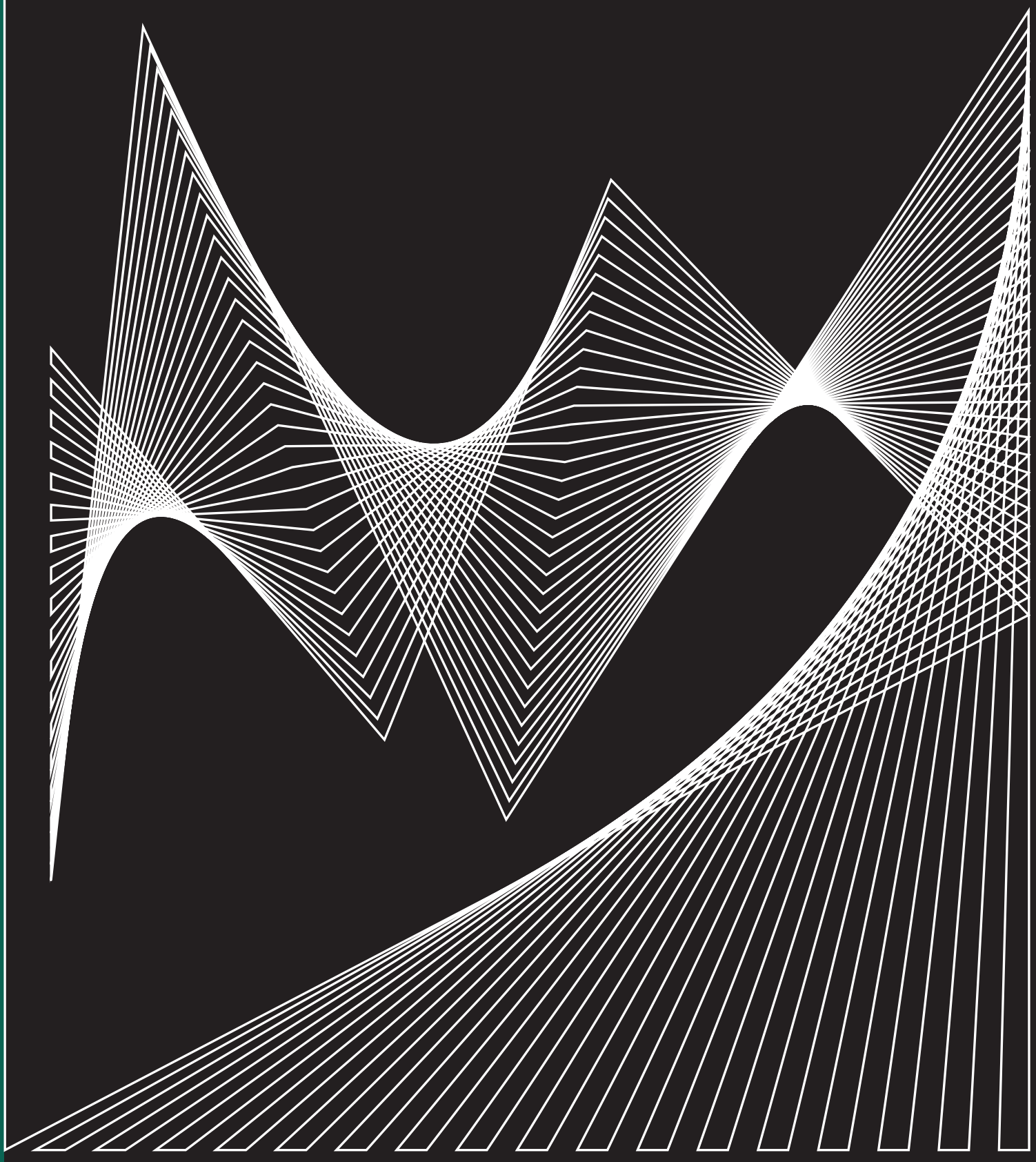
MSOR connections

Articles, case studies and opinion pieces relating to innovative learning, teaching, assessment and support in Mathematics, Statistics and Operational Research in HE.

Volume 14 No. 3



Contents

This journal is published with the support of the **sigma** network and the Greenwich Maths Centre

Editorial

Noel-Ann Bradshaw, Faculty of Architecture, Computing and Humanities, University of Greenwich, London, UK. Email: n.bradshaw@gre.ac.uk

I am delighted to welcome you to this third issue of Volume 14 of *MSOR Connections*: the third edition since the re-launch of the publication last autumn. This issue contains a mix of case studies focussing on maths and stats support, helping mathematics students become more effective learners and embedding aspects of employability into the undergraduate mathematics curriculum.

The issue begins with a timely article by Croft and Grove detailing how to recruit and train postgraduate tutors for mathematics and statistics support and also describing the various training resources provided by the authors and made available via the **sigma** website (http://www.sigma-network.ac.uk/). This is followed by a case study by Fitzmaurice, Cronin, Ni Fhloinn and O'Sullivan, demonstrating the effectiveness of such training sessions in Ireland with postgraduate and faculty tutors.

The maths support theme is continued by Voake-Jones, whose case study demonstrates how undergraduate students can also be used to help augment the services provided by maths support centres. Concluding this set of articles on maths support is a student-authored case study by Collins-Jones (a recent graduate from University of Bath) describing the results of her successful internship in the Maths Support Centre at Bath.

The remaining four articles look at various interventions for maths students at different stages of the student journey. Calvert, Hilliam and Coleman show how they have used diagnostic testing to ensure that prospective students to the OU choose suitable mathematics courses for their level, and explain how this has helped to increase the retention of students. Cox, Cook and Neild describe a successful Peer Assisted Study Support (PASS) scheme which again has been used to increase retention and also the engagement of students. This is linked to the university's Award Scheme so also contributes to the employability agenda.

Employability has been a recurring theme in several previous editions of *MSOR Connections* and this thread is continued in the last two articles in this issue. Firstly Porter and Bartholomew discuss how a first year mathematical modelling module has been enhanced with the addition of talks about industrial mathematics, and then Singh and Chadwick discuss a model to address students' self-motivation and self-efficacy within a second year mathematics module; issues that are highlighted in the HEA Employability Framework.

It has been very encouraging to receive so many submissions to *MSOR Connections* over the last few months. Please do continue to write up your work within the teaching and learning of HE mathematics and maths and stats support, and submit your articles to us via the website below. You can also register if you would be willing to review articles for us.

I would like to conclude by thanking my fellow editors, the editorial board and all reviewers for their support in preparing this issue.

To register for submissions/notifications, and for further information relating to *MSOR Connections* please visit https://journals.gre.ac.uk/index.php/msor

CASE STUDY

Mathematics and Statistics Support Centres: Resources for training postgraduates and others who work in them

Tony Croft, Mathematics Education Centre, Loughborough University, Loughborough, UK. Email: A.C.Croft@lboro.ac.uk
Michael Grove, School of Mathematics, University of Birmingham, Birmingham, UK. Email: M.J.Grove@bham.ac.uk

Abstract

This article provides a rationale for the focused training of postgraduates (and others) who work in mathematics and statistics support centres. It outlines a format for training that has been found to work well through workshop-style events run at universities around the country over the last five years. Within any form of training there are important topics for discussion and a wealth of resources freely available for those centre managers who wish to develop training for their own tutors. Tutors are in the front line of tackling the lack of confidence and skill deficits of students who arrive at support centres looking for help; tutors who are well-briefed in terms of the challenges they are likely to face and how they can best respond to students who are finding university mathematics and statistics particularly difficult will help to ensure that the services offered genuinely contribute to enhancing the student experience. While training for new mathematics support tutors is important, of equal, if not greater importance is identifying tutors with the right skills and abilities to work in mathematics and statistics support. We conclude by considering the recruitment of postgraduate tutors and by undertaking a brief discussion about the value of training to the tutors themselves including contribution to professional recognition that is gaining increased importance. Further sources of information can be found within Croft and Grove (2011) which forms a training resource pack, Croft, et al. (2013) and in the resources section of the **sigma** network website (2016) which includes PowerPoint slides and training activities that can be used in, or adapted for, workshops.

Keywords: Mathematics support, tutor training, support centre, postgraduate tutors.

1. The rationale for providing training

In 2013, Perkin, Lawson and Croft found that 88 out of the 103 institutions responding to their survey offered some form of additional learning support to students, often through Mathematics and Statistics Support Centres. These centres offer facilities and services to students to help them build confidence, address skills gaps and offer opportunities that complement students' traditional diet of lectures, tutorials, problems classes and personal tutorial sessions. This supplementary support is designed to be supportive, non-threatening and non-judgemental. It is a realistic response to the well-documented (see, for example, Croft, et al. (2015) for a summary) day-to-day reality in most universities of significant numbers of students who find themselves ill-prepared for the mathematical demands of their courses.

Many mathematics support centres make extensive use of postgraduate students working as tutors. Providing mathematics support is not the same as the routine tutorial support that many postgraduates undertake as part of their own programmes of study and for which training, typically at an institutional level, may have already been provided. Amongst the reasons for this difference are:

- Tutors are unlikely to know in advance who the students are, the departments they have come from, or the level they are studying at.
- Tutors are unlikely to know what, or indeed how, the students should have been taught and what they should have already learned.
- Students may be from departments that are not traditionally taught mathematics modules (for example geography and business studies) and may be alienated, intimidated and nervous.
- Some students are likely to present with statistical as opposed to mathematical problems and tutors need to be aware that offering statistics support differs, as we shall discuss below, in important ways from offering mathematics support.
- The students may be poorly prepared for what is expected of them due to mismatches between the mathematical or statistical demands of their courses and entry requirements.
- Some students may have additional needs that may or may not have been declared.
- A student's perception of the mathematics support service may be based on a single interaction with the tutor, as opposed to that which can be developed over time through weekly tutorial sessions.

When postgraduate students offer routine tutorials for specific modules:

- They will have contact with the lecturer who has taught the module and can discuss their expectations and requirements of them.
- They will usually have advanced sight of problem sheets, for which solutions are likely to have been provided, and can prepare accordingly. Further they have access to lecture notes, and indeed the lecturer, should queries arise.
- The expectations on tutors are tightly constrained by the module, i.e. they will be aware of pre-requisite modules and may well be based in the same department as the students they tutor.
- Students and tutors can get to know each other in a tutorial group situation and develop a rapport. Building such a relationship is not as straightforward in a support centre environment when students might meet different tutors at different times.

