Ken Brown
School of Engineering,
Letterkenny Institute of Technology
Lecturer
ken.brown@lyit.ie
Ireland
Victor Lally
School of Education,
University of Glasgow
Professor

MYTHS, RHETORIC AND OPPORTUNITIES SURROUNDING NEW TEACHING TECHNOLOGIES: ENGINEERING MATHEMATICS EDUCATION

Abstract: Issues of confidence and self-efficacy and expectancy relating to engineering students are not widely discussed. The transition to third level education is known to be a major stressor in the relationship between students and their prospects of completing their programmes of study. The foundations for this research project lie in a comparative study between students in Ireland and Finland; students participated in a series of questionnaires and group interviews and the thematic outputs of the process formed the basis for questioning of lecturers. Evidence from the data shows many students in the first year of study, demonstrate low levels of confidence, have poor knowledge of the assessment processes employed in Higher Education, and perceive many barriers to progress. Many lecturers do not share the outputs from the student data when individual lecturer interviews are analyzed. The research was extended to gather data from engineering students of similar educational standing in other countries to determine if evidence exists to support the findings. Initial analysis of the data suggests the findings of the initial research are not limited to the participating organisations.

Keywords: Self-Efficacy, Confidence, Expectancy, Online Assessment, Engineering Mathematics.

Research Questions, Objectives and Theoretical Framework

The appropriate pedagogical application of new technologies within Technology Enhanced Learning (TEL) programmes of study has been identified as core to the perceived success of such programmes. As programmes expand beyond the enclosed environments of Higher Education into the public domain, via distance learning, the role of the new technologies becomes not just pivotal to the success of the programmes but is also a major affecting element for students. Digital literacy and skills have been identified within many studies as being critical to the success of both students and their programmes of study.

Computer Aided Assessment is widely employed within Higher Education domains and many see this as a means of coping with the pressures of assessing large

class groups in a fast, efficient manner. Speed of return for feedback in particular is viewed as critical and increasingly the need for personalized feedback (Narciss et al, 2014) as opposed to generalized feedback. Jordan (2013) focused on the assessment technologies employed and suggests that the assessment domain in mathematics is maturing sufficiently to become generally available. A major approach being explored in the literature is the application of Computer Algebra Systems (Sangwin, 2012; Carrol et al, 2016) offering the capability of assessing beyond simple questioning such as Multiple Choice, and basic calculation (Gallimore & Stewart, 2014). The majority of studies in the TEL related assessment literature are practitioner based (Whitelock, Gilbert & Gale, 2013), hence the difficulty in determining suitability of particular assessment approaches.

Analysis of the provision of TEL within Ireland (McCraith, 2015) revealed the use of ICT, transition to third level education and international performance are all issues of concern. Treacy & Faulkner (2015) report the concerns felt by third level academics relating to the lack of skills of incoming students required to engage with third level; particularly mathematical skills. Concerns about the standard of mathematics in the transition to third level in Finland have also been noted (Kinnari, 2010; Rinneheimo, 2010; Cole et al, 2014). Anecdotal observations gathered by the researcher over several years prior to the study are in agreement with the findings of the literature. The joint study project was designed to examine whether, bounded by the first year of study at higher education, if the anecdotal observations were correct. The outputs of the research would provide an evidenced data set to be utilized in the design of mathematics provision of new engineering programmes. The learning process, pedagogical barriers, support requirements, and online engagement, are all areas of interest within the research.

The project was designed within a socio-cognitive theoretical framework of self-efficacy (Bandura, 1977; Artino, 2012) to promote engagement between the researchers and students, and between researchers and lecturers in a non-threatening and open environment. Self-efficacy theory posits that the observations and experiences of the learner influence the actions of the learner and subsequently their

reactions. The experiences of the students may be bounded and discrete or may continue for significant lengths of time hence, the need to interpret the account described by the learner. Based on the interpretations conducted a questionnaire was developed to gather data from other regions.

The research questions being addressed within this study are:

1. Are students prepared for online assessment of mathematics in the first year of study in higher education?
2. Do students perceive barriers that may form impediments to online assessment of mathematics in the first year of study in higher education?
3. Does the self-efficacy of the students affect the perceptions of students with respect to online assessment of mathematics?
4. What level of understanding of assessment and feedback do the students hold?

