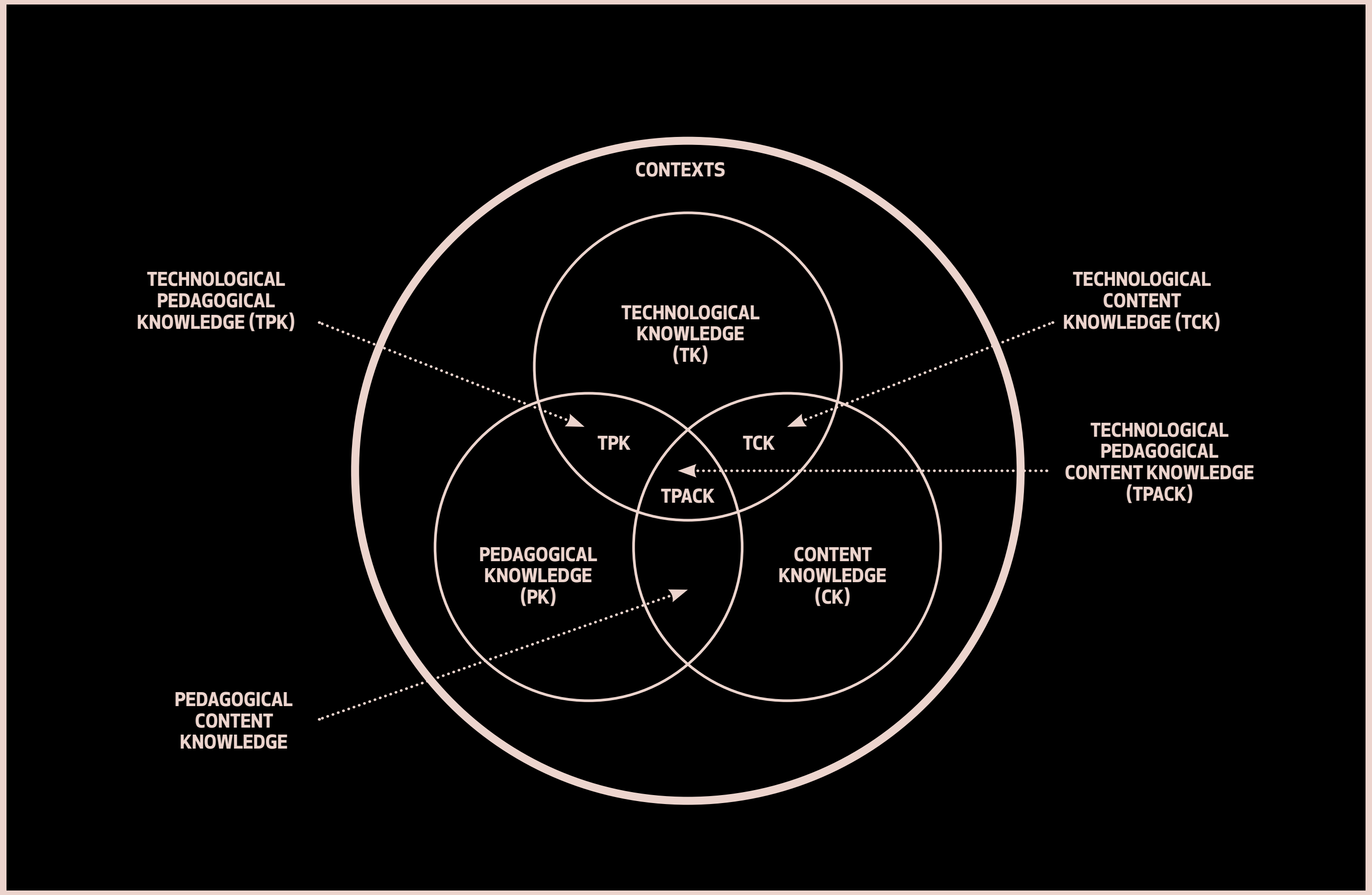

FIG. 1. FRAMEWORK OF TECHNOLOGICAL PEDAGOGICAL AND CONTENT KNOWLEDGE (TPACK: KOEHLER & MISHRA, 2006).

TPCK is the integration of the development of knowledge of subject matter with the development of technology and of knowledge of teaching and learning (Niess, 2005). Good teaching with technology requires understanding the mutually reinforcing relationships between all three elements taken together to develop appropriate, context specific strategies for teaching and learning (Koehler, Mishra & Yahya, 2007, p741). This means that student teachers must in their planning teams be cognisant to the Pedagogical Content Knowledge, that is a knowledge of pedagogy that is applicable to the teaching of specific content, Technological Content Knowledge, an understanding the way in which technology and content are reciprocally related to one another, Technological Pedagogical Knowledge, which is concerned with the capabilities of the various technologies as they are used in teaching and learning settings. The dynamic, transactional relationship between these three knowledge components Technological Pedagogical Content Knowledge is described by Koehler et al.:

> **In this view, good teaching with technology for a given content matter is complex and multi-dimensional. It requires understanding the representation and formulation of concepts using technologies; pedagogical techniques that utilize technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help address these issues; knowledge of students' prior knowledge and theories of epistemology; and an understanding of how technologies can be utilized to build on existing knowledge and to develop new or strengthen old epistemologies (2007, p743).**