With these differences in mind, support centre tutors will benefit from a training session that explores:

- The rationale for mathematics support and how it is implemented including awareness of the various models in use throughout UK universities.
- The ethos of their own centre and the importance of being excellent ambassadors for the service.
- The types of students who might use the centre, the courses they are studying and the level they are working at.
- An awareness of students' different learning styles and specific learning differences.
- Strategies to adopt when problem solving in the support centre and, in particular, what to do in the event of being unable to solve a student's mathematical problem.
- The broad range of issues that might arise including welfare, plagiarism, students seeking help with coursework assignments, and ethical issues.
- To whom they should turn for help and advice.
- The extensive range of existing resources and materials that are available to help them in their role.
- How they might use their experience towards professional and career recognition.

2. A model for postgraduate tutor training

The **sigma** Network is a HEFCE-funded collaborative venture to build a community of practice for those working in mathematics and statistics support. Anyone working in the field is encouraged to get in touch and contribute to its activities with the website (**sigma**, 2016). Through **sigma** a comprehensive range of freely available resources have been developed for centre managers (and others) to use as the basis for local training of postgraduates using a workshop format. Furthermore, a Guide (Croft and Grove, 2011) has been written specifically for postgraduates who tutor in mathematics support centres and is available for free download. The format of this Guide mirrors the structure of the workshops that have been run successfully in the years since 2010 and has involved adapting a format first introduced very successfully by the Maths, Stats & OR Network in 2005 (Grove, Kyle and Cox, 2006) that was applied to postgraduate students who demonstrate mathematics. The format of a typical day-long workshop is shown in Figure 1.

10:30-:10:45	Welcome and introductions
10:45-11:30	Mathematics support – what is it?
11:30-12:30	Problem solving
12:30-13:00	Principles of maths support – do's and don'ts
13:00-13:30	Lunch break and networking
13:30-14:00	Offering statistics support
14:00-14:30	Tutoring in the mathematics drop-in centre – awareness of individual differences and needs
14:30-15:30	Group activity – exploring various scenarios
15:30-16:00	Resources and networking with others
16:00-16:30	Question and answer session

Figure 1: Timings and structure for a typical postgraduate tutoring workshop

Experience suggests that, ideally, the workshop should be delivered by at least two members of staff with experience of delivering mathematics support. Where possible, additional staff with specific expertise (for example a statistician or an additional needs tutor) can be engaged to run, or assist with, specific elements. It is also valuable to invite delegates from several different institutions so that they all learn from the experiences of their peers working in different environments and with different models of mathematics support. Experience also suggests that a total group size of 20-30 is optimal; with too few tutors present the interactions and discussions will be hindered. Grouping delegates in sets of four or five has also been found to work well, particularly when asked to discuss the questions or scenarios posed.

Figure 2: A typical postgraduate tutoring workshop in progress

Here we discuss briefly the key features of each of the sessions of Figure 1. This provides information based upon our experiences of delivering such sessions, but is naturally complemented by the additional detail that can be found within the Guide of Croft and Grove (2011).

2.1. Welcome and introductions

During this brief session delegates are asked to spend a few minutes considering what they want to learn/gain from the day, and at least one question they hope will be answered. They are invited to write these down on Post-it notes that they either retain for later reference or share with others straightaway on a communal board. Examples of questions noted at previous events include:

- *How can we backtrack, and un-confuse a student when a first attempt at an explanation is too complex?*
- *What do I do if I think a student has been told the wrong technique or something is just plain wrong in their notes?*
- *How do we advise students about presenting their answers well?*
- *What if I myself am not sure of the problem or I make mistakes?*
- *How do I divide up my time between all the students who need help?*
- *What is the best approach to helping the "here's my page of algebraic manipulation – where have I gone wrong?" type question – when pressed for time this is the hardest type of question!*
- *How do we approach helping with coursework?*

Here the purpose is not to answer these questions, but to use this session as a means of generating interaction with the tutors that is critical for the success of the day. It is also particularly helpful for identifying any common issues that may be related to, for example, the specific model of support provided by a particular institution.

2.2. Mathematics support – what is it?

Again, to stimulate the necessary interaction with both the workshop leads and between tutors, the following questions have been posed for delegates to discuss in their small groups:

1. *What do you think mathematics support is and why might it be necessary now?*
2. *What is a 'mathematics (and/or statistics) support centre'?*
3. *What do you know about the nature of mathematics support in your institution? Who can access it? Where is the support offered and when? Are academic staff available for consultation where necessary?*
4. *What do you think is the role of you as a tutor in your mathematics support centre?*

The remainder of this session takes the form of interaction between the small groups and the workshop leads to share thoughts and ideas and build discussion. To aid the structure, a PowerPoint presentation is used to share the thoughts of the workshop leads in response to the above questions, however, this again is a basis for stimulating discussion and idea development rather than didactic presentation.

Mathematics support refers to activities and resources provided to support and enhance students' learning of mathematics and statistics, in any discipline, at any level of higher education and which are provided in addition to traditional lectures, tutorials, examples classes, and personal tutorial sessions. Whether this definition is appropriate for the delegates when they are considering their own institution, and in particular whether the local support is available to students in any discipline and at any level, is usually a good starting point for discussion. We have met tutors who only work to support students in a management or business school for example, and others who work in centres where the support is only available to engineers. Experience can be very varied and it is useful for all present to hear about the range of models in use. Tutors usually recognise that this support is informal, not credit-bearing, voluntarily accessed, and should be supportive and non-threatening. Others have suggested that it provides alternative approaches to problem solving and helps develop independent learning (through the discussion of strategies and techniques for problem solving as well as the range of resources available for independent study), and that this is a skill those working in support centres should aim to instil in students.

Discussion about why support is perhaps required more now than ever before enables the workshop leads to present information about:

- "*The mathematics problem*" in terms of insufficient numbers of students studying mathematics post-16 in the UK and the lack of preparedness for the demands of mathematics at university (Hodgen, et al., 2010; Hawkes & Savage, 2000),
- The increasing quantification of disciplines such as the biosciences and the social sciences (ABPI,2008; British Academy, 2012).
- Widening access to higher education to increase participation amongst under-represented groups.
- Students arriving for higher education with increasingly diverse mathematical backgrounds.
- With the marketisation of higher education come demands from students themselves for a high quality learning experience and appropriate academic support.
- Recognition within institutions of the importance of 'student satisfaction' and the National Student Survey.

2.3. Problem Solving

In this session, delegates consider a variety of mathematical problems in their small groups. The aim is not necessarily to solve any of the problems but to discuss problem-solving strategies and

how they would support a student arriving in their support centre with such problems. By providing problems that the delegates will be unfamiliar with also enables debate and discussion about how to deal with scenarios within a support centre where they do not know immediately how to tackle a student's problem.

Subsequent discussion naturally leads to:

- An appreciation that it is not the role of tutors to 'tell the student the answer' and ideally the student should come to their own conclusion(s) with scaffolding provided through the tutor's questioning.
- An understanding that the tutors do not always need to know the answer, but at the same time ensure that the student leaves the centre having made some progress.

A selection of problems that have been used in workshops can be found in the guide (Croft and Grove, 2011) and in the **sigma** resource pack on the **sigma** Network website (2016). Further examples, and indeed an excellent discussion on what constitutes genuine problem solving, can be found within Hawkes (2015).

2.4. Principles of maths support – do's and don'ts

In this session the delegates, within their groups, are asked to think about what they might do (and what they should not do):

1. Prior to working in the centre.
2. During a drop-in session.
3. Afterwards.

Discussion about what tutors might do prior to working in the centre usually includes the following points: getting to know who is responsible for running the centre and who the tutor should contact if they have any concerns; understanding the purpose of their centre and which students can use it; the resources available both in the centre and through associated websites such as **math**centre (2010). It is important that tutors know they can establish boundaries concerning what they have sufficient knowledge to tutor and what they don't (for example statistics, mechanics, research methods, etc.), and this forms a good opportunity for tutors to consider how they can make the most of the skills and expertise their colleagues possess. Finally, there is a need to ensure tutors are aware of emergency evacuation procedures and have information about who to call in case of emergency (for example local first aiders).

When discussing do's and don'ts whilst working in a drop-in session, the following issues usually arise:

- the importance of welcoming students to the centre and introducing yourself as the tutor;
- asking about the course and level the student is studying before commencing the mathematics or statistics - knowledge of the students' course can be very important in determining the approach taken to tutoring the student;
- the importance of sharing your time equitably with all those waiting for help;
- not being embarrassed about letting the student know you don't necessarily understand how to solve a problem – but instead working together to try to understand by asking questions and referring to lecture notes and other resources;
- the importance of showing the student respect and not demeaning them, even inadvertently – remember the student may have needed a great deal of courage to enter the centre at all and the way they feel treated will determine whether they persevere or not; encouraging the student to return, perhaps suggesting some additional work they should do in the meantime.

2.5. *Offering statistics support*

It is generally recognised that offering statistics support is very different from offering mathematics support. There are a number of reasons for this:

- Students may arrive seeking help with introductory exercises to calculate, for example, measures of central tendency or spread. They may be attempting routine exercises, for example using the normal, binomial or Poisson probability distributions. Tutoring these students in a support centre is akin to tutoring mathematical topics.
- However, students might equally arrive seeking help with a particular statistical software package that they are using to analyse data (SPSS, R and others). It is quite possible that the tutor will not have used these packages. The **stats**tutor website (2010), mentioned in the section below, has a wealth resources that can help with these aspects and to which students can be referred.
- Some students may be seeking more complex advice and guidance on how to design and analyse a survey or an experiment. Often this is part of a final year project. Some students may seek to analyse data for a PhD thesis. In these cases assisting the student may demand more time than usual and a broader range of skills to help them.
- The interpretation of the output from statistical calculations is usually critical and might well require detailed knowledge of the context of the problem – knowledge that the tutor may not have.
- It is crucial that the tutor is aware of the level and discipline area of the student – sometimes a simple 'this is how you do it' might well be an appropriate response. For others, especially postgraduate students, it might be appropriate to recommend that the student spends time understanding the statistical requirements of the problem they are tackling and to develop the requisite knowledge for themselves.

