

3U NSTEP

National Initiative in STEM
Education & Practice

STRAND 1

Project Reports



3U PARTNERSHIP
GREATER DUBLIN UNIVERSITIES
DCU · MAYNOOTH · RCSI

“Together
we achieve
even more,”

3U PARTNERSHIP

3U



3U PARTNERSHIP is a new force in Irish higher education that combines the complementary strengths of **DCU**, **Maynooth University** and **RCSI**.

3U's vision is to form a deep and sustainable partnership, which will enable its three partner institutions to achieve much more together than could be achieved on their own.

"Together we achieve even more" is not just **3U PARTNERSHIP**'s tag line. It reflects the underlying philosophy of the Partnership – i.e. to engage in collaborative activities that the individual partners could not do alone but that, by combining their strengths, can be done through 3U.

The key objective of **3U PARTNERSHIP** is to support the individual partner institutions to be more sustainable and competitive across all areas of activity, including academic and research activities as well as international programmes.

“ **3U PARTNERSHIP** established 3U NSTEP, the National Initiative in STEM Education and Practice, in order to encourage research into teaching and learning at university level ”



Dr Ruth Davis
Director 3U PARTNERSHIP

It's no surprise that a key priority for each member of **3U PARTNERSHIP** is to deliver exceptionally high quality education to students.

3U PARTNERSHIP established **3U NSTEP**, the National Initiative in STEM Education and Practice, in order to encourage research into teaching and learning at university level.


3U NSTEP has two strands of activity:

- **Strand 1** concerns research into the teaching and learning of STEM subjects at third level.
- **Strand 2** concerns enquiry-based learning in Mathematics and Science Education across the transitions - primary to second level and second level to third level.

Through this publication, I am delighted to be able to highlight the research outputs of eight research projects that examine the teaching and learning of STEM subjects at third level that were funded under the auspices of **3U NSTEP** Strand 1.

The eight research projects examine many different aspects of STEM education ranging from:

i) exploring the need to integrate interdisciplinary communication skills training into the curricula of STEM students and the effect of different cultural backgrounds on the experiences of students studying STEM subjects through



to ii) developing an understanding of what mathematical knowledge is required to carry out the work of teaching mathematics and iii) exploring the role of metacognition in mathematical reasoning and problem-solving and distinguishing between imitative reasoning and creative reasoning in undergraduate calculus. In one particularly timely project, the views and expectations of students regarding a new five year Integrated Pharmacy Programme are examined, while a further project focuses on the development of a smart phone app prototyping a real-time student response system in a distributed classroom.

This wide diversity of projects highlights the complexity and multidisciplinary nature of the issues influencing the effective teaching of STEM subjects at all levels of education. Each of the projects involves collaborations between academics across all of the 3U Partners and all are excellent examples of how **3U PARTNERSHIP** has harnessed the multidisciplinary academic capacity of **DCU**, **Maynooth University** and **RCSI** to focus on this complex issue.

All of the research outputs are interesting and novel, all contribute to the advancement of STEM pedagogy and all aim to improve the educational experiences of STEM students in each of our partner institutions.

On behalf of **3U PARTNERSHIP**, I would like to sincerely thank all of the academics from across the 3U Partners who participated in Strand 1 of **3U NSTEP** and who gave so freely of their time, enthusiasm and energy to make the initiative a major success.

I hope you find this publication both stimulating and useful. And even more, I hope that these **3U NSTEP** research projects encourage further research on this topic, supporting the continuous improvement of STEM educational practices at third level and beyond.



Dr Ruth Davis
Director 3U PARTNERSHIP



Dr Ann O'Shea

**Chair of the 3U NSTEP
Strand 1 Working Group**

The aims of Strand 1 of the **3U NSTEP** initiative were to encourage STEM lecturers across the **3U PARTNERSHIP** to engage in pedagogical research, and to encourage collaboration between the partner institutions and between staff in Education and STEM disciplines. As can be seen from the research reports in this publication both of these aims have been achieved.

As a participant in the project, I can say that there were many benefits in being involved in this initiative. Chief amongst these was the opportunity to collaborate with colleagues in different disciplines and institutions. All of the research groups consisted of members from at least two of the three 3U Partners and most involved staff from a variety of both academic and support departments. Some of the groups had not met prior to the **3U NSTEP** initiative; for example this was the case for the group consisting of a psychologist and a pharmacist from RCSI and a mathematician from Maynooth University who together investigated metacognition, but their collaboration has led to new avenues of research and continues to this date. The various collaborations forged as part of the initiative have also led to successful grant applications and further research and publications.

“ It has enabled new collaborations between staff in different institutions and between staff and students focused on the design of modules and programmes ”

The initiative has also benefited teaching in the three institutions. It has enabled new collaborations between staff in different institutions and between staff and students focused on the design of modules and programmes, developed innovative teaching resources to engage students in lectures and new analytical tools to study patterns of engagement. It has also generated information about what we assess and how assessment affects different cultural groups.

The **3U NSTEP** Strand 1 Working Group organised two conferences and these allowed researchers to interact with staff in different subject areas and to share their findings. We saw that our disciplines may differ but we have many objectives and challenges in common.

On behalf of all of the researchers involved in this initiative, I would like to thank the **3U PARTNERSHIP** for its vision and support. I would also like to thank my colleagues and co-chairs Dr Judith Strawbridge of **RCSI** and Dr Brien Nolan of **DCU** for all of their work. I hope that **3U NSTEP** will continue to foster co-operation and cross-disciplinary pedagogical research at university level in Ireland.

Ann O'Shea

Dr Ann O'Shea
Chair of the **3U NSTEP** Strand 1 Working Group

3U EDUCATION

The study of education itself is an area where working together can offer a new lens to explore the practice of education, to deliver new insights and innovations, and to develop powerful impacts of national importance.

Together with their affiliated colleges, 3U Partners, DCU, Maynooth University and RCSI, have combined expertise at all levels of education, from early childhood to third-level. Combining such expertise in a smart and complementary way will offer new insights into how we learn and new solutions to the challenges facing modern education.

3U NSTEP NATIONAL INITIATIVE IN STEM EDUCATION AND PRACTICE

A major challenge right now is to increase interest in, and the effectiveness of, education in science, technology, engineering and mathematics (STEM) disciplines.

3U PARTNERSHIP established 3U NSTEP (National Initiative in STEM Education and Practice) to advance teaching and learning in the area of STEM Education.

3U NSTEP has two strands of research:

- **Strand 1 concerns research into the teaching and learning of STEM subjects at third level.**
- **Strand 2 concerns enquiry-based learning in Mathematics and Science Education across the transitions - primary to second level, second level to third level.**

This publication focuses on the outputs of eight research projects funded under Strand 1 of the 3U NSTEP initiative.

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PROJECT

1

Assessment and Culturally Diverse Students: Learning from Students' Narratives to Improve STEM Practice

PROJECT LEADERS

Dr Eloise Tan

National Forum for the Enhancement of Teaching and Learning (formerly DCU)

Dr Aneta Hayes

RCSI, Royal College of Surgeons in Ireland, Bahrain Campus

3U PARTNERSHIP FUNDING

€6,740

ABSTRACT

Globalisation, internationalisation and transnationalisation of higher education require the 21st century teacher to ensure equal opportunities for learning for students from all cultural and linguistic backgrounds. As part of the 3U PARTNERSHIP funded project, the focus of this study was to explore students' experiences with assessment in higher education. One of the important emerging themes in this project highlighted the significance of factors that can ensure equal opportunities for learning for students from different cultures and of varying foreign language proficiency. Narrative inquiry was chosen as the research approach and method of analysis because it privileges the stories and experiences of research participants and tries to understand the personal practical knowledge of learners. Thirty semi-structured interviews were conducted with students in STEM subjects at two international universities as part of the pilot stage of the on-going research. The preliminary findings from the pilot stage suggest that institutional culture of a higher education institution plays a major role in ensuring equality for learning. Despite making indirect links to their societal and previous educational culture, the participants indicated that knowing the codes of a higher education institution is a far more important factor. The data also suggested that students are individually strategic and proactive about their cultural and linguistic backgrounds. It seems that students in the 21st century exercise a great level of control over academic challenges connected with their educational background and language proficiency. At the same time, it is obvious that exercising any level of control over the institutional culture might be very difficult. Therefore, the 21st century teachers should take responsibility for ensuring equal learning opportunities for international students through responding to codes identified in our study within the context of their own institutions.

“The project’s aim is to uncover how the linguistic and cultural backgrounds of international students may affect the assessment process”

PROJECT AIM

This is a qualitative research project that seeks to gather the experiences of culturally and linguistically diverse students being assessed in STEM subjects. The research was conducted across two research sites: RCSI Bahrain and DCU with 30 student participants. Student participants were recruited from undergraduates from Medical Education (RCSI Bahrain) and from Engineering, Computing, Maths, Biotechnology, Biology and Chemical Sciences (DCU). The findings will be useful to enhance STEM practitioners’ knowledge of how this student population experiences assessment and to enhance practitioners’ cultural competence – a key skill for third level educators.