The framework was ideal for this project: the challenge was to prepare student teachers to teach subject content knowledge with knowledge of teaching and learning, or pedagogy, whilst integrating technology in the process. For this to happen as outlined above undergraduate Science content knowledge needed to be understood alongside content of the second level science curriculum and the appropriate skills and awareness of the relevant sensor technology. In science classes a number of pedagogical strategies are used by student teachers. Set within this context the research project set out to explore the use of sensor technology in the promotion of a dialogical pedagogy in science education. Alexander has emphasised the importance of maximising active student participation in classroom talk as a means of enhancing understanding and in moving away from the predominant pattern of teacher-led dialogue in learning (Alexander, 2008). This dialogical conception of pedagogy allows students to construct meaning in their own words and challenges them to make connections and to defend their predictions, adopting a social constructivist approach to the learning. In doing this it enhances students' scientific vocabulary and numeracy skills. This construction of meaning needed to happen in the collaborative planning groups and with the university lecturer before it was possible to explore it at the classroom level. The role of sensor technology in this setting is multifaceted.

Gathering data is a common feature of practical work. Sensor technology enhances this process by allowing students to display graphs and data sets in real time. The approach encourages higher order thinking while allowing students engage in authentic investigation rather than prescriptive experiments that have pre- determined outcomes. Students and their teachers are challenged to move beyond data collection to using scientific ideas to explain and analyse data. The sensors helped to link the physical and virtual learning spaces.

KEY OUTCOMES

The scientific approach, interpretation of data and use of evidence and argument in evaluating information are central to both practical activities and theoretical concepts in science and maths teaching and learning. Student teachers report that in many science classes students are being taught experiments with highly predictable outcomes that do not engage students cognitively. Students follow a list of instructions from their books and copy steps into their coursework manual. Using the sensors student teachers introduced an element of investigation into student practical work. The rapid collection of data allowed more time for comparisons, exploration and for further questioning and investigation. Students were challenged to use scientific ideas to explain the data they had gathered using sensors.

The strength of focusing on students' scientific talk in class as they defend and explain their thinking based on the data from the sensors was powerful as it simultaneously integrated the technology, conceptual understanding and the dialogical pedagogies. It promoted literacy and numeracy and both student teachers' and students' scientific and mathematical vocabulary.

Specific outcomes for student teachers involved in the project were the development of:

- skills in technological pedagogical content knowledge
- skills in accessing information, analysing that information for patterns and meaning, identifying bias and communicating findings
- skills in scientific and mathematical content knowledge due to the type of engagement with the technology and making connections between mathematics and science
- higher order thinking and problem posing and solving skills
- skills needed for participation in a professional learning community in science and maths education.

Implementing this project with the BSc students allowed a deeper engagement with the theoretical aspects of TPCK and provided an opportunity to articulate the lecturers' own TPCK and make it more explicit in teaching. The work on the sensors was organised in collaborative planning groups, it became clear at an early stage that the college lecturers were also developing TPCK and learning by discussing ideas, both pedagogic and scientific.

The graphing software can be used as an Application on iPad and iPod. The divide in the class between the technological savvy student teacher with the not so savvy peer and lecturer meant that collaborative learning was a key part of all lectures using the sensors. This divide was replicated in the classrooms where student teachers used the sensors with second level students.

It became apparent that this project only scratched the surface of the potential in using sensors in science and maths teaching and learning, therefore, the use will be further embedded in the BSc Science and Maths education over the coming year. A partnership has been developed to work with Discover Sensors which will develop over the next year. The sharing of developed resources between student teachers and teachers across Ireland is central to this initiative with Discover Sensors (see www.discoversensors for more information). This partnership with DSE and schools is a key outcome from this project.

IMPACT OF THE PROJECT

Students developed skills in the collection and interpretation of data using sensor technology with a view to using this technology in their teaching practice. It added to their teaching skills and helped them to link theory of learning with content knowledge using technology. They developed skills in working with others and critically evaluating their practice. They developed skills in giving and receiving constructive feedback.

The use of sensor technology in science teaching and learning has the potential to be transformative in the process of teaching when used with theory of teaching. When student teachers are given time to explore the use of technology it enhances their engagement and leads to fruitful learning for all involved.

The use of design teams to plan for teaching using technology has great potential and will be continued. If technology is to have a transformative effect on teaching and learning it needs to be used in context, with content knowledge and pedagogical knowledge, using the framework of TPCK.

The sensors have application in other subject disciplines such as Maths and Geography and co-curricular work between Professional Diploma in Education (PDE) students and the BSc Ed students will be explored.

POTENTIAL FUTURE DEVELOPMENTS

This project is on-going and phase one was mainly about developing the framework for TPCK. This year the use of sensor technology will be embedded to a greater extent into all aspects of the teaching, learning and assessment of the BSc Science and Maths Education. The learning technology by design approach will be implemented and evaluated (Mishra & Koehler, 2006). Using this approach learners have to actively engage in practices of inquiry, research, and design in collaborative groups to design lessons using sensor technology. The software company supporting the sensors has now developed an application for the iPad, iPod and iPhone which opens up further teaching and learning opportunities. The need to evaluate the impact of this on both student teachers' learning and on their pupils' learning will be evaluated in the coming year.