For these reasons, and in an ideal situation, the statistics support tutor should be both a very experienced statistician and teacher. In a less than ideal situation, those responsible for running the centre need to be very clear about which students (courses and levels) can attend for help, and whether the tutors do indeed have the necessary skills and experience. The **stats**tutor website (2010) has training videos concerned with statistics tutoring do's and don'ts.

2.6. *An awareness of students learning styles, differences and needs*

Crucial to the success of a support centre is the tutor's awareness that students present with a wide range of backgrounds, interests, and learning styles. Of course some are likely to have specific learning differences that have the potential to impact upon their learning. There is no expectation that tutors have specialist skills to deal with students presenting with neurodiversities such as dyslexia, Asperger's syndrome, or dyscalculia, but it is possible that they will come across students like this and should know that a level of sensitivity is required. Croft and Grove (2011) contains specific subsections that discuss each of:

- Thinking styles.
- Learning styles.
- Maths anxiety.
- Specific learning differences (SpLD).
- Counselling.

Tutors should be warned that under no circumstance should they attempt a diagnosis nor suggest to a student that they may have a SpLD. If in doubt, they should refer to the centre manager or an appropriate academic such as a personal or welfare tutor.

2.7. Scenarios that might arise

Groups are given several wide-ranging scenarios that have arisen in real support centres and asked to discuss how they would respond. Scenarios provided include ones such as:

- *A first year student turns up at the centre with a copy of a diagnostic test that they have been given during the first week of term, and their marked attempt. They scored 23%. What might you do?*
- *A mature, first-year, overseas student comes into the centre. They have difficulty in explaining what their problem is, but show you a problem sheet from a module being studied in the Business School. The sheet has several questions, each of which has a scenario leading to a linear programming problem. It is clear that the linear programming problem must first be formulated, and then solved using either the simplex method or a spreadsheet (Excel, or a more specialist package). They seem to have little idea where to start. What might you do?*
- *A student arrives and states: "I am doing a final year project and am very unsure of my statistics…My supervisor advised that I make an appointment with someone at the maths help centre and explain my project to them and then perhaps they would explain to me what tests I needed to use and why." What might you do?*

A number of other possible scenarios are available within the Guide (Croft & Grove, 2011) and also in the resources section of the **sigma** website (2013). Of course, there are no simple answers to any of these questions but tutors have found it valuable to hear how others would respond and the suggestions they make.

2.8. Resources

Over the last decade a wealth of resources for use in mathematics support centres, by both students and staff, has been created by the community and through various funded projects. A support centre should have access to these resources so that students can be directed and help themselves. The **math**centre website (2010) focuses particularly on material that is known to be problematic at the transition to university. The **math**tutor website (2010) contains much of the same material – videos, teach yourself booklets, diagnostic tests, etc. but arranged in a sensible order for self-study: arithmetic, algebra, functions and graphs, sequences and series, geometry, vectors, trigonometry, differentiation and integration. The **stats**tutor website (2010) contains a growing collection of statistical resources.

3. Delegate reflections on the training workshops

For each of the workshops that have been run, delegate feedback has been collected. This has not focused upon obtaining ranking scores, but obtaining specific comments that can be used to develop the events through a feedback loop. This has led to the workshop format, structure and content we describe here, and three key principles for delivering these: Practice sharing; an informal environment; and, interactivity.

A key feature of the feedback is that delegates welcome the opportunity to network and share ideas; something that is not always common even if tutors are based within the same institution. As such, this is something those running centres are encouraged to explore to aid the ongoing development of their tutors:

"Very easy to get external opinions on personal queries/dilemmas relating to the job. Also, set us thinking about aspects of our provision that we might not have thought about…"

[Delegate A]

"The brainstorming part of the event was important in terms of knowing each other's approach in dealing with different scenarios that may occur."

[Delegate B]

Another key feature is that to allow the sharing of ideas, an informal and relaxed environment needs to be established for the workshop sessions. Time and effort invested in this at the start of the workshop pays real dividends later and can help build confidence amongst the delegates:

"Very dynamic, interactive and easy going. Helped me get a bit more confidence as to my ability to be a good tutor."

[Delegate C]

But most importantly, it is essential that the sessions are very interactive and not consist solely of presentations by the workshop leads. The interactivity of the workshops is one of the most common comments cited in a section of the feedback form entitled 'what I liked most':

"…nice mixture of interactive sessions."

[Delegate D]

"Activities rather than presentations."

[Delegate E]

3. Recruiting postgraduate research students as mathematics and statistics support tutors

In a workshop held to discuss the training requirements of tutors (Croft, et al., 2013), discussion also took place regarding the *recruitment* of postgraduate research students, and in particular, how to find those with appropriate skills for working in a mathematics and statistics support environment. Advertisements for the post would better achieve their purpose if they were transparent and specified the target audience for mathematics support and their possible level of need. Recruitment was also often undertaken through recommendations from peers, lecturers, supervisors and staff, with an interview process of some kind. Tutor qualities or specifications could comprise of mathematics and statistics qualifications and teaching experience. Qualifications do not necessarily need to be discipline specific as a certain level of mathematics and statistics can be assumed from science based postgraduates. It is important however that learning and teaching skills are either present or that there is a potential for developing these skills with appropriate guidelines, nurturing and mentoring. Important skills are the ability to recognise students' needs, that is, to identify support needs beyond the need perceived by the student, helping students get to the actual need by unpicking the problem and by clever questioning.

Although teaching experience is desirable, tutoring in a support centre requires particular skills hence recruiting tutors with the potential for development as well as qualifications and experience is important. Working in a mathematics support centre is quite different to other forms of university teaching; not everyone possesses the necessary skills or abilities. Providing mathematics support

is not about 'telling' the student the answer, but about encouraging them to identify their own mathematical problems, helping them tackle these for themselves with support and guidance, and providing suggestions and strategies for independent study. It requires individuals who are comfortable working on a one-to-one basis, who are patient, able to explain mathematical ideas in multiple ways, have excellent interpersonal skills, and are able to work with students of a range of abilities and from different disciplinary areas.

4. Recognition arising from mathematics support

Professional recognition for postgraduates for the time spent in training and the experience gained in a support centre is generally thought to be highly desirable. Not all postgraduate tutors will be interested but some, particularly those who have aspirations to work in university teaching might find formal recognition valuable. Certificates of attendance at training events can be produced easily, and in some institutions, training can contribute towards initial learning and teaching qualifications.

In one particular institution (Croft, et al., 2013) a scheme has been established to enable postgraduate research students with teaching responsibilities to achieve associate status recognition from the Higher Education Academy. The scheme allowed selected postgraduates to be supported, by being paired with a mentor, in their submission of an individual application on the basis of their experiences in teaching and learning in higher education.

In some institutions there are examples of tutors going on to secure teaching roles upon completion of their PhDs and working in a mathematics support centre can aid this. Tutors should be reminded of the fact that, for the reasons discussed earlier, they are undertaking one of the most challenging, but rewarding, forms of teaching in higher education. As such, they possess a wide range of skills, and should be encouraged to reflect upon these and cite their experience of working in mathematics support within their CVs and in any applications they might make. Former tutors who secure roles within their institutions can make an important contribution to mentoring and supporting new tutors as they commence their activities in a support centre.

5. References

ABPI, 2008. *Skills Needs for Biomedical Research*. [pdf] Association of the British Pharmaceutical Industry. Available at: http://www.abpi.org.uk/our-work/library/industry/Documents/skills-biomedical-research.pdf [Accessed 10 April 2016].

BA, 2012. *Society Counts: Quantitative Skills in the Social Sciences and Humanities.* [pdf] British Academy. Available at: http://www.britac.ac.uk/policy/Society_Counts.cfm [Accessed 10 April 2016].

Croft, A.C. & Grove, M.J. eds., 2011. *Tutoring in a Mathematics Support Centre: A Guide for Postgraduate Students*. National HE STEM Programme & **sigma**. Available at: http://www.mathcentre.ac.uk/resources/uploaded/46836-tutoring-in-msc-web.pdf [Accessed 17 February 2016].

Croft, A.C, Ahmed, S., Aiken, V., Fletcher, L., Grove, M.J., Mead, A., Patel, C., and Wilson, R., 2013. Offering Training to Postgraduates who Tutor in Mathematics Support Centres, *MSOR Connections*, 13(1), pp.3-7.

Croft, A.C., Lawson, D.A., Hawkes, T.O., Grove, M.J., Bowers, D. and Petrie, M., 2015. ***sigma*** *– a network working!,* Mathematics Today, 50(1).

Grove, M. J., Kyle, J. and Cox, W., 2006. The Weakest Link? Supporting The Postgraduate Teaching Assistant. In Corcoran, D. and Breen, S. eds., *Proceedings of Second International Science and Mathematics Education Conference*, St Patrick's College, Dublin.

Hawkes, T., 2015. Problem solving in a mathematics degree. In Grove, M.J., Croft, A.C., Kyle, J. and Lawson, D.A. eds., *Transitions in undergraduate Mathematics Education*. Birmingham: The University of Birmingham.

Engineering Council, 2000. Measuring the Mathematics Problem. [pdf] London: Engineering Council. Available at: http://www.engc.org.uk/engcdocuments/internet/Website/Measuring%20the%20Mathematic%20Problems.pdf [Accessed 10 April 2016]

Hodgen, J., Pepper, D., Sturman, L. and Ruddock, G., 2010. *Is the UK an outlier: An international comparison of upper secondary mathematics education.* London: Nuffield Foundation.

mathcentre, 2010. *Mathematics resources.* [online] Available at: http://www.mathcentre.ac.uk/ [Accessed 9 April 2016].

mathtutor, 2010. ***math****tutor help yourself.* [online] Available at: http://www.mathtutor.ac.uk/ [Accessed 9 April 2016].

Perkin, G., Croft, A.C. and Lawson, D.A., 2013. The Extent of Mathematics Learning Support in UK Higher Education - The 2012 Survey. *Teaching Mathematics and its Applications,* 32(4), pp.165-172.

sigma Network, 2016. *Tutor training resources.* [online] Available at: http://www.sigma-network.ac.uk/resources/tutor-training-resources/ [Accessed 9 April 2016]

statstutor, 2010. *Statistics support for students.* [online] Available at: http://www.statstutor.ac.uk/ [Accessed 9 April 2016].