Methodology

A self-administered online questionnaire was developed and tested in English within a small pilot in Ireland and Poland to determine if any difficulties would arise. A revised questionnaire comprising sixteen questions resulted from the pilot data. Data gathered by the questionnaire is totally anonymous – no student personal information is requested. Testing with Russia suggested that the questions may pose some difficulty in understanding and a version was translated into Russian. The questionnaire was delivered to whole class groups for completion and is operational in Russia, Ireland, Finland, Poland, Portugal, and Estonia. All questions are closed because the opportunity to probe further in relation to open questions is not available to the main researcher. Apart from two questions relating to gender and whether or not a student had previous experience of Computer Based Testing (CBT) all questions were 6 point Likert scale. The 6-point Likert scale was selected to avoid the tendency by respondents to select the middle value. The questionnaire was designed as follows:

Section 1: 2 questions

Gender (M/F), CBT Experience (Y/N)

Section 2: Computer Based Testing experiences – 3 questions

Confidence, Preparedness, and Barriers.

Section 3: Confidence in Mathematics – 3 questions

Previous abilities in Mathematics, Current abilities in Mathematics, Complete current Mathematics programme.

Section 4: Self-Efficacy in Mathematics – 2 questions

Learning Mathematics, Will complete the overall Mathematics programme.

Section 5: Expectancy in Mathematics – 3 questions

Amount of work in Mathematics, Rewards for work in Mathematics, Perceived awareness of the Mathematics Instructor(s).

Section 6: Expectancy in Overall Study Programme – 3 questions

Amount of work overall, Rewards for work in overall programme, Perceived awareness of the Programme Instructor(s).

Results

The data gathered using Google Forms was copied into an Excel spreadsheet and coded. Using the codes allocated to each question, the mean was calculated. The following is a summary description of the information so far. The number of respondents in LYIT is 45 (95 % response) and the number of respondents in URAL is 51 (The data gathering process is incomplete in URAL at the time of writing). The samples are approximately equal size and are of sufficient magnitude to begin the discussion. Further analysis in greater depth by means of ANOVA will be conducted on the larger sample groups.

1. Gender

The initial difference between LYIT and URAL is considerable (Figure 1).

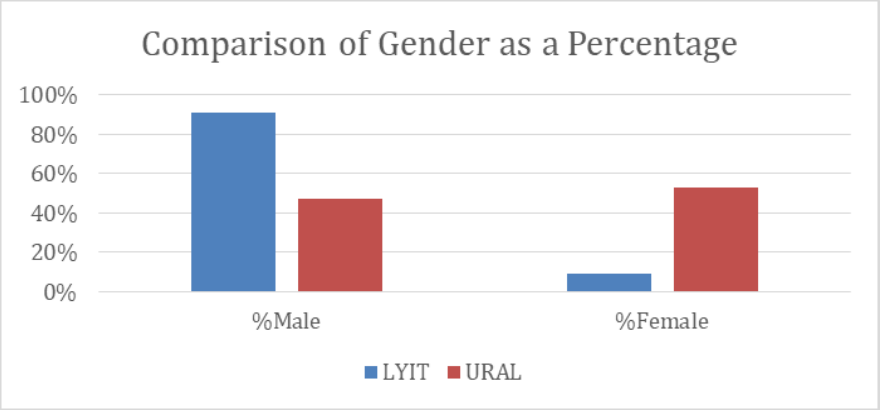

Figure 1. Comparison of gender between LYIT and URAL

Only 10% of students in LYIT engineering programmes are female. The percentage of females in URAL is 41%. This imbalance is a contemporary topic of discussion in Europe as the shortage of female engineers increases.

2. Prior Experience of Computer Based Testing

Only 18% of LYIT students indicated any prior experience of Computer Based Testing. This is in stark contrast with URAL where 80% of students indicate that they had prior experience of Computer Based Testing.

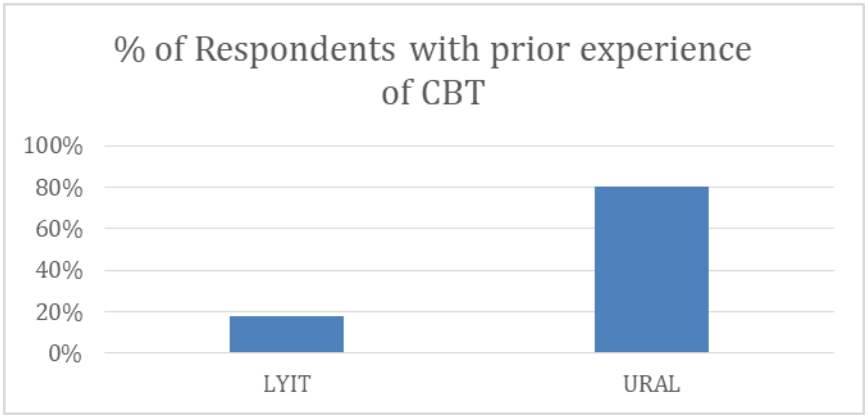

Figure 2. Comparison of LYIT and URAL students having prior experience of CBT

3. Confidence, Preparedness, Barriers, Self-efficacy, Expectancy, Effort and Valence

Issues at first glance referring to figure 3 for comparative purposes:

1) the LYIT students have less prior experience of CBT than students from URAL and yet they indicate slightly higher levels of confidence;

2) both sets of students indicate their levels of preparedness to be similarly high;

3) both sets of students are aware of barriers to their participation in computer based testing but the barriers are not considered to be “too many” as to cause significant hindrance;

4) the URAL students have much higher self-confidence levels compared to LYIT students regarding their prior abilities in mathematics. The LYIT students are typically not from strong mathematics backgrounds and require additional support in the early stages of 3rd level. It would be interesting to determine if this is also true in URAL;

5) both sets of students consider their mathematics ability to be above average – suggestion: This may be as a result of having settled into their programmes of study;

6) both sets of students indicate that their prospects of completing their maths programmes are above average to good. This is interesting when compared to their prior feelings about their abilities in mathematics;

7) LYIT students indicate that they are coping with their mathematics programme and are confident in their own abilities. This compares to URAL students who indicate slightly less confidence in how they learn maths. This may also be a function of the different teaching programmes;

8) LYIT students indicate slightly higher confidence levels that they will complete their current programmes of study compared to URAL. This may also be a function of the programmes as they are taught in each organization.

9) both LYIT and URAL indicate the amount of effort required to complete mathematics assignments is at the correct level – interesting to note that the difficulty settings of the assignments are such that students do not feel aggrieved;

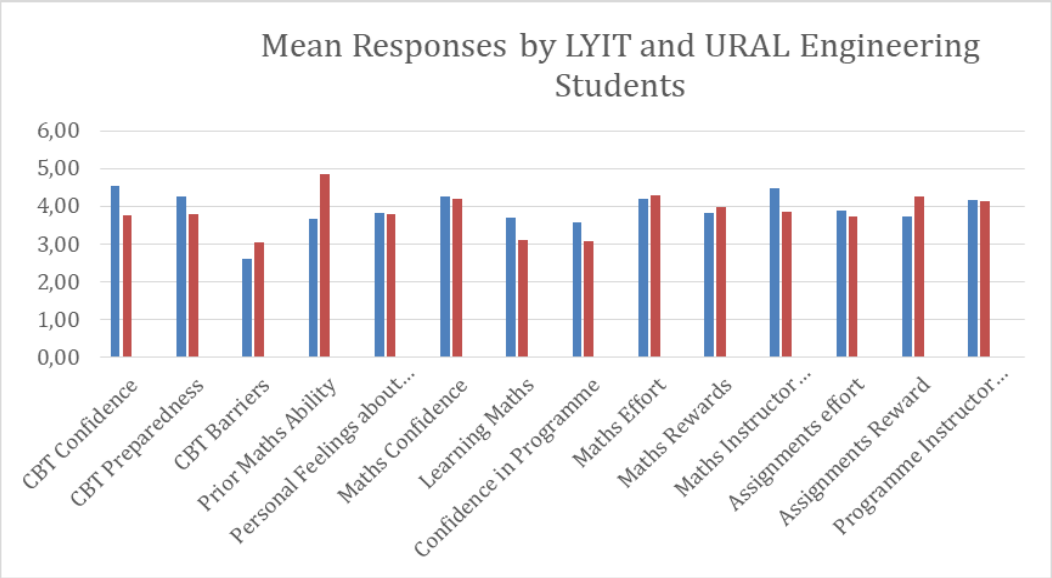

Figure 3. Comparison of mean responses LYIT and URAL

10) both LYIT and URAL consider that the rewards are justified for the effort put into the assignments;

11) both sets of students consider the mathematics Instructors to be very aware of the abilities of the students;

12) both sets of students are in agreement that the amount of effort put into assignments within their programme of study is at the correct level – not too easy and not too difficult;

13) both sets of students are in general agreement that the rewards for their efforts on assignments in general are of the correct levels;

both sets of students consider the programme Instructors to be very aware of the abilities of the students.