The project’s aim is to uncover how the linguistic and cultural backgrounds of international students may affect the assessment process. We (lecturers, institutions, Teaching and Learning Centres) need to know more about how to teach STEM subjects to international students in a way that sets them up for success within the constraints of our current resources. The following research questions guided our work:

- 1. How do the linguistic and cultural backgrounds of students mediate their engagement with the assessment process in STEM subjects?**
- 2. What are the expectations and perceptions of assessment in STEM subjects of students from different linguistic and cultural backgrounds?**

METHODS

Narrative inquiry was chosen as the research approach and method of analysis because it privileges the stories and experiences of research participants and tries to understand the “personal practical knowledge” of participants (Clandinin & Connelly, 2000). Narrative inquiry is a qualitative research method that uses data, usually from interviews, to gather stories about participants’ experiences. Inductive position to coding the data will be adopted because of the exploratory nature of the study and interest in participants’ views and experiences. NVivo will be used to store the data and to facilitate analysis.

It is important to note that a strictly thematic analysis approach would reveal different findings than a narrative inquiry approach. Participants’ individual answers often were misaligned to the larger narrative running through their interview. For example, a participant might share that they do not feel their Pakistani culture has any influence on how they engage with academics, then, go on to tell stories of how the pressure from their family to become a doctor/engineer is so strong because that is the way in their culture. Using a traditional thematic analysis approach the participant’s answer that ‘No, my Pakistani culture has no influence on my academic engagements’ would be coded as ‘No cultural impact’. However the holistic approach inherent in narrative inquiry asks the researchers to consider the participant’s narrative as a whole - we look not solely at individual answers to questions, but the narratives participants relate throughout the interview. The example given above was common throughout analysis.

PARTICIPANTS

Thirty semi-structured interviews were conducted with participants with fifteen interviews at DCU and fifteen at RCSI Bahrain. We chose thirty because this allowed us to target undergraduates from different programmes and it was also feasible in the allocated time of this research grant. Given that we took a phenomenological approach of narrative inquiry, we understand that even a small amount of interviews can provide rich data on participants’ experiences (Baker and Edwards, 2012). The participants were recruited firstly through online recruitment from the International Student Offices at both institutions. Gender parity was targeted given the lack of studies on male international students.

PROJECT FINDINGS

The following are findings to date from interviews analysed:

Identity and Agency

- Students abandon 'their old ways' in order to adapt, because they recognise that it is not meaningful for their own reasons (professional, personal)

Language has not been an issue for the participants

- Language minority students strategically combine their language proficiency with other resources (e.g. science background knowledge), despite the desired linguistic threshold
- This language strategy may only be possible due to the academic nature of STEM programs

Participants are pro-active in adapting to new forms of assessment

- Participants can recognise early on that the assessments will be 'different from what they expect'
- Though they might not understand/support the pedagogical reasons behind the assessment they will be strategic and 'get it done'

Diverse contexts and reasons for student mobility

- 'international' can be a misnomer depending on their second level experience, country of residence, family origin
- International students are a widely heterogeneous group

Participants' previous experiences of assessment are challenged in Irish HE

- Value of group work
- Plagiarism
- Includes doctoral students (how to relate to supervisor, publication expectations)

Lecturers are a widely heterogeneous group

- Varying degree of ability to explain the 'why' of academic concepts such as plagiarism or group work
- Varying degree of cultural competence
- Varying degree of interactions with students through effective feedback, clarity of expectations and conceptualisations of learning outcomes

PROJECT FINDINGS CONT.

- Everyday pedagogical practice of a lecturer was seen as a strong factor in students engagement with assessment
- These factors often depend on intrinsic factors to the lecturer (past experiences, decision to engage with PD in these issues)

The Role of Family

- Participants' interactions with their family tended to be the lens through which they 'experienced/lived' their culture
- International students (and their families) may bring expectations of assessment that are often not discussed with lecturers
- What makes a 'good' grade is often misunderstood by international students and their family and can cause great amount of stress and unachievable expectations set by parents not familiar with the Irish grading system.

DISCUSSION

Clear differences are emerging between DCU cohort and RCSI Bahrain cohorts. These differences may be related to institutional pedagogies and student profile (on institutional pedagogies see Gibbs, 2013). Within DCU, assessment is widely varied and students may experience a vast range of assessments, while at RCSI the assessments are institutionally set with the main forms of assessment being similar to those students experienced at second level.

This wide variety of assessment in DCU could explain why participants from DCU expressed more difficulties in adjusting to the assessment processes at DCU.

To date, analysis points to a complex interplay between identity, agency and structure. While we cannot influence identity or agency directly we are beginning to understand how institutional pedagogies play a role in student adaptation and expectations of STEM assessments. We also have evidence that these findings hold true for postgraduates.

As well, analysis points to the necessity not only to build cultural competence but to build lecturers' ability to explain rationale behind academic concepts which represent a departure for the student from their previous experiences. We are now working towards a conceptual model that represents this and places institutional practice in the centre of students' engagement with assessment. This is in keeping with literature on first year experiences. What makes it unique for international students is that families may also need academic concepts to be explained.

PUBLICATIONS/PRESENTATIONS OF RESEARCH FINDINGS

Assessment and Culturally Diverse Students: Learning from Students' Narratives to Improve STEM Practice. Eloise Tan and Aneta Hayes. Presented at 3U NSTEP Conference, 12 December 2013, RCSI, Dublin.

Assessment and Culturally Diverse Students: Learning from Students' Narratives to Improve STEM Practice. Eloise Tan and Aneta Hayes. Presented at 3U NSTEP Conference 11 September 2014, DCU, Dublin.

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PROJECT

2

Building Mathematical Knowledge for Teaching (MKT) for Pre-Service Mathematics Teachers

PROJECT LEADERS

Dr James Lovatt
School of Education Studies, DCU

Dr Brien Nolan
CASTeL, School of Mathematical
Sciences, DCU

Dr Ann O'Shea
Department of Mathematics and
Statistics, Maynooth University

Majella Dempsey
Department of Education,
Maynooth University

Angela Rickard
Department of Education,
Maynooth University

3U PARTNERSHIP FUNDING

€4,838

ABSTRACT

Mathematical Knowledge for Teaching (MKT) refers to the mathematical knowledge required to carry out the work of teaching mathematics. In this report, we discuss the results of a project in which we assessed pre-service mathematics teachers' awareness and level of MKT, and studied how best to build this within a taught programme focusing on MKT and the reflective study of classroom practices.

PROJECT AIM

The question of what knowledge, skills and attitudes teachers must have has been considered on many occasions (see, for example Darling-Hammond, 2006). One consideration that has been the subject of much debate is that of the relative importance of subject knowledge and (put very bluntly) teaching knowledge. Zooming in, there has also been debate over the ways in which teachers must know and understand the subject that they are teaching. A milestone in this debate was set down by Shulman in his presidential address at the 1985 annual meeting of the American Educational Research Association (Shulman, 1986). In this address, Shulman introduced the concept of pedagogical content knowledge (PCK):

“What emerges from this work is that there is a clearly defined notion of MKT that is important for the job of teaching mathematics; that this can be measured and that this can be taught”

PROJECT AIM CONT.

the dimension of subject matter knowledge for teaching (Shulman, 1986, p.9).

That is, PCK refers to the (frequently unique) ways in which a teacher must know and understand a subject in order to be able to carry out the varied tasks of teaching. While this concept was found to be very useful for teacher educators and educational researchers, Ball and colleagues pointed out that its usefulness was tempered by the lack of a precise agreed definition, and by a lack of empirical evidence validating the concept (Ball, Thames & Phelps, 2008). In an effort to rectify this issue, Ball and her colleagues carried out research that focussed on the work of teaching mathematics. This led to the empirically-grounded notion of Mathematical Knowledge for Teaching (MKT):

the mathematical knowledge needed to carry out the work of teaching mathematics (Ball et al, 2008, p. 395).

This work led to a conceptualisation of MKT and its component parts: these are summarised in Figure 1 below (taken from Ball et al, 2008). In associated research, Ball and her colleagues considered such issues as how to determine the level of MKT that teachers possess (Hill et al, 2004) and the influence of MKT on student achievement (Hill et al, 2005).

What emerges from this work is that there is a clearly defined notion of MKT that is important for the job of teaching mathematics; that this can be measured and that this can be taught.

PROJECT AIM CONT.

The aims of our project were set within this framework, and took as the study group pre-service mathematics teachers in DCU and Maynooth University. We sought to:

1. **Assess the awareness and the level of MKT among our students and**
2. **Build on these through teaching that focussed on the reflective study of various aspects of classroom practice.**

The over-arching aim was to undertake a multi-site case study of students' developing thinking in relation to the teaching of mathematics, using the notion of MKT as a lens.

MATHEMATICAL KNOWLEDGE FOR TEACHING

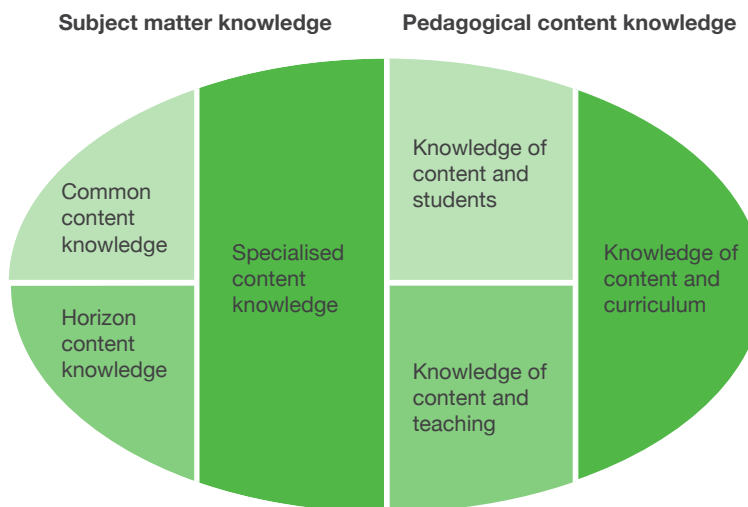


Figure 1: Ball et al's conceptualisation of Mathematical Knowledge for Teaching

METHODS

This project was carried out over the academic year 2013-14, with the teaching taking place in the first semester. The study group comprised two sub-groups, both of whom were second year undergraduate students undertaking a concurrent teacher education degree leading to qualification as a mathematics teacher. One group comprised students in DCU (N = 17), the other students in Maynooth University (N = 13).