CASE STUDY

Preparing Tutors for Mathematics Learning Support

Olivia Fitzmaurice, Department of Mathematics and Statistics, University of Limerick, Ireland. Email: olivia.fitzmaurice@ul.ie
Anthony Cronin, School of Mathematics and Statistics, University College Dublin, Ireland. Email: anthony.cronin@ucd.ie
Eabhnat Ni Fhloinn, School of Mathematical Sciences, Dublin City University, Ireland. Email: eabhnat.nifhloinn@dcu.ie
Ciaran O'Sullivan, Department of Mechanical Engineering, Institute of Technology Tallaght, Dublin, Ireland. Email: ciaran.osullivan@ittdublin.ie
Richard Walsh, Mathematics Learning Centre, University of Limerick, Ireland. Email: richard.walsh@ul.ie

Abstract

This paper reports on a Mathematics Learning Support (MLS) tutor training programme implemented on a coordinated basis across three universities in Ireland in 2015 by the Irish Mathematics Learning Support Network (IMLSN). The training events were conducted in September near the start of the first semester of the academic year. Focus groups were conducted at the end of the semester in the three institutions with tutors who had participated in the training events to evaluate the workshops and their impact on the tutors' MLS teaching.

Keywords: Mathematics Learning Support, Tutor Training.

1. Mathematics Learning Support and the Importance of Good Tutors

The need for Mathematics Learning Support (MLS) in alleviating transition issues to higher education has been well documented in the UK (Hawkes and Savage, 2000) and Ireland (Ni Fhloinn et al., 2014; Gill et al., 2010). In 2012 it was estimated that MLS provision in the UK existed in over 85% of higher education institutions (Mac an Bhaird and Lawson, 2012). In 2015, a survey conducted in Ireland indicated that MLS is offered in 97% of higher education institutions (Cronin et al., 2016). Though the range of supports available is vast (Mac an Bhaird and Lawson, 2012), one-to-one tuition is offered in all drop-in centres and is the support most favoured by students (O'Sullivan et al., 2014, Cronin et al., 2016). In most cases MLS tutors comprise postgraduate students and/or faculty members (Cronin et al., 2016). As tutors are students' first exposure to MLS, it is important that they are trained in order to make their MLS centre an environment that, according to Mac an Bhaird and Lawson (2012; 10), should be 'welcoming, supportive and non-threatening'. One of the recommendations arising from the 2014 Irish Mathematics Learning Support Network (IMLSN) report on student evaluation of MLS (O'Sullivan et al., 2014: 14) was that "(p)riority should be given to bespoke training and development of all MLS staff to ensure the optimal student experience." Leading on from this, in 2014 IMLSN members designed a suite of workshops to address this recommendation and, in 2015, secured funding from the *National Forum for the Enhancement of Teaching and Learning in Higher Education* to deliver the training in multiple locations.

2. Workshop Content and Delivery

In 2015 the IMLSN conducted its tutor training programme in three institutions, with invitations extended to all MLS tutors across all institutions. Forty-two tutors from six institutions participated. Three focus groups were conducted with volunteers ten weeks after the training. Some of the findings from the focus groups are reported in this paper.

The training programmes were facilitated in three similar MLS centres i.e. the support offered is mainly on a drop-in, one-to-one basis, is open to all students of the university and promotes a model

of self-directed learning. The training programme content comprised an amalgamation of tutor training materials designed by members of the IMLSN and **sigma** (Croft and Grove, 2011). The training took place over a half day period and comprised four one-hour workshops which were adjusted as appropriate to take account of local issues. Workshop 1 detailed the importance of the work of tutors in MLS. The mathematical background of students attending the MLS centres was discussed using appropriate local data, in the form of either diagnostic testing data or MLS tutor generated feedback based on the previous six years of MLS visits. This introductory workshop also discussed the initial visit of a student to MLS and what tutors should do, as well as methods of teaching for understanding and issues relating to mathematical language and jargon. Workshop 2 covered listening, explaining and questioning skills with associated exercises and role play. Workshop 3 covered the concept of individual student needs and differences. It also covered non-mathematics skills such as counselling and empathy, dealing with maths anxiety and mental blocks. Workshop 4 related to Do's and Don'ts of MLS tutoring. **sigma**'s 'tutoring in a mathematics support centre; a guide for postgraduate students' was distributed to all participants and used throughout all sessions as a resource. The training programmes were delivered by the managers of the MLS centres at the start of the academic year 2015/16.

3. Evaluation – Data Collection and Analysis

Five tutor training attendees from each of the three institutions were sought and selected to take part in a focus group (see appendix for questions) at the end of semester to evaluate the training programme. A PhD student was hired to conduct the focus groups, collect and transcribe the data. Thematic content analysis involved analysing the focus group transcripts, identifying themes within the data gathered and collecting examples of these themes from the text. Ethical approval was granted for the collection and publication of data retrieved from these focus groups.

4. Results - The Impact of the Tutor Training Programme on the Tutors' Practice

Fourteen tutors, with a varied range of tutoring experience agreed to take part in the focus groups.

4.1 Benefits of the Training Programme

4.1.1 Empathy for Students

A key theme that emerged from the participants was the benefit of the training programme in helping tutors to become more understanding of students' situations. The immediate effect of this aspect of the programme was commented on by one tutor:

"… what struck me as most useful during it was I constantly remembered that a lot of the troubles that the students will have are not at all clear to us".

Other tutors commented on the longer term impact that highlighting this fact in the training programme had on their subsequent practice:

"… the main thing ….that I implemented while tutoring in the Learning Centre was we talked about like some students coming in, they might be under stress or under pressure. I thought I was trying to be a little more empathetic that way… just trying to understand where they were coming from".

4.1.2 Catering for Different Abilities

The main theme that emerged here was the benefit of the training programme for highlighting to tutors the broad range of abilities with which they would be greeted.

"I am well aware of people who have different learning abilities… but still it's useful … to bring that out and highlight it".

However, even with this, tutors were still surprised at some students' levels of knowledge.

"I always had the assumption that these people coming into college must have some sort of base knowledge but a lot of them actually don't … you … have to go back to ground zero".

4.1.3 Getting Acquainted with Other Tutors

The workshop was a good opportunity to meet other tutors.

"What I found most helpful was getting to see the other tutors here and knowing who they are because I didn't know the other tutors in the MLC and I think that's the most useful thing because it's a team".

This was not the case in all focus groups however; as one participant highlighted that in future the training should enable him to

"… meet all the tutors because I have never met X. Like we are in the same place now, we are in what? week 11".

To counteract this, they felt that the introductory workshop might include ice-breaker activities between tutors (both new and existing?) in future.

4.1.4 Tutor as 'Expert'

Some participants highlighted how the programme was beneficial in reassuring them that they did not need to know everything.

"I was really nervous because I'm good for maths but I'm not really good for stats for example so it was really good, you know, we don't really have to answer every single question that we have, you know, that we only focus on what we actually know so that was really helpful".

"I think for me the session beforehand was helping me understand that it's OK for me not to help others. … It's OK to not understand … Last year I felt so guilty".

The focus on tutors' content knowledge was a recurring theme and will be discussed later.

4.2 Teaching Strategies

The following subsections relate to findings from the focus groups with reference to tutoring in a one-to-one MLS drop-in setting, which was the focal point of the workshops. However, it emerged from some of the data that tutors want training to deal with a larger classroom teaching setting (e.g. tutorials). The development of further workshops to facilitate this is necessary so that they are available for use in institutions where that need is evident and not already fulfilled by other training.

4.2.1 Explaining

For some tutors, the training emphasised that the role of a tutor is to act as a facilitator and to draw the knowledge from the student.

"[What] I took from it basically was to try and get them to do the work and not feel under pressure that you are supposed to just like give them solutions to homework or anything like that".

One tutor compared his explaining prior to the workshop and now this year since engaging in the tutor training as follows:

"… there were a couple of instances even last year you know in the Maths Learning Centre where people asked you to explain something, and you would go and show them an example of how to do the questions instead of explaining the stuff really simply and I think the workshop kind of addressed that".

Students' expectations of tutors was a recurring theme in all three focus groups. Participants discussed how it was difficult to remain enthusiastic for students that were only there to get the answers from you. All interviewees maintained that the students that came to the MLS Centres at the same time every week wanted to understand and got the most from the support facility. However, those who were not there regularly and just arrived when an assignment was due viewed it as the tutors' job to give them the solution. One tutor portrayed a similar sentiment highlighting that some students appeared to have the attitude "*yeah, why would I [do the question], you're here".*

4.2.2 Questioning

Predominantly the feeling that emerged from participants was that this aspect of the training programme was rushed and not interactive enough. As one tutor commented:

"I mean tutor training for me like there was no like one on one experience. You weren't actually doing anything in it and you were just being given advice".

Similarly, another recommended:

"[m]aybe make it a little more interactive as well".

"It was kind of rushed … It was five minutes of 'oh yeah this is how you do it' and it was me and X [looking] at each other, oh yeah that's how you do and that's it".

Another tutor did indicate the importance of questioning to identify the gap in the students' knowledge. She stated:

"… one of the things they [the tutor training programme] mentioned is trying to find the root of the problem and as you X were saying sometimes it can be a really basic thing".

5. THE ROLE OF THE TRAINING PROGRAMME IN PREPARING MLS TUTORS

5.1 Value of the Training Programme

The overall verdict from participants in each interview was that the training programme was very worthwhile. This was illustrated in one focus group interview by participants suggesting that it should be mandatory for anyone that is teaching a module and that this should be examined at a departmental level.

Other tutors were also very much in favour of the training with one stating:

"I would like to say now that I actually thought the [training programme] was a great idea and I was delighted I was there … the very fact that there was [a training programme] was great and, you know, a very good start".

5.2 Content Knowledge

A recurring theme across each interview was the matter of tutor content knowledge. For some, this was a major concern and left them feeling 'guilty' or 'inadequate'. One tutor alluded to negative student responses if they came to the MLS Centre and nobody there was capable of helping them. Another tutor also highlighted this negative response when the tutor is not entirely sure of the content and is trying to understand it themselves before attempting to teach it. He stated:

"…sometimes you will get a situation where you don't know the stuff instantly and they will take out their notes and they see you reading the notes and trying to figure things out as you go and they will just take the response of 'he doesn't know what he is talking about so he is useless to me".

However, the interviews uncovered strategies tutors employed to overcome this obstacle and presented ideas how this could be developed in future.

5.3 Role of the Training Programme in Developing Tutors' Content Knowledge

One tutor felt that the training programme did not prepare her sufficiently to help with more difficult mathematics. She stated:

"…I'm at a loss in the Maths Learning Centre when someone comes in with … 2nd or 3rd year Actuary or something like this and I didn't get enough from the session to enable me to know what to do so I have struggled in that regard".