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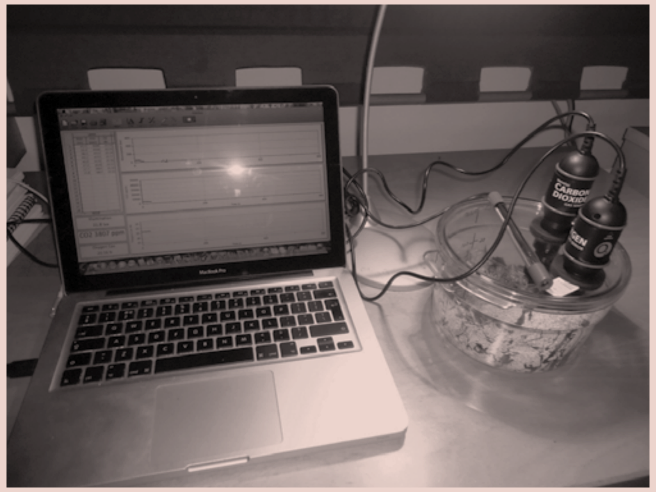
APPENDIX: IMAGES FROM THE PROJECT

CARBON DIOXIDE, OXYGEN AND LIGHT SENSORS

COLLECTING DATA



DEPARTMENT OF ENGLISH

Mandatory Peer Tutoring in the English Department

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This project extended an up-and-running peer tutoring programme by requiring that first year students identified as struggling by their writing instructors attend at least one peer tutoring session. Up until this year, limited funding has meant that tutoring was offered for a restricted number of hours, and that those who attended did so voluntarily. This project rolled out peer tutoring to those who most needed it, at a crucial time in their academic and intellectual development: during students' first year.

During the first term, if a student seemed to be struggling after several weeks of continuous assessment, that student's writing instructor required that they make an appointment (through me) to attend a half-hour session with a trained peer tutor; the tutor reviewed the essay with the student and encouraged him / her to attend again during the process of writing the next essay.

At the start of the second term, I contacted any first year student who had received a mark of 50 or below to make an appointment to see a peer tutor. Over the course of the year we thus saw 64 first-year students for at least one appointment (one fifth of the first year class).

Since the peer tutoring programme's inception in 2009, it was clear to me that the students who were attending – and attending repeatedly – were students who were already performing fairly well. We saw a high proportion of mature students, and also a number of honours English students, and relatively few students whose work sat on the borderline. With increased advertising and word getting around about the centre over time, footfall increased, but still not in the student base that needed the help most. I felt that if we could target students whose writing was leading to failure or very low marks, we could achieve better results by intervening at a time when students were also the most likely to drop out: during first year.

In addition, because the English department has such high numbers in first year, it seemed important to offer some form of one-to-one contact for students who might be intimidated by the thought of contacting lecturers themselves for help. The peer tutoring centre thus offered a way of helping to solve a problem that was partly numbers based, but also reflected anxieties that students have in transitioning between school and university.

REVIEW OF RELEVANT LITERATURE

There is a lot of data on the impact of peer tutoring, but little that I came across dealt with impact on this particular discipline. Data is also largely from North American and mostly from American-based studies, as peer tutoring is most common in the United States, where it is used in school systems as well as at university level. Research on the impact of peer tutoring on younger students is mixed, and does not suggest a necessary impact on study habits or on final marks. At university level, however, there is a good deal of evidence to suggest that peer tutoring programmes have a very positive impact on tutors themselves – influencing not only their cognitive capacity (see Annis 1983, for instance) but also their own results in the subject. The most recent review of peer tutoring in general, which covered all major previous reviews and new research, is Topping 1996, which this Fellowship considered in setting up the current programme, and in its planning of the year's project.

Tutoring has, in study after study, been shown to have a positive impact on students who participate and attend sessions. Seeing and hearing a tutor 'model' the problem-solving involved in re-writing / editing or brainstorm to create ideas for an essay can prove extremely effective as a demonstration of 'what to do' (see Moust and Schmidt 1994a). Moust and Schmidt found that 'students felt peer tutors were better than staff tutors at understanding their problems, were more interested in their lives and personalities, and were less authoritarian, yet more focused on assessment. Economic advantages might include the possibility of teaching more students more effectively, freeing staff time for other purposes. Politically, peer tutoring delegates the management of learning to the learners in a democratic way, seeks to empower students rather than de-skill them by dependency on imitation of a master culture, and might reduce student dissatisfaction and unrest' (in Topping 1996, 325).

There are, however, potential problems with peer tutoring. As Topping notes, 'The quality of tutoring from a peer tutor may be a good deal inferior to that from a professional teacher (although this should not be assumed), and the need for monitoring and quality control cannot be overstated. This also significantly consumes time and resources. Likewise, the tutor's mastery of the content of tutoring is likely to be less than that of a professional teacher, so curriculum content coverage in peer tutoring maybe much more variable' (Topping 326).