To assess the students' (pre-test) awareness of MKT, we presented them with a qualitative survey asking two questions relating to the mathematical work carried out by teachers. The aim was to determine the extent to which

METHODS CONT.

the students were aware of the variety of tasks undertaken by teachers in which their mathematical knowledge must be harnessed. To assess the students' (pre-test) level of MKT, we used test items released by the *Learning Mathematics for Teaching* team of the University of Michigan (Learning Mathematics for Teaching, 2008). These sample items form part of a bank of survey questions designed for "measuring teachers' knowledge for teaching mathematics" (Learning Mathematics for Teaching, 2008, p. 2). Each of the 13 test items used relates to an aspect of MKT outlined in Figure 1. Thus we had the opportunity to test students' level of particular aspects of MKT.

A variety of teaching activities were used across the two universities to build the students' level of MKT. In both, our students read articles and took part in structured discussions (incorporating group activities) on the topic of MKT. They also undertook a study of the mathematics of fractions from an advanced mathematical point of view, with the aim of developing the knowledge and understanding that underpins the teaching of this topic at second level. In DCU, students also undertook video analysis exercises, where the focus was on identifying (opportunities for) the use of MKT in the classroom, and on notions of what comprises high quality teaching of mathematics. In Maynooth University, this activity was replaced by one involving the design of rich tasks using the notion of MKT as a guide, and using a levels of cognitive demand framework. These varied teaching activities were accompanied by assessment tasks that have generated a large amount of qualitative and quantitative data relating to the students' developing perspectives on MKT.

Finally, both groups of students completed the 'awareness' and 'level' surveys for a second time, towards the end of the second semester, as a means of gathering one form of post-test data.

PROJECT FINDINGS

Given the small numbers, the variation in student experiences, the lack of a control group and various other factors, we view the data as an evolving narrative of the students' developing thinking on MKT, rather than as quasi-experimental data relative to pre-test and post-test states. However, within these limitations, we were able to identify one data set amenable to a pre- and post-test interpretation, namely the average scores on the survey of the students' level of MKT. As noted, this test comprised 13 different items, yielding a total of 18 individual questions. These were constructed to have answers that were either correct or incorrect, and so a mark of +1 was awarded to a correct response, and 0 to an incorrect response. A total of $N = 14$ students undertook both the pre- and post-test survey, and we found an increase in the mean mark from 7.3 to 9.6, significant at a level $p = 0.05$ (a related samples Wilcoxon signed rank test was used). This indicated a statistically significant increase at least among this portion of the study group.

PROJECT FINDINGS CONT.

A large and varied amount of data has been generated, a significant proportion of which remains to be analysed. This analysis has been carried out for one other data set, namely that relating to the students' awareness of MKT. Recall that these data were generated by means of a qualitative survey using open-ended questions. Two questions were asked: *What specific knowledge and skills do you think a mathematics teacher needs?;* and *List different teaching situations where a teacher uses his or her knowledge of mathematics.* Our analysis of the responses (which were coded independently by two of the authors) led to the following observations: For the pre-test survey (beginning of Semester One), our pre-service teachers reported that knowing content was paramount. There were few references to knowing about students and their attitudes and skills. Generic actions and attributes were referenced, rather than teaching skills and PCK. For the post-test survey, there were more frequent references to students, to teaching skills and to making mathematics real and relevant. Several of our students adopted the use of the MKT vocabulary. We interpret this as evidence of an overall richer understanding of the mathematical work of teaching mathematics. Two quotes reinforce this, both from the post-test survey:

the teacher needs to be able to do the maths themselves. Not only that, they need to know how to introduce it, link it, sequence it and assess it. Teachers need to be able to use students' answers to perhaps lead them. They need to identify, what questions and ideas are worth exploring. Teachers need to be able pick appropriate questions, to challenge students, using appropriate language. Therefore the teacher must know his/her students and class as well and his/her maths! [Post-test, DCU student number 4].

They need to notice the different types of questioning in order to allow students to become more confident in their ability (repetition, lower order thinking, higher order thinking etc.). They must be aware of the misconceptions that are common and ensure that from day 1 student understand why they are doing certain things in Maths. Relate Maths to the practical world. Present similar problems in different ways to accommodate all types of learners [Post-test, Maynooth University student number 4].

DISCUSSION

We have presented a very brief summary of the results of the surveys used in the project, and have not discussed the data gathered from the assessment elements of the teaching unit. However, we feel that a picture emerges that reflects a growing understanding of mathematical knowledge for teaching among our students. This can be seen in a variety of ways. For example, the structure of some of the test items in the survey of the students' level of MKT generates some insight into the students' thinking. Independent analysis of

DISCUSSION
CONT.

these items brought members of the research team to the same conclusion, that among some of the test items, there is a pattern of migration away from responses that are indicative of a 'teaching for rote-learning' approach, and towards a 'teaching for understanding' approach.

Even if this growth can be established clearly and objectively, it remains an open question as to whether this was engendered by our teaching approach. This is a manifestation of the ever-present fundamental problem of distinguishing correlation and causation in social science. Thus the on-going analysis of the data generated by this project is emphasizing the evolution of our students' thinking in relation to the teaching of mathematics. The MKT framework provides us with a language to discuss this, and provides important points of reference in the broad spectrum of knowledge, skills and attitudes that we seek to engender in our pre-service teachers.





PUBLICATIONS/PRESENTATIONS OF RESEARCH FINDINGS

Building Mathematical Knowledge for Teaching (MKT) for Pre-Service Mathematics Teachers. Brien Nolan, Majella Dempsey, James Lovatt and Ann O'Shea. Presented at 3U NSTEP Conference, 12 December 2013, RCSI, Dublin.

Building Mathematical Knowledge for Teaching (MKT) for Pre-Service Mathematics Teachers. Brien Nolan, Majella Dempsey, James Lovatt and Ann O'Shea. Presented at 3U NSTEP Conference 11 September 2014, DCU, Dublin.

Brien Nolan, Majella Dempsey, James Lovatt and Ann O'Shea Developing Mathematical Knowledge for Teaching (MKT) for pre-service teachers: a study of students' developing thinking in relation to the teaching of mathematics, In Adams. G. (Ed.) Proceedings of the British Society for Research into Learning Mathematics 35(1) February 2015.

Building pre-service teachers' mathematical knowledge for teaching: professional vision and awareness of MKT. Majella Dempsey, James Lovatt, Brien C. Nolan, and Ann O'Shea. (Submitted to an international journal.)

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PROJECT

3

Examining the Relationships between Attendance, Online Engagement and Assessment Outcomes in Undergraduates: an Observational Prospective, Multicentre Study

PROJECT LEADERS

Dr Mark Glynn
Teaching Enhancement Unit, DCU

Morag Monro
Teaching Enhancement Unit, DCU

Evelyn Kelleher
School of Nursing & Human
Sciences, DCU

Dr Jane Holland
Department of Anatomy, RCSI

Eric Clarke
Health Professions Education
Centre, RCSI

3U PARTNERSHIP FUNDING

€3,200

ETHICAL APPROVAL

RCSI Ethics Committee (000848)

ABSTRACT

Non-attendance is known to have a detrimental effect on performance, but traditional manual monitoring of attendance may be problematic. These methods are time-consuming, particularly with increasing student numbers, and recording errors are difficult to entirely eliminate. Automated capturing of online activity may be a more time-efficient manner of identifying struggling students at an early stage, allowing appropriate intervention and supports to be put in place as appropriate. Our study utilised the Reports and Logs function within Moodle to identify on-line indicators of students who are struggling or disengaging from the course during the first semester of the academic year. Ethical approval was granted by RCSI Ethics Committee. There were three main student cohorts included within this study: (1) RCSI Foundation year (2) RCSI Junior Cycle (3) DCU School of Nursing. For the RCSI Junior Cycle students, data from 2 modules were included (NM and AS). A single cohort of 365 students undertook both modules, 30 of whom were repeating. Comparison of medians showed significant reductions in all parameters within the repeat student group. In NM, regression analysis showed

“This research utilised the Reports and Logs function within Moodle to identify on-line indicators of students struggling or disengaging from the course during the first semester of the academic year”

ABSTRACT CONT.

continuous assessment had the largest effect size on summative examinations for both first-time and repeat student groups ($R^2 = 0.545$; $R^2 = 0.289$). Among repeat students, online access of lecture notes had a larger effect size than physical attendance at small group tutorials, while both these indices were less contributory ($R^2 < 0.1$) for first-time students. In AS, continuous assessment showed the largest effect size for first-time students ($R^2 = 0.585$), while online access of lecture notes was most contributory among repeat students ($R^2 = 0.35$). Within the RCSI Junior Cycle cohort, effect sizes are most notable for continuous assessment, but online activity correlates with summative performance and is more predictive for outcomes among repeat students than physical attendance. These indices may be useful to screen at-risk students for individual intervention and support. We will now develop and utilise a “plug-in” for Moodle to enable easier observation of student engagement, following actions such as lecture and activity views.