The participants in that focus group interview were of the opinion that workshop hours developed to upskill tutors in certain topics would be a beneficial addition to the training. They all agreed that it would be impossible to be specialised in every area, but a revision workshop on certain popular areas such as algebra and statistics would be very helpful. Three participants at one of the focus groups all stated that they believed that they would be better tutors if they were able to help a greater number of students by developing their content knowledge.

Another tutor disagreed with this view as regards the role of the training programme. He felt that it was not the duty of the programme to upskill tutors in mathematics but instead the tutors' own responsibility. He highlighted that their mathematics was at the requisite level to help a certain portion of students but if they engaged in other activities such as working together or tutoring a module, as suggested by another tutor, then they would develop their content knowledge.

"… the maths support has hired us at the level we are. I mean we are at a good enough level to handle a certain percentage of the students and that's the important thing and going beyond that is just up to ourselves I think".

Within each interview participants suggested ways of helping students in topics they (the tutors) were not overly familiar with. These are now discussed.

5.4 Overcoming the Obstacle of 'Content Knowledge'

5.4.1 Diagnosing Students' 'Actual' Problems

Despite their lack of content knowledge in some areas, tutors were in agreement that the root of the problem could often be something they could help with. One tutor highlighted an example of this *"… sometimes it's something to do with differentiation rather than the statistics of it*". Another tutor noted a similar experience with regard to mathematical physics which '… wasn't [her] strong point' but the student's difficulty "*was actually … differentiation*", which she could help with. Several tutors noted how they adopted the technique of getting the students to explain to them the topic they were doing. In that way they were in a better position to "*try and pinpoint where [the student's] problem is".*

5.4.2 Timetable

Participants in the focus groups felt that a better or "more rounded" timetable would enable them to cater for a broader range of students and get to know the mathematical competencies of other tutors.

"… If you had a list of names of who felt comfortable in a particular [topic], you could say that person is on at that time and come back with your problem then".

This practice seemed to be already in use in other centres however. One tutor noted that when students were looking for support with statistics, an area he was not comfortable with, he would respond *"no, you have to come back on stats day for stats*". Likewise, one tutor described his response when he was struggling to help a student:

"Like I always know X is the stats person … I'll basically just get X to come over and talk through the problems that I can learn as well".

He was confident in doing this as in that learning centre *"you are working with the same tutors every week so you know whose strong point".*

5.4.3 Access to Notes

A frequently aired opinion was the importance of the students bringing their notes to help the tutor teach "*using the same notation as the teacher*" and "*in the same terminology that they are using*". In one centre, participants agreed that due to the many platforms being used, such as Sharepoint, SULIS and lecturers' personal websites, accessing notes for modules was very difficult, but this was not an issue elsewhere.

5.4.4 Use of the Internet

It emerged that tutors regularly used the internet to help them while working in the centre if there was content they were unfamiliar with.

"… a few times I have actually walked away from some people going 'right I can't help' but I have then went straight on my phone and I actually started looking stuff up. It might be a branch of maths I have never seen before but I will start looking stuff up specific to their question and maybe then actually find something and go back to them and they'd be like oh this actually helped".

The workshop encouraged tutors to give students the tools to help themselves.

"I feel like I have so many students this semester and the most useful skill I've shown them is how to type something into Google".

6. CONCLUSION

The overall opinion shared by participants in the focus group interviews was that the tutor training programme was beneficial for their tutoring practice. Indeed many recommended making training compulsory for anyone involved in mathematics tutoring in Higher Education. While this is generally out of the remit of MLS managers, it is something that could be recommended to heads of department. MLS centres have the potential and experience to make a valuable contribution to such training. Further feedback attained from focus groups held with fourteen out of all forty-two training programme participants provided the IMLSN committee with ways we can enhance the training process for all practicing and prospective tutors.

One notable issue arising from the focus groups was tutors' feeling of isolation working in MLS. They made a request to facilitate them getting to know other tutors in a bid to feel part of a team. While difficult to do in larger MLS centres, any team building intervention should ideally take place at the start of the academic year where possible. Future training programmes should be designed with an induction/ice breaker session for tutors to get to know other members of their own MLS team and familiarise themselves with other tutors' areas of mathematical and/or statistical expertise.

The training programme was tailored to provide advice for tutors who give one-to-one tuition on a daily basis. They requested that, in future sessions, more time is dedicated to development of tutors' questioning and assessment skills. Some of the tutors interviewed also stated that they would like more training in teaching group/tutorial sessions.

Tutors are hired for their strengths in specific areas be it mathematics or statistics and they are then required to help students according to what their particular needs are. They are not required to be expert across all mathematical disciplines and this was reinforced in the training programme but perhaps greater emphasis needs to be placed on this important issue at future training programmes. Tutor content knowledge was a recurring theme in all three focus groups. While participants stated that the training programme was useful in reassuring them they did not need to be expert in all mathematical areas, many stated that they would benefit from subject content sessions in future training programmes. This is something to be considered by all MLS practitioners - that tutors need to be supported throughout their MLS practice.

7. Acknowledgements

The authors would like to thank Mr. Stephen Quirke, for conducting and transcribing the focus groups, and the fourteen tutors who kindly gave their time to participating in the focus groups. We would also like to thank the *National Forum for the Enhancement of Teaching and Learning in Higher Education* who provided the funding that made this work possible.

8. Appendix

8.1 Questions for tutor focus groups:

8.1.1 How did the tutor training workshop impact on tutors' practice?

How much teaching in MLS had you done prior to the training workshop?

For those of you who had taught before, do you feel that the tutor training sessions impacted on your teaching in any way? How?

Can you give any example(s) of anything you did differently?

If there was no impact, why do you think this was?

The tutor training day focussed on issues relating to

- Your explaining,
- Listening,
- Questioning
- Catering for students with different levels of ability

What did you think of these?

Is there anything you were told during the training day that you would not have thought of otherwise with respect to mathematics instruction?

8.1.2 Did the training workshop prepare MLS tutors adequately for their role?

How well did the workshop prepare you for the semester that followed in terms of your MLS teaching?

Was there anything in the tutor training sessions that you disagreed with (or didn't think was useful) on the day? Why/why not?

Have your thoughts changed on this in any way? Why/Why not?

Are there any areas of teaching that you find particularly challenging or would like further training on?

How can the training be improved?

Is there anything you have learned from your tutoring/teaching that you feel would be important for new tutors to consider or do when they are starting out?

What would incentivise you to do more MLS training?

9. References

Croft, A. and Grove, M. eds., 2011. Tutoring in a mathematics support centre: a guide for postgraduate students. Birmingham: National HE STEM Programme. Available at: http://www.mathcentre.ac.uk/resources/uploaded/46836-tutoring-in-msc-web.pdf [Accessed 24 March 2016].

Cronin, A., Breen, C., Clancy, M., Cole, J. and O'Sé, D., 2016. Mathematics Learning Support in Ireland in 2016: a survey of 31 third-level institutions on the nature and extent of mathematics learning support and the associated challenges and developments. In press.

Engineering Council, 2000. *Measuring the Mathematics Problem*. [pdf] London: Engineering Council. Available at: http://www.engc.org.uk/engcdocuments/internet/Website/Measuring%20the%20Mathematic%20Problems.pdf [Accessed 24 March 2016]

Gill, O., O'Donoghue, J., Faulkner, F. and Hannigan, A., 2010. Trends in Performance of Science and Technology Students (1997 - 2008) in Ireland, *International Journal of Mathematical Education in Science and Technology*, 41(3), pp.323 - 339.

Mac an Bhaird, C. and Lawson, D., 2012. ***sigma*** *Guide: How to set up a mathematics and statistics support provision*. [pdf]. Coventry: Coventry University. Available at: http://www.mathcentre.ac.uk/resources/uploaded/51691-how-to-set-upfinal.pdf. (Accessed 17 Feb 2016).

Ní Fhloinn, E., Fitzmaurice, O., Mac an Bhaird, O. and O'Sullivan, C., 2014. Student perception of the impact of mathematics support in higher education, *International Journal of Mathematical Education in Science and Technology*, 45(7), pp.953-967.

O'Sullivan, C., Mac an Bhaird, C., Ni Fhloinn, E. and Fitzmaurice, O., 2014. *An Irish Mathematics Learning Support Network (IMLSN) Report on Student Evaluation of Mathematics Learning Support: Insights from a large scale multi- institutional survey*. [pdf] Available at: http://supportcentre.maths.nuim.ie/sites/supportcentre.maths.nuim.ie.mathsnetwork/files/uploads/docs/IMLSNFinalReportPrePrinters.pdf [Accessed 17 Feb 2016].

CASE STUDY

Employing Student Ambassadors to Enhance Mathematics Support Provision

Cheryl Voake-Jones, Mathematics Resources Centre, University of Bath, Bath, UK. Email: C.Voake-Jones@bath.ac.uk

Abstract

The Mathematics Resources Centre (MASH) at the University of Bath received funding from the Thriplow Charitable Trust to provide employment opportunities to vocational entry students. We have used this funding to enhance the support provision for students who have difficulties with the mathematical content of their course. Ideas were given to the students as to what support provision enhancement may look like, but ultimately it was left up to them to determine the most appropriate focus of any additional support. In this article, the approaches taken, the changes made and the results achieved to date are presented.

Keywords: Student employment, mathematics support, vocational entry.

1. Background

Since 2011, the University of Bath has provided support for vocational entry students entering Higher Education (HE) who have difficulties with the mathematical content of their course. This has included: provision of pre-sessional material, additional small group support and alternative teaching arrangements. Development of this support has been informed by current students entering through the BTEC route in three subject areas: Sports and Exercise Science (SES), Electronic and Electrical Engineering and Computer Science.

Activities have been developed recently to also include support for local Further Education (FE) students via the '*On Track to Uni*' initiative. This is a year-long programme designed to encourage students from widening participation backgrounds to apply for selective universities. It includes preparatory mathematics tutorials held locally in FE colleges and a residential summer school held on campus at the University of Bath.

Staff from the Mathematics Resources Centre (MASH: Mathematics and Statistics Help) at the university lead and deliver these activities, supported by colleagues from the Widening Participation Office, Admissions, and Student Experience Officers. The Centre received funding from the Thriplow Charitable Trust (Charity Number 1025531), which provides grants to support the furtherance of HE and research in institutions, to provide employment opportunities to vocational entry students.