Knowing this kind of information ahead of time, the project aimed to provide as thorough a tutor training session as was possible. The one-day training event was revised considerably from the previous year in order to include best-practice recommendations (such as modes of tutoring; suggestions for planning a session; how to provide feedback and so on), and also to maximize the impact on the tutors themselves and their own work/ approach to writing. Every effort was made, as well, to avoid the types of problems noted by Topping: tutors were consistently reminded that they were not tutoring subject material and only writing concerns, were supplied with prepared handouts on any manner of writing difficulties both to refer to and provide to attendees, and we arranged monthly meetings as a group so that tutors could share their experience, express concerns and so on. Because the peer tutoring room is literally three doors from my office, I stopped by whenever I had a moment and the tutors were free, so that there was also a great deal of informal monitoring and opportunity for exchange. While it is true that the centre requires a good bit of monitoring, that monitoring was not tedious in that the tutors themselves are such an outstanding and also simply likeable bunch of students.

Topping's review of peer tutoring writing programmes concludes that 'In summary, of nine studies on peer assisted writing, five give only subjective feedback, but this is generally very positive. Four studies give data on gains in writing competence and of these, two good quality studies show tutee gains, one shows no statistically significant difference and a third shows some tutee gains of equivocal status. Other improvements included raised deadline attainment rates, reduced failure rates, and self report of improved writing the tutors' (Topping 337). Based on these prospects, I had realistic aims: to reduce failure rates by actively intervening both prior to the first term's marks being given and after the first term results; to create an atmosphere in which first-year students felt welcomed and able to express their worries and difficulties in adjusting to university-level writing; to offer the tutors, as a select group of students, the opportunity to participate in the life of the English Department.

KEY OUTCOMES

This project could be deemed a success even based solely on the number of students who came through the doors of the peer tutoring centre during the year: the peer tutors between them saw 64 first years (out of a class of approximately 330 – or about one fifth of the class). This in itself is a great achievement: to have that many first years receive a one-on-one session means that one fifth of the class received individual help with their writing for a minimum of a half an hour. And, as has been the case in the past, we found that students who attended tended to come back for more help: out of 45 visitors in the first term, a minimum of 6 returned (the tutors were so busy at times that they were unable to note attendees names in the books, so some of the data is uncertain). Out of 48 in the second term, a minimum of 2 returned, and a minimum of 4 who had attended in first term returned.

The second success of the project is evident when we consider that these 64 students are not random students, but those whose work was at the bottom of the marking scale, coming in at 50 and under. This means that it was, crucially, the struggling students who received one-on-one attention. While the intervention of the peer tutoring sessions are difficult to gauge numerically – we don't know whether it was the impact of the session(s) itself on their final marks, or whether these students simply upped their game more generally in the second term – but students' responses to the sessions were overwhelmingly positive. They clearly felt cared for by the department, and also found the sessions useful for their writing, and these things are significant.

Another outcome of the project is the attention that it brought in general terms to the peer tutoring centre: it is now very much a known entity within the department, and a place to which students gravitate for even quick advice sessions on proofreading or essay submissions. The department itself noted that the room in which the peer tutors were based became a hub during term-time, particularly during weeks when essays were due; the tutors were often so busy that they did not record detail about a session other than to note that there were 'more visitors than we could keep track of'. This bodes well for the continuation of the centre next year and for footfall. A quarter of visitors to the centre were second- and third-year students.

A final – and rather unexpected – outcome of the project has been the benefit to the tutors themselves, who have become an active and vocal constituency within the Department, one that has provided the Department with many of its MA applicants. They report that their own writing has immensely benefited from the process of tutoring, and their involvement with the Department has clearly led them to consider further teaching or academic careers.

IMPACT OF THE PROJECT

This project impacted on two student groups' learning: the attendees and the tutors themselves. Attendees of the peer tutoring centre repeatedly remarked on the usefulness of the centre, and how helpful it was to receive individual guidance on writing for university essays. Many reported learning about essay structuring for the first time in the peer tutoring centre, and also reported realizations about the need to draft material, plan ahead, and schedule their time appropriately. In that sense the project created an atmosphere in which students learned what it would take to acquire knowledge at university level.

Studies have found that 'Students who had tutoring in writing from faculty and peers were compared by Oley (1992) with those who had tutoring from peers only or faculty only. Many of them had been identified as weak writers, and some received participants help voluntarily and some on a compulsory basis. Assignation to conditions was random. Those who received attained peer tutoring subsequently higher grades than those who did not' (Topping 1996, 337). While impact on our own students marks are difficult to gauge, none of the students who attended peer tutoring failed the year; many who attended in first term did considerably better in the second term (between 5-10 points on average). Those who attended in second term only also fared considerably better (again between 5-10 points on average). We are now considering rolling the programme out to all first years.

The project also had an enormous impact on the tutors, as noted above. All of the tutors have reported a high level of satisfaction with their work over the past year, and all have reported an increased awareness of their own writing abilities and weaknesses. As this group has turned into a cohort who tend across the board to apply to MA programmes in the university and more specifically in the English programme, their own awareness and improvement of critical skills is a boon to them as well.

PROJECT LEARNING POINTS

One concern I had from the outset was that students identified by their seminar leaders as in need of writing help would feel that the peer tutoring centre offered a remedial service; I worried that making attendance a requirement would make students feel as if they were being targeted or feel under-par in some way. In fact, feedback from the attendees suggests the opposite: they actually felt cared for. I also learned that requiring attendance, as opposed to recommending it, made a massive difference in footfall.