PROJECT AIM

Non-attendance at lectures and tutorials is recognised as having a detrimental effect on subsequent examination performance in undergraduate students (Cleary-Holdfort, 2007; Massingham and Herrington, 2006). It has been observed that the beneficial effects of attendance are most marked for non-anglophone students (Gatherer and Manning, 1998) and for assessments which require a degree of understanding and conceptualisation of material,

PROJECT AIM CONT.

rather than more straightforward descriptive answers (Sharma et al, 2005). There can be many reasons for non-attendance (Massingham and Herrington, 2006; Gatherer and Manning, 1998; Sharma et al, 2005; Dobkin et al, 2007) - care must be taken to discover the root cause in individuals as a simplistic approach of making attendance mandatory without additional student supports being provided may be ineffectual (Rodgers, 2002).

Monitoring of attendance may be problematic; traditional manual methods are time-consuming, particularly with increasing student numbers, and recording errors are difficult to entirely eliminate (Newman-Ford et al, 2008). Other methods, such as proprietary software or biometrics require a large infrastructural commitment (Newman-Ford et al, 2008; Spalding, 2011; Taxila, 2009). Development and validation of effective monitoring through existing Virtual Learning Environments (VLEs) such as Moodle (Edgar, 2012), which are already employed in third-level institutions, may be a more cost-effective way to address this issue - automated capturing of online activity may be a more time-efficient manner of identifying struggling students at an early stage, allowing specific interventions and supports to be put in place as appropriate.

This research utilised the Reports and Logs function within Moodle to identify on-line indicators of students struggling or disengaging from the course during the first semester of the academic year.

Our aim was then to determine whether these online indices of engagement and, concomitant physical attendance records correlated with subsequent summative examination performance.

METHODS

Ethical approval was granted by RCSI Ethics Committee. Modules were identified for inclusion within this study within RCSI & DCU, from the first year of their respective courses:

- RCSI - JC1-NM (Neuromuscular System), JC1-AS (Alimentary System)
- DCU - NS116 (Safety in Nursing Practice) & NS118 (Core Nursing)

Data collection from each of these modules examined physical attendance, online activity reports (Moodle), continuous assessments and summative examination performance (Table 1). All data were anonymised, and then analysed with IBM® SPSS® Statistics 20.

METHODS

CONT.

Data	RCSI	DCU
Physical attendance	Small group teaching sessions	Small group teaching sessions
Online activity	Lectures viewed within 28 days	Online resources & quizzes
Continuous assessment	2x Mid-semester quizzes 3x anatomy vivas	
Summative performance	Summative examinations	Summative examinations

Table 1. Data Collection

PROJECT FINDINGS

Within RCSI, a single cohort of 365 students undertook both the NM and AS modules, 30 of whom were repeating. Comparison of medians showed significant reductions in all parameters within the repeat student group ($p < 0.005$ for all, Mann-Whitney U; Table 2).

		Physical attendance	Online activity	Continuous assessment	Summative performance
NM	1 st - time	8	25	2.8%	63.0 %
	Repeat	7	17.5	2.2%	53.8 %
AS	1 st - time	12	26	2.8%	66.3 %
	Repeat	8	19	2.2%	54.4 %

Table 2. RCSI, Descriptive Statistics

These data showed a very different pattern of online activity emerging between the repeating students, and those attending the course for the first time (Figures 1 & 2). A very low percentage of repeat students accessed all lecture notes within 28 days.

PROJECT FINDINGS

CONT.

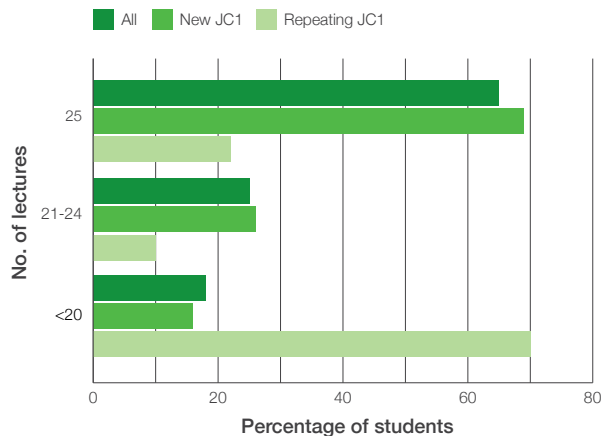


Figure 1. RCSI, NM lecture access by students within 28 days (maximum 25)

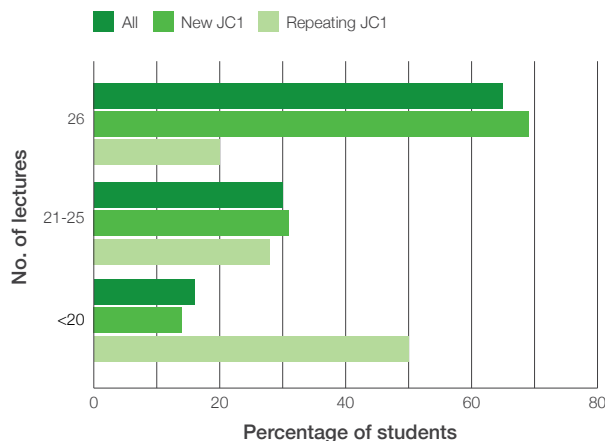


Figure 2. RCSI, AS lecture access by students within 28 days (maximum 26)

Initial diagnostics were then performed, confirming basic assumptions prior to regression analysis; all parameters were significantly correlated with summative performance, and formal tests for tolerance and variance inflation factor (VIF) showed no evidence of multicollinearity (Norman and Streiner, 2000).

In NM, analysis showed that continuous assessment had the largest effect size on summative performance for both first-time and repeat student groups ($R^2 = 0.545$; $R^2 = 0.289$). Among repeat students, online access of lecture had a larger effect size than physical attendance at small group tutorials, while both these indices were less contributory ($R^2 < 0.1$) for first-time students (Table 3).

Within AS, continuous assessment showed the largest effect size for first-time students ($R^2 = 0.585$), while online access of lecture notes was most contributory among repeat students ($R^2 = 0.35$; Table 3).

PROJECT FINDINGS CONT.

		Physical attendance	Online activity	Continuous assessment
NM	1 st - time	$R^2 < 0.1$	$R^2 < 0.1$	$R^2 = 0.545$
	Repeat	$R^2 < 0.1$	$R^2 = 0.16$	$R^2 = 0.289$
AS	1 st - time	$R^2 = 0.11$	$R^2 < 0.1$	$R^2 = 0.585$
	Repeat	$R^2 = 0.23$	$R^2 = 0.35$	$R^2 = 0.289$

Table 3. Predictors of summative examination performance

CONCLUSIONS

Effect sizes are most notable for continuous assessment, but online activity correlates with summative performance and is more predictive for outcomes among repeat students than physical attendance.

We are now in the process of developing a “plug-in” for our virtual learning environment (Moodle) to enable easier observation of student engagement, following actions such as lecture and activity views. We intend to use these indices to as a screening tool to identify at-risk students for individual intervention and support.

Proposed plug-in

The tool we intend to modify is called the “Progress Bar” in Moodle. It visually shows what activities/resources a student is supposed to interact with in a course. It is colour coded so students, and teachers, can quickly see what they have and have not completed/viewed.

https://docs.moodle.org/27/en/Progress_Bar_block

The progress bar can be easily modified / edited by an administrator who can select which activities to include, and by which time they should be viewed. There is an overview page allowing teachers to see the progress of all students in a class, which is helpful for finding students at risk. However, this page currently has no way to download this information as a report (i.e. as .csv or excel), and so the plug-in will be written to provide this feature.



PUBLICATIONS/PRESENTATIONS OF RESEARCH FINDINGS

Holland, J., Clarke, E. and Glynn, M. (2016) Out of sight, out of mind: Do repeating students overlook online course components? *Anatomical Sciences Education*, doi: 10.1002/ase.1613.

Examining the relationships between attendance, online engagement and assessment outcomes in undergraduates; an observational prospective, multicentre study. Jane Holland, Eric Clarke, Morag Monro, Evelyn Kelleher, Mark Glynn. Presented at 3U NSTEP Strand 1 Conference, 12 December 2013, RCSI, Dublin.

Examining the relationships between attendance, online engagement and assessment outcomes in undergraduates; an observational prospective, multicentre study. Jane Holland, Eric Clarke, Morag Monro, Evelyn Kelleher, Mark Glynn. Presented at 3U NSTEP Conference 11 September 2014, DCU.

Examining the relationships between attendance, online engagement and summative examination performance. Jane Holland, Eric Clarke, Morag Monro, Evelyn Kelleher, Mark Glynn Poster Presentation at the Association of Medical Education in Europe Conference, September 2014, Milan.

Examining the relationships between attendance, online engagement and assessment outcomes in undergraduates; an observational prospective, multicentre study. Jane Holland, Eric Clarke, Morag Monro, Evelyn Kelleher, Mark Glynn. Peer-reviewed conference presentation at Irish Network of Medical Educators ASM, University of Limerick, February 2015.

Selectively analysing your course data. Jane Holland, Eric Clarke, Evelyn Kelleher and Mark Glynn. Peer-reviewed conference presentation at MoodleMoot 2015.