All SES students without A-Level Mathematics (or equivalent) are required to take a credit-bearing mathematics module in first semester of Year 1, Foundation Mathematics 1. The content comprises of both refresher (GCSE standard) and new (AS-Level standard) material. Due to the high numbers of SES students with a vocational qualification (usually BTEC), teaching is split between A-Level and vocational entry students. Assessment and content is identical; the split simply allows BTEC entrants to receive more dedicated support.

All students at the university can also access support with mathematics and statistics via daily MASH drop-in sessions and one-to-one appointments for more complex statistical queries.

This article focuses on the recent developments made in enhancing support provision for SES students. I am the MASH Coordinator at the University of Bath, and also the lecturer for the BTEC cohort of Foundation Mathematics 1. In 2014/15, 102 students were enrolled on the module, of which 47 came via a vocational entry route. Respective figures for 2015/16 are 85 and 40. For ease of discussion the 2014/15 intake is henceforth referred to as Cohort A, with the current Year 1 intake (2015/16) as Cohort B. Despite these activities being undertaken by and for SES students, many of the learnings can be applied to any degree discipline.

2. Project Overview

During the spring of 2015, we employed three Cohort A SES students to work alongside us on this project. They were all from a vocational background (BTEC or Access to HE) and at the time were in Year 1, having recently completed the mathematics module. Ideas were given to the students as to what support provision enhancement may look like, with the following four ideas put forward for projects:

- Creating a survival guide for freshers';
- Creating an alternative prospectus for recruitment;
- Discipline-based mathematics resources; and/or
- Peer support.

However, ultimately it was left up to them to determine the most appropriate focus of any additional support and the direction of the project. They were given the job title of BTEC/Access Mathematics Ambassador, and as such are referred to as Ambassadors in this article.

3. Methods

The Ambassadors felt that the realisation of the importance of mathematics in their degree only really came after the completion of the module. They decided that the main aim of their work was therefore to address this issue; increase engagement with current resources and content delivery, not the development of new resources. There were two strands to their overall objective; embark upon new initiatives to enhance engagement with the current set-up, and to make improvements to the current set-up. It was made clear that large changes to the module could not be achieved in a timely manner and that the content itself was not really an area for prospective change.

Student input was key. The three employed students all had similar experiences in Year 1. They each engaged well with the mathematics module, put in a good amount of effort and achieved good grades. However, they crucially realised that they were the exception, not the norm, and wished to explore the experiences of other students in their class. Aside from informal word of mouth and anecdotal evidence, it was difficult to determine precisely how to better support students with the unit.

Two formal activities were undertaken to ascertain student opinion and feedback, a survey and a focus group. The survey was conducted via the free surveying website, SurveyMonkey (SurveyMonkey, 2016). The link to the survey was sent to all SES students and 20 responses were received. The focus group lasted approximately one hour and ten students attended. The feedback received via these avenues, alongside personal reflection from the Ambassadors, informed the activities consequently undertaken and recommendations made.

4. Actions

An overview of feedback received is given below, alongside changes made for 2015/16. Suggestions relate to how the current mathematics module and other support provision could be

amended. Many of these changes required minimal effort but often have resulted in a big impact. There have to date also been two main *new* initiatives; a freshers' survival guide and a video (more about this later).

4.1. Better and more-timely information

Students reported that the revelation of having to take a mathematics module was very off-putting, so much so that university choice was an extremely close call. More needed to be done to better inform prospective students about the support available, as well as educating them as to the purpose of the inclusion of mathematics for their degree programme. Most students were also surprised to find that there were other vocational-entry students on their degree programme, something which they would have liked to have known about sooner.

What we did: The Ambassadors attended the departmental open day that is typically popular with BTEC students. This is the time when current students reported first hearing about the mathematics module and immediately becoming panicked. As part of the information session, they spoke about the module and support offered by MASH, and were also available after the session to answer queries. The high numbers of BTEC entry students admitted to the course was also highlighted by the Admissions Tutor.

4.2 Greater encouragement for BTEC students

Entering HE from a non-traditional background can be daunting and students reported feeling less smart than their A-Level counterparts. The alternative teaching arrangements for BTEC SES students, despite being established to help them and despite assessment being identical for all students irrespective of background, felt for some like they had been put in a remedial class. They perceived that staff had lower expectations, which in turn led to reduced motivation. Students therefore need additional encouragement and need reminding that once entry to university has been achieved, all students are assessed equally. Indeed, it is worth reminding vocational-entry students that many of them thrive at university, and that their entry route can have a positive effect.

What we did: The survival guide includes clear information to address this issue. The reasoning behind the alternative teaching was explained, and also reiterated during the first week of classes. The advantages of coming via a vocational-entry background were also discussed. At open day, the Admissions Tutor also spoke about the excellent grades that can be achieved by BTEC students, highlighting that they would not keep accepting them onto the course if they were not good enough.

4.3. Shock tactics.

The mathematics module begins with a gentle introduction of rudimentary topics taught at GCSE, including BODMAS, fractions and solving simple algebraic equations. Some students were led into a false sense of security at this point and attendance soon dropped. It was suggested to include some form of assessment earlier in the semester to address this over-confidence.

What we did: The first Foundation Mathematics 1 class for Cohort B included a diagnostic exercise for all students. It lasted 20 minutes and was sat under examination conditions, with no calculators permitted. A range of topics, all to be covered in the following semester but also at GCSE level, was included. Students commented that this helped them realise how much they had forgotten.

4.4. Weekly online quizzes

In their other modules, students are used to completing weekly online quizzes that contribute a small percentage to their final grade. Given that this practice is well-established, it was recommended to introduce this in their mathematics module.

What we did: Such changes, particularly to summative assessment, cannot easily be achieved, but online resources were uploaded to allow students to self-assess progress. The majority of uploaded resources are notes, exercises and quizzes from **math**centre (2010). Weekly formative quizzes were included in class under the guise of 'Mental Maths' (no calculators allowed). An auto-transitioning slideshow, containing 10-20 questions, was used and students would attempt the questions alone. No marks were collected but it allowed students to discover which topics they might need to put more effort into; all questions were based on topics covered in the previous one or two weeks. Additionally it was highlighted which topics would feature in the coming weeks.

4.5. Dedicated drop-in support

Students reported finding general MASH drop-ins to sometimes be intimidating, due to having 'simple' questions in an environment often dominated by students studying more complex topics. Many SES students require more assistance than a typical visitor to a drop-in, so during busy sessions they reported really struggling to get appropriate help and consequently were less motivated to attend in future.

What we did: One drop-in session per week was arranged specifically for support with Foundation Mathematics 1. Attendance has been relatively good, and the session is complemented by the presence of a recent SES graduate who can help put the mathematics into context. She is volunteering in these sessions as work experience before applying for a place on a Mathematics Postgraduate Certificate in Education (PGCE) course and is a valuable asset to the sessions.

An anonymous online forum was also introduced, where students can post questions to be answered by peers or by staff. This is via Lino (Lino, 2016), a website which allows users to create a virtual noticeboard. Posts are made via a "sticky", a virtual post-it note, which can include images. This has proven to be a useful functionality in mathematics where taking a photograph of an equation is typically a simpler option than writing an equation where mathematical typesetting is unavailable.

4.6. Post-module advice

Despite efforts to tailor the module to SES topics, some students failed to fully understand that topics covered would appear later their degree. Instead the module was considered a standalone. Notes were not necessarily kept and many students aimed simply to pass the module, and not to do well in it. Better information was required as to how and why each topic was taught, where it would feature later in their degree, and the importance of not simply aiming for a pass.

What we did: Increased focus on explaining the purpose of the module has been employed at every opportunity. This includes the open day, the survival guide and in class. Most crucially, the Ambassadors, now in Year 2, attended class in the first week of the semester to speak about the module to Cohort B students. The change in attitude, when been spoken to by a peer and not staff, was palpable. The Ambassadors spoke about how many topics came up later in Year 1 as well as Year 2, and about the importance of a good set of grades if applying for placement (a popular option for SES students). The importance of attending lectures, asking for help early and attending extra support classes was highlighted.

The freshers' survival guide (Figure 1; available upon request) was created using Microsoft Publisher and is a booklet of length 12 pages, size A5. It includes information about the module, information about MASH, student quotes, an A to Z of how to survive Year 1, a list of do's and don'ts, and contact information. The overall theme of the guide is the mathematics module and support available for it, but other more general advice is included also. A copy was handed out in the first mathematics class for Cohort B and was very well-received.

Figure 1: Freshers' survival guide (front cover)

Four Cohort A students feature in the video (Figure 2), the three SES Ambassadors plus one other student who was part of the A-Level stream. Discussion topics were guided by asking questions off camera. The style is intended to be an informal chat between friends; discussing everything from their pre-conceived ideas of the module through to where the topics appear later in their degree. Once complete (it is currently in post-production), the video will be shared online and played at future open days.

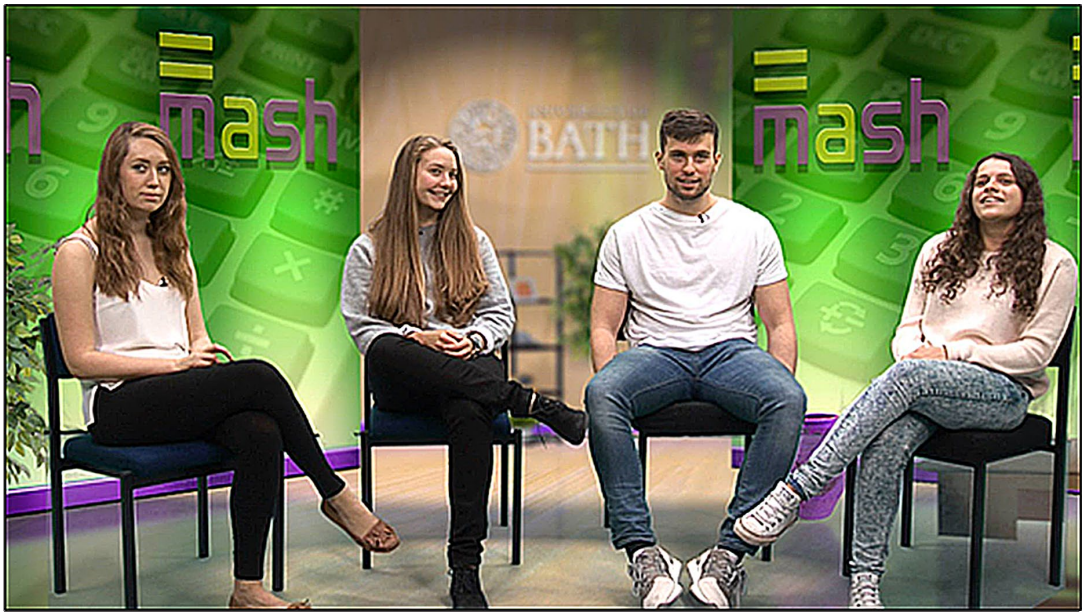


Figure 2: Filming the video

5. Preliminary Results and Next Steps

The activities undertaken were student-designed and discipline-specific. By handing ownership of the project over to the students, and deliberately not being prescriptive about the required outcomes

or deliverables, support was highly targeted. I believe that any changes to teaching activities or support provision should always be informed by students. Many of the minor amendments made have required very little effort on my part, but are things that would never have been contemplated without student input. It was made very clear to the Ambassadors that I wanted to make adjustments in order to improve the module and support provision, so that they should not feel any apprehension in suggesting changes.