LEARNING POINTS FOR OTHERS

Peer tutoring offers departments the opportunity to foster a genuine sense of community and exchange not merely between faculty and students, but among students. One of the main – and largely unanticipated – benefits of the peer tutoring centre to the department has been the sense of engagement that the tutors feel with the life of the department, and the resulting sense of community that they create by being simply present in the peer tutoring room and visible to the student population (with the glass walls of Iontas building rooms certainly helping out!).

POTENTIAL FUTURE DEVELOPMENTS

North American university systems often require that first year students attend one session of peer tutoring regardless of their apparent abilities; this ensures that at least once in the first year, a first year is paired with an older student who has been there and done that, an experience that serves not only to offer help with any writing difficulties, but also an informal mentoring service that offers reassurance and insider information on how to survive. Were funding available, NUI Maynooth might consider this possibility, particularly in arts subjects where much writing is required or when class sizes can otherwise prohibit individual attention on that scale.

At a departmental level, it would be fruitful, I feel, to require students identified as struggling to attend a minimum of two sessions; this way, we would be able to see more directly the impact that the sessions were having by viewing a follow-up writing assignment.

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APPENDIX – FEEDBACK FROM ATTENDEES

Below is a compilation of anonymous feedback from attendees.

'I think the peer tutoring is an excellent support service and especially valuable to mature students. I've had three sessions with the service. The tutors are very professional and polite, not to mention knowledgeable! After my first two sessions I've got a much better grasp of referencing. Referencing is so important and I was very worried about it. It was like a mini mountain in front of me for weeks! After the third session I got an insight into building or constructing an essay and I'm sure this will be a big help to me for future essays. We first years had our first big essay due last Friday. I know from speaking with some matures who attended the service that they resolved issues and most importantly were reassured by the peer tutors. This is so important to help our confidence and consequently drive our motivation! I noticed last Thursday that Stuart (Stewart!) was very busy because he was alone for one hour and there was a big demand on his time. This is because the 2,000 word essay was due the following day. He did really well under pressure. The support service for English is excellent and I for one, am very grateful for it.'

'I haven't got any negative feedback for you. The peer tutoring session was excellent. Even for the 20 minutes I was there, they helped solve so many problems. I know I will return to them because they are so easy to sit and talk to and they seem to understand it all. All my friends in the subject have said the same thing. Really really helpful. The only thing I can think of is maybe it should be advertised more because I knew nothing about it until you wrote to me. Thanks very much for notifying me in the first place. It has really helped.'

‘I found the service a great help. The peer read my essay plan and made suggestions in relation to the few scattered notes of the tutor. He made things clearer to me which gave me back the confidence I had lost. He also showed me how to outline an essay plan a lot more carefully which can be used across all subjects. It was a pleasure to have worked with him. Great guy with tons of patience for first years like us. Feel free to pass on my thanks to him. Oona, I was going to email you regardless to say the above as I thought it necessary to show my appreciation for the service and his time. ’

‘I found the peer tutoring service very useful. When I went, there were two tutors available and both of them went through my work with me which was very helpful as I had two different opinions by the end of the session. The tutors asked me what aspects of essay writing I struggled with, this is what I found the most helpful with the service as during the session we then concentrated on writing conclusions as this was my main weakness that I wanted to focus on. I have been back to the writing centre twice since then as I was stuck for ideas on essays I had due. On both occasions the tutors bounced ideas around seeing if I would be able to write about them and if they would help me answer the question I was being asked. I think its an excellent facility for students and I also think an hour session with the peer tutor service should become compulsory for English students. ’

‘I would be glad to provide feedback. My admittedly short visit to the peer tutoring centre was quite beneficial. In just a few short minutes, the tutor identified the key issues in the structure of my assignment and my overuse of the first person and personal response. He provided alternate ways to convey ideas in an academic fashion. He empathized with my difficulty in progressing from secondary-level English to third-level and was keen to offer further assistance. On my next two assignments I received Bs, a significant improvement. I will no doubt be returning to the peer tutoring centre after I receive my grade for the 2000 word essay if I feel I need further assistance, which I no doubt will. Many thanks for running this service and continually making the students aware of it- I fully intend to avail of it again.’

DEPARTMENTS OF GEOGRAPHY AND COMPUTER SCIENCE

A Virtual Portfolio Application

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The idea for this project was for students to create a virtual portfolio of images and text relating to GY333 Global Foodscapes. The system we developed allows users to interact with the site using laptops or mobile devices and provides an intuitive front-end, which the user can easily navigate, and a backend of the system for administrators.

The system allows students to bring a practical aspect to the module. It allows them to obtain content that they find relevant to the module and present it as a virtual portfolio. Students can interact by sharing ideas in the site's forum and by voting and commenting on each other's images.

This application was used in GY333 Global Foodscapes module in Semester Two.

There were 83 students enrolled and they were divided into groups of five or six.

They twice repeated three stages of the project.

- **Stage 1 (Mon - Wed): The students took photos of ‘foodscape’ and uploaded the images with 140-character ‘tweets’ to describe the photo's significance**
- **Stage 2 (Thu): Students voted on the other photos and ‘tweets’ in their group**
- **Stage 3 (Fri - Sun): Every group's top two photos and ‘tweets’ were voted on by the whole class with a view to identifying each group's winner, as well as an overall winner for the week.**

At the end of the two weeks, students were given their scores based on participation and whether they had finalists or even winning photos.