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PROJECT

4

An Exploration of Students' Views and Expectations about a New Integrated Pharmacy Programme

PROJECT LEADERS

Dr Mark Philbin, Lecturer
School of Nursing and
Human Studies, DCU

Professor Paul Gallagher
School of Pharmacy, RCSI

Dr Judith Strawbridge
School of Pharmacy, RCSI

3U PARTNERSHIP FUNDING

€4,817

ABSTRACT

Changes in the pharmacist's role have occurred at different rates internationally. The World Health Organisation (WHO) has called for greater involvement for pharmacists in the healthcare system and wider use of their academic background (Wiedenmayer et al, 2006). The new paradigm for pharmacy requires the education and training that will equip pharmacists for new roles in patient care (Department of Health, 2008; Atkinson and Rombaut, 2010). The Pharmacy Education and Accreditation Reviews (PEARs) study was commissioned by the Pharmaceutical Society of Ireland as a comprehensive review of education of pharmacists (Wilson and Langley, 2010). The research, supported by international trends in pharmacy education, led to a recommendation that in Ireland:

"The current 4 +1 model of pharmacy first education should be replaced by a five year fully integrated programme of education, training and assessment as the basis for application for registration as a pharmacist". (Wilson and Langley, 2010)

Positive benefits have been identified when students are consulted and input into their education (DeLander, 2005). Consulting students allows educators to approach the design of new curricula from another perspective enabling alignment with student learning and future practice (Wilson et al, 2006).

“ This study was designed to understand the users’ needs to fully inform the design of the new Integrated Pharmacy Programme ”

AIMS

This study was designed to understand the users’ needs to fully inform the design of the new Integrated Pharmacy Programme and answer the following research questions:

- 1. What are pharmacy students’ expectations of an integrated programme?**
- 2. What do pharmacy students perceive as the merits, value and challenges of studying pharmacy and in particular through an integrated programme?**

METHODS

Qualitative methodology was used to explore students’ opinions on what they would want from an integrated pharmacy degree, along with the perceived advantages and disadvantages. Focus groups were the main method of data collection as they are ideal for investigating unexplored areas (Anderson, 2010; Bhavsar et al, 2007; Powell and Single, 1996). The themes were:

- Choice of pharmacy and valued functioning – exploring student perspectives on what they value about being pharmacists and doing pharmacy. This will provide insight into how a new educational programme could help build capacity for “valued functionings”
- Understanding of an integrated pharmacy programme
- How an integrated pharmacy programme should be taught, and why
- Optional subjects
- Advantages and disadvantages of an integrated programme.

METHODS

CONT.

Nine focus groups were conducted. These were derived from all years of the programmes and captured the views of students with different demographics (see Table 1). Pharmacy students facilitated the focus groups to encourage freedom of expression. They were given training in qualitative research methods and conducted the focus groups as part of their research skills module in the final year of their programme at RCSI. The focus groups were recorded and transcribed verbatim. The data was coded and analysed in accordance with published guidance (Krueger, 1997; Krueger and Casey, 2008; Morgan, 1996).

Focus Group	Number of students	Year of study	College
1	7	3 rd and 4 th	TCD
2	5	1 st , 2 nd , 3 rd and 4 th	TCD
3	14	1 st	UCC
4	8	2 nd	UCC
5	6	3 rd	UCC
6	12	4 th	UCC
7	7	1 st	RCSI
8	6	3 rd	RCSI
9	13	4 th	RCSI
Total	78	All	All

Table 1: Composition of focus groups for exploring views and expectations about a new integrated programme

PROJECT FINDINGS

The study showed that students recognised that the role of the pharmacist is changing. Many reported embarking on a career in pharmacy due to an interest in science and the desire to interact with people and provide patient care. The broad scope of the degree and flexibility of career options appealed to students. Understanding of the new integrated programme was limited, with some students reporting that there was very little information – *“It’s very hard to get information on it because I have actually tried you know...”* Generally there was an appreciation that the experiential learning was distributed through the programme – *“It’s not just a science degree anymore and it’s not tagging on all your experience at the end”*. Students felt that an integrated programme would provide better context for learning and preparedness for practice, illustrated in

PROJECT FINDINGS CONT.

the comment *“you would be much better prepared for when you start working.”* There was an expectation that experiential learning would be provided in all sectors in an equitable and transparent manner.

The advantages of having these placements organised was highlighted in comments such as; *“You could get to do a placement in a hospital... that is something that is really hard to get”* and *“If you are ever in trouble [on placement] you can use your lecturers as a point of assistance”*. Students generally favoured a case based approach to teaching and learning.

There was strong support for optional subjects, with comments such as *“with Medicine there’s a self-selected module. If pharmacy did that, it would be fantastic”* and *“it would kind of differentiate us as well if there were a lot of options.”* Students suggested options ranging from pharmacy specific topics to *“artier”* subjects, languages and business studies. Emerging themes included the strong preference for placements overseas, illustrated in the comment: *“That’s one thing that is lacking in the degree. That’s probably the number one thing I would be campaigning for in an integrated 5 year programme.”* Other emerging themes included the need for inter-professional education and the desire to preserve differences, and therefore choice, between programmes offered nationally. The major disadvantage identified by students involved the fiscal constraints, which were perceived as a potential barrier that might impact on the feasibility and attractiveness of the degree.

CONCLUSION

Exploring student views and expectations is an important aspect of student-centred curriculum design. This study is enabling a student-centred approach to the development of the integrated pharmacy programme nationally.

ACKNOWLEDGEMENTS

Professor Anne-Marie Healy and Dr Astrid Sasse, TCD, Professor Stephen Byrne and Dr Eoin Fleming, UCC, Professor Teresa Pawlikowska and the Health Professions Education Centre team and Dr Fiona O’Brien, RCSI, Ms Lisa Leonard and Ms Jennifer Wilkinson, RCSI, Student participants at TCD, UCC and RCSI.

PUBLICATIONS/PRESENTATIONS OF RESEARCH FINDINGS

An Exploration of Students' Views and Expectations about a New Integrated Pharmacy Programme. Judith Strawbridge, Mark Philbin and Paul Gallagher. Presented at 3U NSTEP Conference, 12 December 2013, RCSI, Dublin.

An Exploration of Students' Views and Expectations about a New Integrated Pharmacy Programme. Judith Strawbridge, Mark Philbin and Paul Gallagher. Presented at 3U NSTEP Conference 11 September 2014, DCU, Dublin.

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PROJECT

5

The Role of Metacognition in Mathematical Reasoning and Problem-Solving

PROJECT LEADERS

Dr David Wraith
Department of Mathematics and
Statistics, Maynooth University

Dr Frank Doyle
Department of Psychology, RCSI

Michelle Flood
School of Pharmacy, RCSI

3U PARTNERSHIP FUNDING

€4,968

ABSTRACT

Metacognition is the act of thinking about thinking, and in particular the conscious exertion of control over one's thought processes when engaging with a task. Behaviour resulting from metacognitive control includes such activities as predicting, planning, revising, selecting, classifying and checking. There is evidence to suggest that metacognitive skills play an important role in problem-solving situations (Schoenfeld, 1992).

In undertaking this study we hoped to provide evidence in support of this, as well as comparing the metacognitive skill levels between the three groups of students who have very different levels of experience in mathematical problem solving.

PROJECT AIM

This pilot project aimed to explore the metacognitive skills of university level students from different educational backgrounds (pharmacy, advanced mathematics and mathematics education/teaching). Perhaps the most important aspect of the project – and we believe the most original – was to investigate whether intervention could influence metacognitive skill levels, and whether this would lead in turn to enhanced problem solving outcomes.

“ This pilot project aimed to explore the metacognitive skills of university level students from different educational backgrounds ”

METHODS

The project centred on a collection of mathematical problems which were developed to display two common features. Firstly, the mathematical background required to complete the problems was kept to a minimum (equivalent to no more than Irish Junior Certificate level) to avoid knowledge being the determining factor in their successful completion. Secondly, the level of difficulty of the problems was such that participants were unlikely to solve them without some degree of thought, providing the researchers with the opportunity to look for evidence of metacognition. The level of difficulty varied from problem to problem, ranging from the relatively straightforward to the very challenging.

In order to look for evidence of metacognition, participants were asked to think aloud as they engaged with the problems. Both their written work and their spoken commentary were then saved for analysis. This approach yielded rich data and provided a means of observing processes that would be otherwise difficult to identify (Ericcson and Simon, 1993; Van Someren et al, 1994). A researcher supervised the participants to ensure that they continually verbalised their thoughts.

Upon completion of the problems, participants were asked to rate their confidence about the extent to which they had been successful on a five point Likert scale. One group (consisting of mathematics teachers) was designated as an intervention group. After completing the test, they took an academic course which focused on problem-solving, and dealt explicitly with metacognitive issues. The group were then re-tested after completing the course. This involved working on problems with a similar style and range of difficulty to the original set, under exactly the same conditions.

METHODS

Participants (n = 20) were recruited and took part in the study, completing the mathematical problems while following a think aloud protocol. The participants' audio files have been fully transcribed, and the data analysed qualitatively using deductive coding. The codes were derived from work completed in similar studies in other contexts e.g. Artz & Armour-Thomas (1992) and others.

PROJECT FINDINGS AND CONCLUSION

The long-term outcome from the project should be to provide a blueprint for classroom instruction which will impact positively on students' problem solving abilities, and build on work already completed in Maynooth University (O'Shea and Wraith, 2010). This will be achieved by an improved understanding of the levels of metacognitive skill which can be expected in different student groups, as well as insights into the effects of direct intervention. In the medium term, the project will inform further studies which will explore these issues in greater depth.