One of the most noticeable impacts was having Year 2 students speak to Year 1 students at the start of the semester. Effort put in to assessment was typically low for Cohort A, with many students being very open that they simply aimed to pass the module. The attitude has, to date, been completely different from Cohort B, with students much more motivated to achieve a high grade and to understand as much of the material as possible. I believe that the potential between the groups is similar, it is simply a shift in attitude, which I also believe is largely attributable to having their peers speak to them about the module. Assessment includes a midterm test which contributes 20% of the overall module mark. Results for the midterm and overall module grade are shown in Table 1.

Table 1: Assessment results for both cohorts

Cohort	Midterm (/40)		Overall unit mark (%)	
	Mean	S.D.	Mean	S.D.
A (2014-15)	18.2	9.6	50.3	18.8
B (2015-16)	33.9	5.6	71.8	12.7

S.D. = standard deviation

Differences between the cohorts are statistically significant, $p < 0.0005$ in both cases (Mann-Whitney U test).

Now that the Ambassadors are in Year 2, they are in an even better position to understand how mathematics is used throughout their degree. We are now looking at what other enhancements can be made. They are all keen to still be involved in this work and we will also employ one Cohort B student to work alongside them.

6. Acknowledgments

The author wishes to thank the Thriplow Charitable Trust for providing funding for this project. Thanks also to all students involved in this work and particularly the Ambassadors for their hard work and enthusiasm.

7. References

Lino, 2016. *Lino sticky and photo sharing for you*. [online] Available at: http://en.linoit.com/ [Accessed 24 March 2016].

Mathcentre, 2010. *Mathematics resources*. [online] Available at: http://www.mathcentre.ac.uk/ [Accessed 24 March 2016]

SurveyMonkey, 2016. Survey Platform. [online] Available at: https://www.surveymonkey.com [Accessed 24 March 2016]

STUDENT-AUTHORED CASE STUDY

Interning for the Mathematics Resources Centre at the University of Bath – a student reflection

Emma Collins-Jones, The University of Bath, The Mathematics Resources Centre, Bath, U.K. Email: ecj26@bath.ac.uk

Abstract

In the summer of 2015, **sigma** and the Mathematics Resources Centre funded three student internships at the University of Bath to look at a student-centred approach to promoting a mathematics support centre. A recent graduate of BSc Sport & Exercise Science, I worked on this project alongside Lynn Luong (BSc Economics) and Inès Righi (BSc Politics with Economics). In this short article, I will reflect upon my experience.

Background

The Mathematics Resources Centre at the University of Bath, also known as MASH (Mathematics and Statistics Help), offers help with mathematics and statistics for all students. The MASH Coordinator, Dr Cheryl Voake-Jones, supervised the internship, and she was my first point of call in learning all about MASH. MASH offer many services, including general drop-ins, a one to one Statistics Advisory Service (SAS), and peer mentored sessions. The team also deliver lecture content on many courses, as well as working with the Students' Union to host skills workshops and a weekly puzzles café.

During my four years at University, I had made use of SAS to get help with my final year project. However I thought the drop-ins were for maths students only, and I was unware of all of the other services! I was therefore both surprised and impressed to learn more about MASH; the need for more effective promotion to students was clear.

1. Our project

As part of my initial research for the project, I wanted to understand what did and didn't work in terms of promotion. As well as talking to students, I spoke to University staff and other professional services including the Writing Centre and Careers Service. Distributed via the **sigma** mailing list, a survey was also sent out to other maths support centres. Thank you to everyone who replied. Many colleagues commented that they also had difficulty promoting their services to students and social media was highlighted as something that many centres, as well as MASH, wanted to start using but didn't know how or felt constrained by time.

Project activities included (but were not limited to) enhancing MASH's profile on social media, making a promotional video, and developing the range of posters used across campus. I had experience of managing social media in my part time job, and on my placement year, and therefore took the lead on this. However, I learnt a lot from bouncing ideas around with Cheryl, Inès and Lynn, and we all had slightly different thinking about how things should be done and had to work out the best strategy for MASH.

Facebook and Twitter were chosen as our social media platforms of choice, as they were already being used by other professional services on campus, as well as widely used by students. I was keen to establish a 'brand' for MASH and this was done by being consistent with eye-catching branded images on Facebook and Twitter. In terms of content and interacting with students, previously the posts had been sporadic, but it was decided that MASH should put out content every

day. I set up a Hootsuite account, which enables the posts to be scheduled easily. Hootsuite (https://hootsuite.com/) is a social media management dashboard, and I would recommend it to anybody using more than one social media platform.

Since starting this project, our social media profiles have been transformed. Posts include not just MASH events but anything interesting that's going on, both on and off campus (public lectures, online courses, Students' Union news, …). and every Friday, MASH posts a maths joke or pun (see Figure 1). One of Cheryl's initial concerns was whether we would have enough content to post about, but the reality is that once you start looking, there is plenty out there. In two months, MASH went from less than ten friends on Facebook and followers on Twitter, to 490 Facebook friends and 160 Twitter followers. As a result of this project, MASH now ask students how they knew about the service when they first attend a drop-in, so that they know how effective their different promotional strategies are. It's been pleasing to see students reporting Facebook and Twitter.

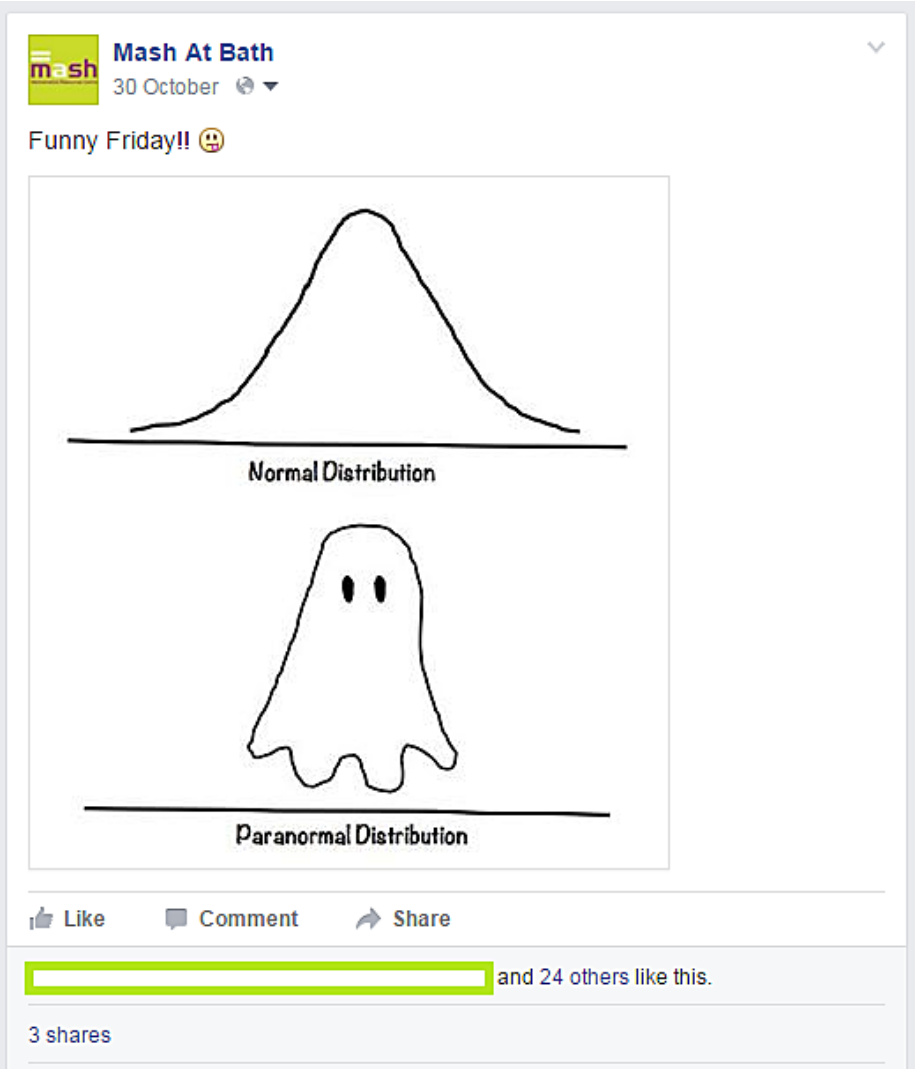


Figure 1. Example Facebook post

To follow MASH on social media, search 'Mash At Bath' on Facebook, and @BathMASH on Twitter.

2. On our travels

During the internship, Cheryl and I were invited by Dr. Ciarán Mac an Bhaird, Lecturer and Maths Support Centre Manager at Maynooth University, to present at the *Irish Mathematics Learning*

Support Network Workshop on using Social Media to Promote Services. This was a great opportunity for me to gain experience presenting and, although somewhat nerve wracking to present to a room of academics having just finished my undergraduate degree, I was confident that the work we had done with social media at MASH was worth sharing. I presented on the practical aspects of social media, defining terms such as 'likes' and 'shares'. I didn't go through a PowerPoint but instead did somewhat of a virtual tour of Facebook and Twitter (where to post, search for contacts etc). Questions, and playing around on laptops, was encouraged and this approach made the session interactive and less boring (hopefully). Despite the early start (we flew to Ireland and back again the same day), it was great to meet colleagues from different universities and Ciarán gave us a fun tour around Maynooth!