Alistair also showed the whole class each group's winning photo and ‘tweet’ from both weeks and used these results to form a wider discussion of the project's content.

As a final step, students were asked to complete an online survey to gauge their reaction to the project and determine what steps could be taken to improve everything.

CONTEXT

Alistair identified a possible use for a web-based system within his Global Foodscapes Module that would allow students to engage more with the content and ideas in the module. He felt that an online system that allowed the students to upload and monitor their photographs and those of others would add extra value to the module. He then made contact with the Centre for Teaching & Learning and Lisa O'Regan there put him in touch with Aidan in Computer Science. Following initial discussions, an application for the Fellowship was submitted and then in the summer of 2011 the bulk of the work was completed by two CS graduates under guidance of Aidan and to a lesser extent Alistair.

KEY OUTCOMES

The main outcome of the project was a web based system which could be used by students in the Global Foodscapes module to upload and save images relating to the module. The system modified the web space for the students on the module depending on the phase of the week. The system is comprised of a front end which the students interact with and a back end which allowed the administrators to interact with the system.

The back end of the system allowed the administrators to modify and tailor the site to the requirements at certain times of the week. Initially the administrators were responsible for inputting all of the users of the system and also determining what group each student would be in. The administrator could determine which pages of the site would be visible at certain times of the week. The administrators could also view all of the images uploaded on the system and monitor the descriptions uploaded for them.

The system also has a forum area where students can post any issues or questions relating to the system. The forums are monitored by the administrators and can respond to any issues posted in the forum.

The images uploaded by students had a brief description associated with them. The idea of this 140 character “tweet” was that the student would have really think about what they were describing, which would force them to put a relevant and refined description.

The images of a group were all visible to the students in that group allowing them to rate their groups' images. This rating system was integrated into the system and administrators could analyse the results of these ratings. Subsequently all the students in the module would rate the top photos from each group. A slideshow was constructed to allow the students to view these but a glitch in the system (in the first week) forced us to abandon the slideshow and use a similar technique to the group rating section.

IMPACT OF THE PROJECT

Alistair surveyed the students using the Bristol Online Surveys software. Some of the standout results are as follows:

- 51 of the 83 students completed the survey. Impressively, 100% said they enjoyed the project.
- 56.9% and 35.3% respectively 'strongly agreed' and 'agreed' that they learned a lot about the 'foodscapes' by completing the project.
- 88.2% said it had 'just enough' of a group component; 11.8% said it had 'too little'.
- Among some of the 'other' responses, students said:
  - *'Found the project very enjoyable, and made us get to grips with "foodscapes" in a more practical way';*
  - *'Definitely the most enjoyable group project, or even individual project I have taken part in since starting in NUIM';*
  - *'I liked the project. It's unique. It's creative. [...] it was the most enjoyable assignment I've had to do!'*
  - *'I would just like to say this was the most interesting and most fun assignment I have done in my college experience.'*

Alistair found that doing the project gave students a real boost and forced them to go outside and look for indications of what he was teaching. It was a fieldwork-friendly project that used the technologies Aidan understood to create a peer-reviewing, peer-assessment and fun way of interacting. The students enjoyed it, as the comments above indicate; but they also learned by seeing what each other was identifying and then thinking about the comments others in the class were making in the tweets and in the comments section.

We found that working across two disciplines allowed us to learn a lot from each other. Working across disciplines identified talents within the university that otherwise would not have crossed paths. This Fellowship has also created links between our departments which will be built up over the years with numerous more collaborations. We strongly believe there is significant additional scope to build relations between Computer Science and Geography with a view to developing these sorts of 'apps' and software environments.

We also believe that the software system we created can be adapted for other modules within numerous departments in the university. We have already discussed modifiying the system for *Roinn na Nua Ghaeilge* for one of their modules. We also feel that this module can be adapted to a Biology module where students go on field trips and record species of plant and animals encountered. Finally, we have applied for an additional Fellowship with a view to rolling out the software in a large-group methods module in Geography.

POTENTIAL FUTURE DEVELOPMENTS

There are a few features to the system which we would like to improve upon. We would like to automate the site so that it automatically adjusts the content of the site depending on the phase of the week.

Another feature that we would like to improve on is the slideshow feature for the final ratings phase. The slideshow developed did not work when the system went live so we would like to look at the reasons for this and look at ways to improve it.

Peer Mentoring for At-Risk Students

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A pilot peer mentoring scheme ran during the 2011-12 academic year which targeted forty one first year Science students who were deemed to have the weakest mathematical background of their cohort. We will discuss the background to this project, in particular why we chose a peer-mentoring scheme, how we selected both the mentees and mentors, and how the mentoring operated. We will look at the effectiveness of the scheme by analysing its impact on students' levels and quality of engagement and we discuss the feedback received from both the mentors and mentees. Finally we will look at the lessons learned from the outcomes of this pilot scheme and how they are guiding us in our considerations for a permanent and more inclusive mentoring scheme.