Discussion/Conclusion

The results of both sets of students show remarkable similarity in many areas such as the rewards they receive for assignments and the effort required for completion. There is a general feeling that instructors are aware of the abilities of the students and instruct/assess accordingly. Of note is the initial perception of confidence by the URAL students regarding their abilities in mathematics. This level of confidence is supported by research conducted into levels of confidence of third level students (Maloshonok & Terentev, 2016; Van Rooij et al, 2016). However, the levels of confidence of both sets of students are now similar and they are equally confident they will complete the current mathematics programme successfully.

The self-efficacy of the LYIT students suggests they have greater belief that they will complete their programme compared to URAL students. This is of interest due to the perceived lower levels of confidence prior to their studies at third level. The expectancy of both sets of students is quite similar as is their perceptions of the awareness of their instructors.

The initial results demonstrate that the students in both regions hold similar beliefs in their abilities and expectations. A note of caution in the use of TEL is the perception of barriers to online engagement. Given correct levels of support in a timely fashion it is possible to break down the barriers, perceived or otherwise. Greater operationalization of blended learning programmes requires staff to be aware of this issue. Combined with low self-efficacy and motivation the potential to drop out from a programme of study is increased.

References

1. Artino Jr, A.R. Academic self-efficacy: from educational theory to instructional practice / A.R. Artino Jr // Perspect Med Educ. – 2012. – № 1. – P. 76 –85.

2. Bandura, A. Self-efficacy: Toward a Unifying Theory of Behavioral Change / A. Bandura // Psychological Review. – 1977. – № 84(2). – P. 191–215.

3. Carroll, T. EAssessment in Mathematical Sciences / T. Carroll, D. Casey, J. Crowley // Numbas as an engagement tool for first year Business Studies students. Conf. E-Assessment in Mathematical Sciences, Newcastle [accessed online: 04/11/16] www.teame.ie/wp-content/uploads/2016/10/Newcastle-paper.pdf.

4. Cole, J.S. Mathematics Background of Engineering Students in Northern Ireland and Finland / J.S. Cole, C.D. McCartan, R. Tuohi // Proc of the 10th Intl CDIO Conference, Universitat Politecnica De Catalunya. – 2014.

5. Gallimore, M. Increasing the impact of mathematics support on aiding student transition in higher education / M. Gallimore, J. Stewart // Teaching Mathematics and its Applications. – 2014. – № 33(2). – P. 98–109.

6. Jordan, S. E-assessment: Past, present and future / S. Jordan // New Directions. – 2013. – № 9(1). – P. 87–106.

7. Kinnari, H. A study of the mathematics proficiency / H. Kinnari // 1st intl workshop on maths and ICT: Education, Research and Applications, Bucharest. – 2010. – P. 35–39.

8. Maloshonok, N. Match between student educational expectations and realities and predictors of student satisfaction and academic achievements / N. Maloshonok, E. Terentev // European Conference on Educational Research, Dublin. – 2016.

9. McCraith, B. Average is no longer good enough – it’s time for a step change in STEM education in Ireland / B. McCraith // In *Education Matters*, Yearbook 2016, 13–18.

10. Narciss, S. Exploring feedback and student characteristics relevant for personalizing feedback strategies / S. Narciss, S. Sosnovsky, L. Schnaubert // Computers & Education. – 2014. – 71. – P. 56–76.

11. Rinneheimo, K. Methods for teaching mathematics case Tampere University of Applied Sciences / K. Rinneheimo // 1st intl workshop on maths and ICT: Education, Research and Applications, Bucharest. – 2010. – P. 48–55.

12. Sangwin, C. Computer Aided Assessment of Mathematics using STACK / C. Sangwin // 12th International Congress on Mathematical Education. – 2012.

13. Treacy, P. Analyzing the effects of the introduction of the new Project Maths syllabus on beginning undergraduates' performance of basic mathematical skills in Ireland / P. Treacy, F. Faulkner // 13th Intl Conference of the mathematics education for the future project: Mathematics education in a connected world, Catania, Sicily, Italy. – 2015.

14. Van Rooij, E. Ready for university? Profiling secondary school students on university readiness / E. Van Rooij, E. Jansen, W. Van de Grift // European Conference on Educational Research, Dublin. – 2016.

15. Whitelock, D. e-Assessment tales – what types of literature are informing day-to-day practice? / D. Whitelock, L. Gilbert, V. Gale // Report to Higher Education Academy, [accessed online: 30/08/15] http://www.researchgate.net/publication/272357064.