This project has yielded a significant quantity of valuable quantitative and qualitative data, the analysis of which is still ongoing. The presentations resulting from this study are listed in the panel, and work is continuing on the preparation of journal articles (three expected). The funding awarded through NSTEP was vital for both the existence of this project and for bringing together a team of researchers with an interest in metacognition who would not collaborated otherwise. It is hoped that this collaboration will continue into the future. Additional funding has been secured via the Research Summer School in RCSI to fund a student for two months to continue the data analysis.

PUBLICATIONS/PRESENTATIONS OF RESEARCH FINDINGS

The Role of Metacognition in Mathematical Reasoning and Problem-Solving. Michelle Flood, Frank Doyle and David Wraith. Presented at 3U NSTEP Conference, 12 December 2013, RCSI, Dublin.

The Role of Metacognition in Mathematical Reasoning and Problem-Solving. Michelle Flood, Frank Doyle and David Wraith. Presented at 3U NSTEP Conference 11 September 2014, DCU, Dublin.

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PROJECT

6

An Analysis of the Opportunities for Creative Reasoning in Undergraduate Calculus Courses

PROJECT LEADERS

Dr Brien Nolan
CASTeL, School of Mathematical
Sciences, DCU

Dr Ann O'Shea
Department of Mathematics and
Statistics, Maynooth University

Dr Ciarán Mac an Bhaird
Department of Mathematics and
Statistics, Maynooth University

Dr Kirsten Pfeiffer
School of Mathematics, Statistics and
Applied Mathematics, NUI Galway

3U PARTNERSHIP FUNDING

€4,937

ABSTRACT

We report here on a study of the opportunities for creative reasoning afforded to first year undergraduate students. This work uses the framework developed by Lithner (2008) which distinguishes between imitative reasoning (which is related to rote learning and mimicry of algorithms) and creative reasoning (which involves plausible mathematically-founded arguments). The analysis involves the examination of notes, assignments and examinations used in first year calculus courses in DCU and Maynooth University with the view to classifying the types of reasoning expected of students. As well as describing our use of Lithner's framework, we discuss its suitability as a tool for classifying reasoning opportunities in undergraduate mathematics courses.

PROJECT AIM

In this project, we aim to study the opportunities for creative reasoning afforded to first year undergraduate students using the framework developed by Lithner (2008) to characterise different types of reasoning. He defines reasoning as 'the line of thought adopted to produce assertions and reach conclusions in task-solving' (Lithner, 2008, p 257). His definition includes both high and low quality arguments and is not restricted to formal proofs. For this reason, the framework is useful in studying the thinking processes required to solve problems in calculus courses, where often proofs are not given or required

“In this project, we aim to study the opportunities for creative reasoning afforded to first year undergraduate students using the framework developed by Lithner (2008) to characterise different types of reasoning”

PROJECT AIM
CONT.

but students are expected to make plausible arguments and conclusions. In this project, we use this framework to classify the reasoning opportunities available in a range of first year calculus modules offered in DCU and Maynooth University. We are considering both courses for specialist and non-specialist students, as well as compulsory and non-compulsory modules. (Note that by specialist students we mean students who intend to take a degree in mathematics, while courses for non-specialists are often called service courses). We will report here only on the data from the non-specialist courses.

Studies have shown (for example Boesen et al, 2010) that the types of tasks assigned to students can affect their learning and that the use of tasks with lower levels of cognitive demand leads to rote-learning by students and a consequent inability to solve unfamiliar problems or to transfer mathematical knowledge to other areas competently and appropriately. It is therefore important to investigate whether first year students in our universities are given sufficient opportunities to develop their reasoning and thinking skills.

Some studies have been carried out, notably in the UK and in Sweden, to investigate if there is evidence for these comments. Pointon and Sangwin (2003) developed a question taxonomy to classify a total of 486 course-work and examination questions used on two first year undergraduate mathematics courses. They concluded that the majority of questions required the use of routine procedures only.

PROJECT AIM CONT.

In Sweden, Bergqvist (2007) used Lithner's framework to analyse 16 examinations from introductory calculus courses in four universities. She found that 70% of the examination questions could be solved using imitative reasoning alone and that 15 of the 16 examinations could be passed without using creative reasoning.

In this study, we aim to investigate whether assessment in first year undergraduate courses in Ireland resembles that of Sweden and the UK and if the emphasis on procedures and algorithms at second level persist in university modules.

METHODS

Conceptual Framework

In this project a *task* will be any piece of student work including homework assignments, tests, presentations, group work etc. Lithner (2008) distinguishes between imitative and creative reasoning. Imitative reasoning (IR) has two main types: memorised (MR) and algorithmic (AR). Tasks are classified as MR if they can be completed by recalling a complete answer. This type of reasoning is seen most often at the undergraduate level when students are asked to recall a definition or to state and prove a specific theorem. Algorithmic reasoning tasks are those that require students to recall a procedure and then implement it. Lithner calls a reasoning sequence creative if it has the following three properties: novelty (a new reasoning sequence is required), plausibility, mathematical foundation (the arguments are based on mathematical properties). The creative reasoning (CR) classification can be further divided into two subcategories: Local creative reasoning; and Global creative reasoning. A task is said to require local creative reasoning (LCR) if it is solvable using an algorithm but the student needs to modify the algorithm locally. A task is classified in the global creative reasoning (GCR) category if it does not have a solution that is based on an algorithm and requires creative reasoning throughout (Bergqvist, 2007).

In this study we classify tasks from two first year calculus courses; one at DCU and one at Maynooth University. One of the courses is a business mathematics module and the other is a module for science students. The data in this project consist of the following types: lecture notes, textbooks, assignments, examination questions. We collected all the relevant information with the cooperation of the module lecturers. The data analysis of each module was carried out by two independent researchers from the research team who did not work in the home university of the module. The inter-rater reliability for both courses was high; it was over 90% in both modules. This inter-rating approach ensures reliability of the analysis of the course material from the different modules (see e.g. Chapter 5 of Cohen et al, 2000).

METHODS CONT.

A difficulty with this type of analysis is that we do not know what other learning experiences the student has had – for example in secondary school, in tutorials, in Mathematics Learning Support Centres, etc. We can only classify tasks using the information we have from the notes and textbook. This is a possible weakness in the study. However, it should be noted that this difficulty mirrors the situation in which the lecturer finds him or herself: they must make decisions on teaching and assessment in the absence of detailed knowledge of their students' prior learning experiences.

PROJECT FINDINGS AND DISCUSSION

Both of the modules in this study had regular assignments which were submitted and counted towards the continuous assessment portion of the module grade. They both had practice or tutorial questions, and the Science module also had optional questions. All of these questions were classified. The results are shown in Tables 1 and 2.

Reasoning Type	Practice Questions	Submitted Questions	Exam Questions	Total
IR	93	100	20	213
MR	0	0	0	0
AR	93	100	20	213
CR	55	2	2	59
LCR	33	2	2	37
GCR	22	0	0	22
Total	148	102	22	272

Table 1. Numbers of Questions in Each Category for Business Maths

Note that 21.7% of the Business Maths questions and 29.2% of the Science Maths questions were classified at the CR level. The difference in these proportions is not statistically significant. If we look at the types of tasks that were classified as CR we see that the vast majority were practice or optional questions with relatively few CR tasks appearing on graded assignments (2% in Business Maths and 27.3% in Science Maths).

The Business Maths course had a high proportion of CR tasks (37.2%) in the practice questions, while almost all of the optional questions in the Science course were classified as CR. Both courses had low proportions of CR tasks on examinations (9% in Business Maths and 11.7% in Science Maths); these proportions are much lower than those reported in the Swedish Study (Bergqvist, 2007) where 31% of examinations questions were classified as CR.

PROJECT FINDINGS AND DISCUSSION CONT.

The results of our study show that the students in the courses under consideration were given some opportunities to engage in creative reasoning, and that these opportunities arose most frequently in practice or optional questions. It is not surprising given the subject matter of the modules that the majority of the questions in each course were classified as requiring algorithmic reasoning. The challenge for each individual mathematics lecturer who teaches courses for non-specialists is to achieve a good balance between imitative and creative reasoning tasks. Note that none of the questions classified required memorized reasoning.

Reasoning Type	Practice Questions	Submitted Questions	Optional Questions	Exam Questions	Total
IR	97	40	1	15	153
MR	0	0	0	0	0
AR	97	40	0	15	153
CR	19	15	27	2	63
LCR	15	11	5	2	33
GCR	4	4	22	0	30
Total	116	55	28	17	216

Table 2. Numbers of Questions in Each Category for Science Maths

Classifications like this can help us as lecturers to make sure we balance our assignments and examinations to ensure that students are presented with an appropriate variety of reasoning tasks, and to avoid an over-emphasis on rote-learning. By highlighting this process, we hope to provide a useful tool for other mathematics lecturers involved in curriculum design.

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PROJECT

7

Interdisciplinary Communication Skills - Facilitating Students from Different Disciplines to Learn With, From and About Each Other

PROJECT LEADERS

Professor Dermot Brabazon
School of Mechanical and
Manufacturing Engineering, DCU

Dr Alison Farrell
Centre for Teaching and Learning,
Maynooth University

Dr Bob Lawlor
Department of Electronic Engineering,
Maynooth University

Dr Kevin Casey
Department of Computer Science,
Maynooth University (formerly DCU)

Dr Judith Strawbridge
School of Pharmacy, RCSI

3U PARTNERSHIP FUNDING

€7,200

ABSTRACT

Our group project involved exploring interdisciplinary communication skills and collaborative learning across STEM disciplines. In order to examine the topic, we completed a literature review and surveyed staff from the three institutions about their views on interdisciplinary communication and collaborative learning at undergraduate level. We also held two focus group sessions on the topic with staff from the three partner institutions.