INTRODUCTION

In the Department of Mathematics and Statistics we have many supports available for all our undergraduate students. There are weekly assignments which are graded and returned to students in small group tutorials. A very successful Mathematics Support Centre (MSC) was set up in 2007. There are additional supports which are aimed specifically at 1st years, including weekly workshops and an online mathematics proficiency course (MPC). All incoming first year service mathematics students take a diagnostic test and those who get below a certain grade are automatically enrolled in the MPC. These specific extra supports for first years aim to revise basic material covered during second-level education, and discuss how this material relates to first year coursework. Students are reminded repeatedly of the many supports available, e.g. during lectures and during tutorials, and they receive weekly emails with updates from the MSC.

We categorize students as at-risk if they received a grade of B1 or lower in the ordinary level (OL) Leaving Certificate (LC) Mathematics exam, or if they fail the diagnostic test. Previous research in NUIM and elsewhere (Patel and Little 2006, Mac an Bhaird, Morgan and O'Shea 2009) has shown that students who regularly avail of the supports on offer can do better in their exams. This is especially true for students who are at-risk. However, these studies also show that a minority of at-risk students do not avail of the supports available. We commenced a separate study in 2009 to determine the reasons why students do or do not engage with mathematics. The second author offered a mentoring scheme to some of the students involved in this study during the 2009-10 academic year (Mac an Bhaird, 2012). As a result of comments from students during the research project (Grehan, Mac an Bhaird and O'Shea, 2011, 2011b, 2011c), and the outcomes of the mentoring scheme, we determined to introduce a pilot peer mentoring scheme for at-risk students.

The second and third author were awarded a Teaching and Learning Fellowship to introduce a pilot peer mentoring scheme for the academic year 2011-2012, the first author was selected as project co-ordinator. The scheme attempted to target the incoming first yTear service mathematics students who we deemed were most at-risk of failing their mathematics examinations.

We decided on the scheme structure after considering the wide range of mathematical supports already available to students, along with discussions with other departments within NUIM who run mentoring schemes and considering some literature in the area (Bidgood 2004, Kane and Sinka 2009).

We will detail how the programme was set up and how it proceeded during the academic year. We will also discuss the impact of this scheme in terms of engagement, results and evaluation of both mentees and mentors. Finally we will discuss the main lessons we have learned from this pilot scheme.

METHODOLOGY (THE MENTORING PROCESS)

In this section we will explain how we selected the mentees and mentors, how the mentors were trained and how the scheme was implemented.

SELECTION OF MENTEES
Prior to the commencement of the 2011-12 academic year, 41 students who were due to study Science at NUIM and who had received a C1 or lower in their LC Mathematics OL exam were contacted by the second author and asked to participate in this project. Of these 41 students, 3 did not enrol in NUIM, the other 38 students agreed to participate in the scheme and 4 of these deregistered during semester 1.

SELECTION OF MENTORS
In August 2011, the second author contacted 24 undergraduate Science students, 14 were due to enter 2nd year and 10 were due to enter 3rd year. Some of these students had not continued with the study of mathematics after 1st year. All of the students were chosen based on their LC mathematics grades, their 1st year mathematics grades and their engagement levels with the supports available. All 24 students had achieved a grade of B1 or less in their OL LC exam and thus had been classed as at-risk students upon entry to NUIM. However, all 24 students had passed their 1st year mathematics exams. This was crucial as we wanted the mentees to feel that their mentors had been in the same position as them a year or two previously. Of the 2nd and 3rd year students who were contacted, 15 replied and agreed to ultimately participate in the scheme as mentors. One student was subsequently unable to participate in the scheme. The remaining group of 14 mentors were made up of 8 2nd years and 6 3rd years. There were 8 females and 6 males in the group.

TRAINING
All of the mentors attended a training session with the authors. During this session we discussed the scheme, detailed how it would work and went over basic rules. These were put in place for the benefit of both the mentors and mentees. They included rules such as: mentors were not to help mentees with mathematics; personal relationships were not permitted; if the mentors were unsure of anything they were asked to immediately contact the first author.

The mentees were given similar details regarding the implementation of the scheme and the same rules were outlined. We had a joint meeting in the MSC at the beginning of semester one, after the mentors' training session, when the mentees were introduced to their mentors. We explained the rationale for this scheme to both groups, and we also made them aware that all contact between them must be at reasonable hours of the day.

When initially contacting potential mentors, we asked them to provide one piece of important advice for incoming first years. The second author collated and edited these responses, which were distributed to both the mentors and mentees as an advice sheet. A list of supports and online resources were also made available to both groups.

HOW THE MENTORING WORKED
The mentees were split into 7 groups with 5 or 6 students in each group. Each group had 2 mentors assigned to it. The third author attempted to keep a good male/female balance when selecting members for each group, to have a 2nd and 3rd year mentor paired together, and to have a mixture of abilities among the mentees in each group.

We asked that mentors meet with their mentees weekly until the mid-term, and subsequently once every two weeks. They were to decide among themselves where and when to meet but we recommended the MSC as a location. At the end of every week (or after having contact with students) the mentors were asked to fill in an electronic form with details on each student, then email it to the first author who coordinated the day to day running of the scheme. This form included information on which students had attended the meetings, what issues were discussed, and what advice the mentors gave. After mid-term, during the weeks in which the mentors and mentees were not meeting, they were asked to e-mail each other and check to see if there were any problems. Mentees were encouraged to contact the mentors at any stage.

The first author arranged a short meeting with mentors during semester one to discuss the scheme and iron out any issues. The mentors could also contact the first author at any stage if they felt they were unable to give appropriate advice or if they felt there was a common issue that needed attention. At the end of the academic year all mentors and students were asked to fill in an anonymous questionnaire to evaluate the scheme.

RESULTS

In this section we will consider the engagement of students with the mentoring scheme and its impact on student engagement with available supports.

ENGAGEMENT WITH THE MENTORING SCHEME
In semester 1, 3 groups arranged 6 meetings, 2 groups arranged 5 meetings and 2 groups arranged 4 meetings. Of the mentees who completed the year, 9 (26.5%) attended no meetings, 11 (32.4%) attended 1 meeting, 7 (20.6%) attended 2 meetings and 7 (20.6%) attended 3 meetings.

The mentors reported that some students had difficulty attending meetings due to timetabling issues, however there were also some students who failed to respond to e-mails or text messages or just did not show up to a meeting that had been arranged. The first author contacted mentees who were not attending meetings via e-mail to remind them of how beneficial the meetings could be to them. Some mentees did respond to these e-mails and either explained why they had not attended or to say they would try better in future. However there were also students who did not respond at all.

This timetabling issue and the problem with non-responsive students continued, and increased, in the second semester. The second author contacted all the mentees after semester one results were released, to encourage them to continue to engage. However, none of the groups had any official meetings despite the mentors' best attempts.

ENGAGEMENT WITH AVAILABLE SUPPORTS
In an effort to measure if the mentoring scheme had any impact on students' engagement levels with the supports available at NUIM, we compared the group of mentees to a group of 40 students with similar LC results from the 2010-11 academic year. When we compared both sets of students we found that in the mentees in 2011-12 had increased levels of engagement with regards to the means for the number of tutorials attended in semester one and two, the number of assignments submitted in semester one and two, the number of MSC visits, extra workshop attendances and usage of the MPC (which the majority of these students were enrolled for). Only two of these differences were shown to be statistically significant: tutorial attendance for semester one (Independent Samples Mann-Whitney U test, $p=0.012$); and tutorial attendance for the whole year (Independent Samples Mann-Whitney U test, $p=0.031$). However, the 1st Science mathematics class as a whole, showed improved levels of engagement with all of these supports in comparison to the previous years cohort. This improvement could be due to two monitoring schemes that we introduced in 2010-11 to try to improve student engagement with both the tutorial and assignment system, and with the MPC. The schemes have increased student engagement significantly. Complete descriptions of both schemes and the outcomes are available (Burke, Mac an Bhaird and O'Shea, 2012, 2012b).

FEEDBACK FROM MENTEES AND MENTORS

At the end of the academic year we issued an anonymous questionnaire to all mentees and mentors. We decided against using an online questionnaire due to the expected low rate of completion, however despite having the questionnaires available for collection in the MSC, emailing and posting copies out, only 8 were returned by the mentees and 9 by the mentors. However, there are still some interesting comments from both groups.

The majority of positive comments made by the mentees were about the mentors. The mentees appreciated that the mentors came from a similar mathematical background to them and that they treated the mentees in a manner that put them at ease and gave some of them confidence in dealing with mathematics at 3rd level. The negative comments were due to the timetabling issues, other mentees not participating fully with the scheme and some students wanting more help with mathematics rather than advice about how to deal with it themselves.

Comments by the mentors indicated that they had similar thoughts and issues to those of the mentees. The timetabling issue was quite a common comment and the problem of mentees not engaging was also raised again. Some mentors also commented on being able to help the mentees with some mathematics problems they had and they felt this might encourage mentees to engage more with the mentors.

Some quotes from the mentees:

> **"I thought the mentors were the best part of the scheme. It was great to be able to talk to students who have gone through first year and have them share their experiences. It was great to go to them for advice and help."**
>
> **"It helped me be more confident about maths"**

CONCLUSIONS

The aim of this scheme was to try and increase the engagement levels of the most at-risk mathematical students entering NUIM. Levels of engagement with the mentoring scheme were good at the beginning of the scheme. The students who participated in the mentoring scheme attended more tutorials, did more assignments and had more visits to the MSC than their peers from the previous academic year. However it is difficult to credit the mentoring scheme with this improvement as the rest of the class showed similar improvements.

The qualitative data from the questionnaires shows that both the mentors and mentees thought that the scheme was worthwhile. We saw that the busy timetable and lack of free periods was a serious impediment for both mentors and mentees. The fact that the mentors were not supposed to work on mathematics with the students was also raised by both groups, and it is clear that many of the mentors and mentees would have preferred a peer tutoring scheme.

The authors will carefully review the analysis of the scheme, and discuss how best to proceed with any future mentoring projects.

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Members of the Centre for Teaching and Learning team acted as contacts to the Teaching Fellows during 2011-2012, providing support to them throughout their projects.

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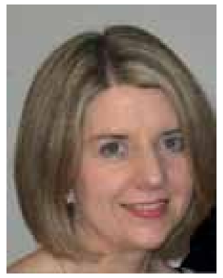

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