One of our intended project outcomes was a design model for interdisciplinary approaches to communication skills. However, as a result of the literature review, we redefined our purposes and instead, in the first instance, developed a set of guiding principles for the effective integration of interdisciplinary communication skills training into existing and future programmes.

“The aim of the project was to investigate a set of research questions relating to interdisciplinary communication skills and collaborative learning across STEM disciplines”

PROJECT AIM

The aim of the project was to investigate a set of research questions relating to interdisciplinary communication skills and collaborative learning across STEM disciplines. These research questions were as follows:

Mobilisation related questions

1. Should interdisciplinary communication skills be considered as essential elements of the higher education STEM curriculum?
2. What is the interdisciplinary vision/goal(s) among faculty and administration staff involved in the development and delivery of existing STEM programmes within the three participating universities?
3. What existing STEM programmes within the three participating universities would be well suited to the integration of interdisciplinary communication skills?

Implementation related question

4. What existing STEM programme directors/boards within the three participating universities would be interested in participating in the development and integration of an interdisciplinary communication skills element(s) into their programmes on a pilot basis?

Institutionalisation related questions

5. At each of the three participating universities, who are the primary stakeholders required to institutionalise interdisciplinary communication skills development as an essential element of the higher education STEM curriculum?

PROJECT AIM CONT.

6. What are the main barriers to such institutionalisation e.g. skills gaps, resources etc? Such barriers need to be identified and quantified.
7. What is the recommended strategy to overcome these barriers?

METHODS

We used three primary research methods to address the above questions, namely:

- A literature review
- A 3U staff survey
- Two 3U staff focus group sessions

PROJECT FINDINGS

A review of the literature relating to communication skills training in higher education reveals three general approaches, namely, stand-alone communication modules, embedded communications training, and dedicated science communication courses:

Stand-alone Communication Modules

Traditionally and still commonly, communication skills are taught as generic stand-alone modules where topics such as academic literacy and personal development skills are taught in parallel with the core subject content of courses. An advantage of this method from a time-tabling perspective is that the module is relatively easy to 'bolt-on' to an existing programme without the need to modify that programme.

However, a disadvantage is that these skills are divorced from core content, often taught by generalists with no guarantee that they could be applied in the disciplinary area. Moreover the status of such courses is often questionable with teachers of the disciplines and students themselves failing to recognise their full value in advance.

Embedded Communications Training

A more modern approach involves embedding communication skills within the subject area (Amos and McGowan, 2012: 4). It has been argued that core content and communication skills development should be integrated within a disciplinary or interdisciplinary framework (Grant and Dickson, 2006). However, such skills are not acquired by osmosis, and need to be explicitly recognised in the learning objectives and their assessment. The Aalborg model of Problem-Based Learning is a good example of this approach.

PROJECT FINDINGS CONT.

At Aalborg University, project work accounts for 50% of the students' time and this percentage is also allocated to the project assessment (Moesby, 2004). Studies show that this percentage is optimal in the sense of allowing students sufficient time to actively reflect on the application of the taught material in a real problem-solving scenario (Moesby, 2002; Kjersdam and Enemark, 1994). DeGraff and Kolmos (2003) cite the absence of such alignment of time allocation and assessment methodology with target learning objectives as 'one of the classic mistakes made when changing to PBL'.

Dedicated Science Communication Courses

Indicative of the growing importance of science communication in general, this is a recent development in communication studies showing rapid growth. It integrates scientific understanding and the dissemination of such understanding to a wide variety of public and often non-technical audiences. Such courses often combine scientific literacy (often interdisciplinary) with techniques of oral, written, visual and online presentation skills. These courses may utilise workshop techniques and are often delivered by a combination of subject teachers and communication professionals.

Survey & Focus Group Feedback

We carried out a comprehensive survey of academic staff from across three universities, namely, the Maynooth University, RCSI, Royal College of Surgeons in Ireland, and DCU. We received 75 responses from academics working in a broad range of STEM disciplines as well as business, education, careers and finance. The aim of the survey was to gather both quantitative and qualitative data relating to existing practices and attitudes on communication skills training at both undergraduate and postgraduate level across the three universities. Selected feedback is presented and discussed below.




Communication skills are an essential element of the Higher Education STEM/STEAM curriculum			
Agree strongly		78.7%	59
Agree		20.0%	15
Disagree		1.3%	1
Disagree strongly		0.0%	0

Table 1. Attitudes relating to importance of communication skills

PROJECT FINDINGS
CONT.

As shown in Table 1, the vast majority of those who responded recognise the importance of communication skills development. There was also a strong consensus that the communication skills development should be integrated into the programme modules as opposed to through a ‘bolt-on’ module (Table 2). This raises the follow-on question as to whether these attitudes are reflected at the programme design and assessment levels. We explored this point further to find that just over half of the respondents had communication skills deliberately included in their discipline-specific taught modules (Table 3).

At undergraduate level, communication skills should be part of programme modules			
Always	<div></div>	57.3%	43
Sometimes	<div></div>	41.3%	31
Rarely		0.0%	0
Never	<div></div>	1.3%	1

Table 2. Integration of communication skills

The related qualitative feedback indicated that such training components typically took the form of written reports, assignments and oral/multi-media presentations. Such components were generally confined to within discipline-specific modules as opposed to spanning modules.

At present, are communications skills deliberately included in the discipline specific modules that you teach?			
Yes	<div></div>	54%	41
No	<div></div>	35%	26
Don't know	<div></div>	11%	8

Table 3. Existing practice on communication skills

This was somewhat encouraging although it does raise the further question as to the extent to which communication skills were deliberately included in these modules. We explored this through a follow-on question, namely, *‘if yes, where possible, please note the title of one module where this occurs and the percentage of time devoted to communication skills, as opposed to content delivery/negotiation, that occurs across the module’*.

The responses to this follow-on question indicate that the percentage of time devoted to communication skills was typically in the range 5% to 20%.

PROJECT FINDINGS CONT.

This suggests that the widespread feeling of the importance of communication skills development is not generally reflected in the programme design and assessment.

Also, the qualitative feedback from both the survey and the focus groups suggested that these communication skills activities were largely confined to specific modules with very little inter-module interaction, even within a discipline-specific programme. The one exception to this was final year capstone project work which had the potential to draw on taught module content from across the programme and also allocated significant time and marks to communication tasks such as report writing, presentations, interviews etc.





At undergraduate level, communication skills should be discipline-specific			
Always		12.0%	9
Sometimes		69.3%	52
Rarely		14.7%	11
Never		4.0%	3

Table 4. Discipline-specific communication skills

We also explored attitudes relating to communication skills development within discipline-specific programmes/modules (Table 4). The responses shown in Table 4 show that more than two thirds feel that communication skills can be at least partly developed within a specific discipline.

In the literature, there are several variations on the communication skills theme e.g. interdisciplinary, multi- disciplinary, trans-disciplinary communication. For many programmes, such subtle variations can safely be ignored at first-degree level where the emphasis is more on discipline-specific expertise and the effective and coherent integration of the fundamentals of good written, oral and multimedia presentation skills into these programmes. These latter goals should be a primary focus at undergraduate level, even for programmes which are by their nature interdisciplinary e.g. biomedical engineering, manufacturing with business, and biotechnology production systems.

DISCUSSION

Based on the literature review and a preliminary analysis of the survey and focus group feedback, we conclude that the systematic integration of communication skills training should be given strong consideration at all stages of higher education programme design, implementation, assessment and review.

As a contribution to such considerations, we present the following set of draft guiding principles for the effective integration of fundamental communication skills training into existing and future programmes:

1. Fundamental communication skills training would need to be seen as valuable. The perception would need to be shifted, so that rather than people just paying lip service, they would actually agree that it was valuable enough to include.
2. It needs to be adequately resourced.
3. It needs to be carefully designed, managed, aligned and sequenced, from programme design through to assessment.
4. The allocated programme time and assessment marks must reflect its importance as a learning outcome.
5. It must be integrated with the learning process. Learning happens in communication (writing, projects, peer learning, etc.) and learning is demonstrated through communication.
6. It must be integrated across the entire programme. A phased approach is suggested.
7. Staff need to have the necessary knowledge. For example, they need to be aware of existing matrices that might set out parameters for different phases in this approach.
8. Staff should be aware of what's going on in other modules, have a sense of what everybody is doing, be aware of the linkages and the 'big picture'.
9. Students should also be made aware of the 'big picture', i.e. of how the programme hangs together. They should be reminded of this from time to time.
10. Students need to be aware that this is a process. You become a more proficient communicator in your discipline over the course of your degree. (In the same way that you don't know your discipline after one year, or one module: this too is a process over the 3/4 years of your degree.

DISCUSSION CONT.

11. Learning from the Aalborg model suggests that any type of collaborative project work needs to be tied in and linked with the semester's taught modules, in order to be successful.
12. For any collaborative group project work, staff need to have the necessary theory and know-how to implement successful and meaningful learning experiences.
13. Staff need clearer guidelines in relation to assessing individual contributions to collaborative work.
14. It may be considered possible to introduce shared interdisciplinary modules towards the end of a degree programme, depending on the programme in question.

Divorcing 'communication skills' from learning (in 'bolt-on' modules) does not make sense when the demonstration of communication skills is also viewed as a demonstration of learning. This was succinctly described by a focus group participant as *'learning to communicate and communicating to learn'*. In other words, students' capacity to communicate (write, present, teach) reflects not only their communication skills but also their knowledge of their subject matter. There is widespread recognition among and beyond the higher education community of the importance of communication skills training in higher education programmes. However, this importance is not reflected in the design and implementation of many such programmes with 'bolt-on' communication skills modules and inadequate marks and time allocation being commonplace. Pressure to get through discipline-specific content-heavy curricula, coupled with little incentive for academics to venture outside of their comfort zone, are likely contributing factors to this mismatch. Some progress has nonetheless been made in systematically integrating process competency training such as communication skills, team-work skills, project management etc into higher education programmes without diluting the all-important discipline-specific learning objectives. Examples of institutions showing strong evidence of such progress are comparatively rare and generally result only from a coordinated effort by all stakeholders involved in the higher education programme in question. The educational model adopted in Aalborg University involves substantial group project work throughout entire programmes. For example, at Aalborg University every semester is designed around a particular theme with approximately 50% of the time/marks allocated to a substantial group project associated with that theme and the other 50% allocated to taught modules also associated with the theme. Conventional exam-based assessment is also employed.

DISCUSSION CONT.

We present the above set of draft guiding principles as work-in-progress points for consideration by those interested in systematically integrating communication skills training into their existing and/or future programmes. The next phase of our work is to apply these principles on a pilot basis within a number of taught programmes across the three partner institutions and we invite the reader to join with us in this regard.

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PROJECT

8

On a Smart-phone based Student Response System in a Distributed Classroom

PROJECT LEADERS

Dr Conor Brennan

School of Electronic Engineering, DCU

Dr Seamus McLoone

Department of Electronic Engineering,
Maynooth University

Dr Rudi Villing

Department of Electronic Engineering,
Maynooth University

3U PARTNERSHIP FUNDING

€5,000

ABSTRACT

Student response systems, such as clickers, offer several important pedagogical benefits including improved student learning, increased student interaction, improved student attendance, better student satisfaction and the creation of an enjoyable learning atmosphere. Most notably, they provide a mechanism for anonymous submission, thus allowing students to respond without the fear of being identified. While several different types of such systems exist, most of them have several drawbacks associated with them.

These include: (i) limited input capabilities, as they typically only offer a multiple-choice option and/or a numerical and textual based submission, (ii) practical issues in terms of portability, as the lecturer is typically responsible for having to carry a large number of devices to the classroom, and (iii) lack of suitability for distributed classrooms, as most systems employ short range infra-red communication that restricts their use to the physical classroom.

In our work, we proposed and implemented a smart phone based student response system that overcomes these issues. This new system built upon existing work by the authors, whereby a tablet-based system was developed for in-class use. The work focused on two key aspects – the first related to modifications to the existing tablet-based solution and the second involved the evaluation of the new system in a distributed classroom setting.

“**Student response systems, such as clickers, offer several important pedagogical benefits including improved student learning, increased student interaction, improved student attendance, better student satisfaction**”

METHODS

There were two key aspects to this work, namely implementation of the updated student response system (SRS) and an evaluation of the final system within a classroom context.

1. Updates to existing SRS

The existing tablet-based SRS was very much a beta version, with limited functionality and it was developed for viewing on the large screens associated with tablets – as such this system was not ideal for direct deployment on smart phones. In this work, we carried out three significant improvements to the tablet-based SRS. Although some of these improvements were made with a smart phone in mind, they are still valid for the tablet interface.

Firstly, the original system could only be used by a single class of students at any given time, as all students shared the same database for submissions. The updated SRS now contains a user log in screen for both the student and lecturer applications. Here, the lecturer first creates a session on their device, by entering a suitable session name. The name of this session is then communicated to the students, so that they can log on to the correct module session. Now, the students and lecturer for this session have their own dedicated database for submissions. This feature allows the new version of the SRS to be used simultaneously by different classes.

METHODS CONT.

The second new feature involves using templates. The lecturer can prepare and store template sketches in advance of a class to be ready for use during class. Templates have multiple uses - they can be used as the basis for predetermined questions for class. Alternatively, they can be used as an outline framework for common repetitive processes such as using Karnaugh Maps for logic minimisation. Here, it is useful to have a template outline of the Karnaugh map to send to students. This is particularly beneficial for users of the phone-based SRS as they don't need to worry about sketching a relatively neat Karnaugh Map on their small screen of the phone.

The third and final important system improvement is to include a zoom-in zoom-out function on the student sketch app. In the original SRS, the screen was fixed, with no zoom options. This was more than adequate for use on tablets but very limiting for use on the phones. On the new system, students can now zoom in on their sketch to include more detail, if necessary.

2. Evaluation of SRS

The SRS was used and evaluated by students of the Year 3 Computation and Simulation module, which was delivered in a distributed classroom setup as follows. The module was hosted by the School of Electronic Engineering in DCU and was taken by students from both DCU and Maynooth University. The lecturer of the module was based in the DCU classroom along with the DCU students while the Maynooth University students were based in a classroom in Maynooth University, with individual pc access. Big Blue Button (<http://bigbluebutton.org/>) was used as the virtual classroom software. There were about 40 DCU students and 14 Maynooth University students, comprising mostly of male students. Overall the combined class included a small number of mature students and a cohort of approximately 17 international students. The evaluation of the SRS took place on two different lecture occasions over the duration of the module (in this case the module was completed in a 5 week period from February – March 2014).

Both DCU and Maynooth University students were presented with different questions at various times throughout the lectures and the responses from their individually owned smart phones were collated and viewed in real-time on the lecturer's tablet. The questions related to material covered in the class and required students to answer with suitable sketches. For example, one such question required students to graphically depict how the Euler method for solving ODEs would approximate the actual solution function, which was supplied in the template as a reference.

PROJECT FINDINGS

Both sets of students were surveyed using paper questionnaires for their views of the new phone-based SRS (see Table 1). Unfortunately, only 12 survey responses were collected (6 from DCU and 6 from Maynooth University), representing approximately 22% of the class. This low number is directly attributed to the fact that only a small percentage of students had smart phones and, in addition, the SRS currently only operates on phones using the Android operating system. Thus iPhone owners were unable to participate in this evaluation. Nevertheless, the results obtained provide useful insight to the effectiveness of the phone based SRS. It is also worth stating that there was no notable difference in the responses of the Maynooth University (remote) and DCU (non-remote) students.

Statement	Average rating (1-5)	Std. dev.
I found the app easy to use	4.0	0.85
I felt the app was quick and responsive	4.0	0.43
The app performed as expected	3.9	0.67
The app provided a good way to interact in class	4.1	0.29
The app provided a good way to give feedback/responses	4.2	0.58
The flexibility of providing a sketch is really useful	4.1	0.67
The use of the response system makes my learning more enjoyable	4.1	0.79
I was motivated to respond to the lecturer's questions using this system	4.2	0.60
I would like to use this response system again	4.0	0.77

Table 1. SRS Evaluation Results

In brief, the students found the application easy to use, with no prompting required. They liked the overall system and felt it made their learning experience more enjoyable and, moreover, wanted to use the system in future classes. More importantly, students found the idea of responding with sketches

PROJECT FINDINGS CONT.

as useful, flexible and a good means of giving feedback and interacting in class. In terms of additional feedback obtained, via comment boxes, some students noted that the system was “a nice way of learning” and “makes lectures more enjoyable”. Most of the students stated that they liked the fact that responses were anonymous, expressing that they were no longer afraid of giving wrong answers.

The Computation and Simulation lecturer was also asked for his opinion on the smartphone-based SRS, as he had no knowledge of this system prior to using it for the first time in the class. His first impression was that the response system was extremely beneficial, well worth using and appeared to capture the interest of his students almost instantly. He found it particularly useful for breaking up the lecture which, in this case, alternated between 2 and 3 hour sessions. He noted that it worked well in the distributed classroom setting and that there were no apparent issues with delayed responses, etc.

By way of improvement, the lecturer suggested that it would be nice to have the ability to create templates with perfect shapes, i.e. a proper square or circle as opposed to one sketched by hand. He also made an interesting observation on the use of the SRS. He found that it was useful to, at some point during the session, allow students to draw and submit a random sketch (i.e. whatever they felt like drawing). This one-off dispensation seemed to satisfy any temptation they may have to misbehave and focused their minds on properly responding to actual questions thereafter.

CONCLUSIONS

The new smartphone-based student response system, with freeform input capabilities, offers significant advantages over existing solutions, particularly to STEM disciplines. Evaluation results show that students are strongly in favour of this new system. They find the system easy to use, like the flexibility that a sketch input offers and appreciate the fact that it offers anonymity to the student. The evaluation also revealed that the SRS can easily be used in a distributed setting whereby students are physically located in two different classrooms whilst sharing the same module.

ACKNOWLEDGMENTS

We would like to thank the Centre for Teaching and Learning, Maynooth University and the **3U PARTNERSHIP** for providing the research funding for this project. We would also like to thank all the students and staff who partook in the surveys of our SRS.

This project was part of the successful application to the National Forum for the Enhancement of Teaching and Learning's Building Digital Capacity scheme.

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info@3u.ie

3U.ie

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