Another great opportunity was to present as part of the student plenary session at the 2015 CETL-MSOR conference at The University of Greenwich (see Figure 2). Being at the conference gave me a broader insight into maths support, and I enjoyed meeting not only staff but students from other universities who had been interning that summer. I was impressed by the broad range of projects being worked on. Lynn, Inès and I received lots of positive feedback about the work we presented, and we noticed other institutions setting up social media accounts after our talk. It has been really rewarding to have worked on a project that helps not only MASH at the University on Bath, but other institutions too.

Figure 2. Inès, Cheryl, Lynn and Emma (from left to right). Smiles all round after our CETL-MSOR presentation.

3. Personal benefits

My internship with MASH was eye-opening and rewarding. The experience of going from student to staff in the University was very empowering. I enjoyed setting up meetings with different departments, presenting, and working creatively with the other interns. I was able to put some of the skills I learnt in my degree into practice; for example analytical and problem solving, and could use my experience as a student to make meaningful contributions. I even got to use the staff canteen!

A benefit from my internship is that MASH now employ me for a few hours a week to manage their social media, among other tasks. My supervisor, Cheryl, lists ideas for things to post on social media and then I spend an hour or two a week writing them in a student friendly way, creating images, researching other articles, etc. Using Hootsuite (mentioned earlier), I can schedule the posts to go

out at different times each day. Furthermore, I have also been approached by **sigma** to deliver more social media workshops and to look further into the use social media in maths support.

4. Next steps

A social media guide is being put together which will cover the very basics of what social media is and how to use it, as well as how best to engage with students (and other academics and services). I hope other centres can take the lead from MASH and increase their social media presence to engage more students and help them with maths and stats.

5. Acknowledgements

I would like to thank **sigma** and MASH (in particular my supervisor Cheryl) for giving me this opportunity.

CASE STUDY

Improving retention for all students, studying mathematics as part of their chosen qualification, by using a voluntary diagnostic quiz

Carol Calvert, The Open University, Milton-Keynes, UK. Email: carol.calvert@open.ac.uk
Rachel Hilliam, The Open University, Milton-Keynes, UK. Email: rachel.hilliam@open.ac.uk
Juliet Coleman, The Open University, Milton-Keynes, UK. Email: juliet.coleman@open.ac.uk

Abstract

This case study demonstrates the issues and advantages in encouraging students to take responsibility for their learning and to be better prepared both in terms of knowledge and expectations for their study. The study outlines the improvement in retention achieved when students were encouraged to use a voluntary diagnostic quiz on a first year university mathematics module. Initially the power of the diagnostic quiz, in predicting future success on the module, was identified using predictive analytics. Students were contacted by experienced Education Guidance staff who encouraged them to take the quiz prior to course start with the aim of using their results to steer them to start on the "right" course. The diagnostic quiz total score was made available to the student's course tutor prior to course start to enable further tailoring of support to individual students. Early indications show an improvement in early module retention. The module in this case study was for distance learning students on an open access mathematics course.

Keywords: diagnostic quiz, predictive analytics, retention, distance education, learning analytics.

1. Introduction

The Open University UK (OUUK) is a distance learning environment with an open entry policy where the vast majority of the undergraduates are studying part-time. Students are initially advised by a generalist advice service supplemented later by an education guidance team specialising in their chosen curriculum. Students are supported during their study by a local personal tutor who is an Associate Lecturer at OUUK. Powerful statistical analysis, using predictive analytic techniques, has recently added to the evidence base upon which to base advice and support. There is an increased amount of this type of work, called learning analytics, in the University.

OUUK allows its students considerable flexibility in managing their pace and volume of study together with their qualification route. OUUK modules are typically 30 or 60 credits of study with one credit being the equivalent of 10 hours of study. Three hundred and sixty credits are required for an honours undergraduate degree. OUUK Level 1 study is broadly equivalent to first year undergraduate study. There are three mathematics modules at Level 1 and all are 30 credit modules. They are not only studied by Mathematics students as they also form compulsory or optional elements of a range of qualifications from other disciplines like Engineering and Science.

"Essential Mathematics 1" (MST124) is the standard start mathematics module. It is a core option for around 20 qualifications and it is compulsory on over 40 qualifications. The module has a poor pass rate and it is possible for a number of qualifications for students to study an alternative starting module "Discovering Mathematics" (MU123). There is a high quality diagnostic quiz "Are you ready for MST124" (OUUK, 2016) which is underused by students and its power, in terms of helping students with MST124, is underrated. The quiz is designed to be ideally taken pre-registration in order to aid module choice and as such is freely available to both current and prospective students.

The approach taken in this case study was to first demonstrate the potential of the quiz as a predictor variable for future success on MST124. The evidence was then shared with staff for use in an advisory conversation with students prior to module start. Students with low or no quiz results were contacted and encouraged to do the quiz or advised about options if they had a low score.

Calvert (2014) identified a core set of explanatory variables linked to student success at different points, or milestones, in a student journey. The same approach has been adapted to apply specifically to MST124 with the addition of one specific explanatory variable: the results of the diagnostic quiz for that module.

2. Mathematics Diagnostic quizzes

Mathematics diagnostic quizzes are widely used to establish the mathematics ability of students preparing to study mathematics and non-mathematics qualifications. Batchelor (2004), provides a literature review and a specific example of a mathematical diagnostic test for Pharmacy undergraduates. Many students who take the OUUK standard start mathematics MST124 module are not mathematicians: most are from other disciplines including a large group of engineers.

The Engineering Council (2000) commissioned work on the teaching of mathematics for Engineers, and this included looking at mathematics diagnostic quizzes in use at several universities. The Engineering Council had four key recommendations of which the first two were:

1. Students embarking on mathematics-based degree courses should have a diagnostic (maths) test on entry;
2. Prompt and effective support should be available to students whose mathematical background is found wanting by the tests.

OUUK has a long tradition of using diagnostic quizzes prior to entry level study. As a distance learning institution the OUUK does not have students physically on campus, this provides challenges both in terms of encouraging students to undertake the quiz and then providing the support to enable students to understand the implications of their chosen study module based on their quiz score.

Lockwood (1989) evaluated the effectiveness of such OUUK diagnostic materials including a Mathematics Preparation Pack which included a diagnostic quiz. Over 90% of the students he surveyed self-reported that they did the quiz, but only 14% decided to study further material recommended to improve their level of preparation for their chosen course. Centrally held data suggested that 7% of 2014 MST124 October entrants had taken the MST124 Diagnostic Quiz. However this is an underestimate as it does not take into account students who take the quiz on the OUUK external website prior to registering or elect to take a paper rather online version. In these cases it is not possible to link the quiz score to the student and therefore not included in the 7%.

Donavan & Loch (2013) describe one way in which active learning can be achieved in large first-year mathematics classes. They also provide a literature review of active learning and highlight that “in active learning approaches, students take responsibility for their learning”. MST124 is potentially an entry level module and the diagnostic quiz “Are you ready for MST124” is very much in the spirit of active learning with immediate feedback and with students retaining the decision about whether to take the MST124 module or transfer to MU123 or, indeed, study a different module completely. The quiz consists of 20 questions and each question can be attempted three times before the correct answer is supplied. The questions cover algebraic manipulation, solving equations, factorisation and

expansion and basic trigonometry. A first correct answer scores 5 points, a correct answer on the second attempt 3.33 and on the third attempt 1.67. After two incorrect attempts a hint is given and a full answer is given after a third incorrect attempt.

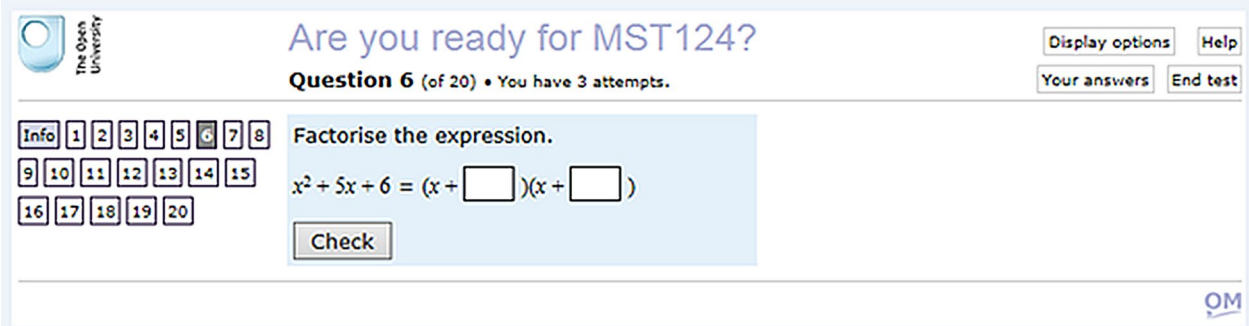


Figure 1: Example of a diagnostic quiz question for MST124

3. Demonstrating the usefulness of the quiz

OUUK have a statistical model based on logistic regression which identifies key variables which can be used to predict student success at different milestones in their OUUK student journey (Calvert, 2014). The model is very flexible and runs with a standard set of thirty possible variables from which the most statistically significant factors at particular milestones are selected. The model was adapted in the case study to run specifically against MST124 and with new variables relating to whether the quiz was taken or not (quiz_flag) and the quiz score.

The quiz is optional and hence, merely by taking the quiz, it indicates a measure of engagement with study by the student. Additionally, it is a relatively direct measure of ability in mathematics and hence potentially a measure of mathematical success. There are therefore two strong theoretical reasons to believe the quiz would be closely associated with success on the module. The quiz is available to be taken prior to module start and it is therefore possible to include the quiz results in runs of the model well before students start study on MST124.

The model, running on data available before students started on the October 2014 presentation, identified that simply taking the quiz, was a significant variable in predicting if the student would be present at crucial fee points part way through the module. A fee point is where English students become liable to the English student loan company for a percentage of their study fees. For the first fee point the quiz_flag was one of nine variables identified. For the second fee point it was one of eleven variables and for the third fee point one of twelve variables. Students complete MST124 when they sit the examination and quiz_flag was one of fourteen variables identified as predicting completion and one of eleven useful in predicting passing the module.

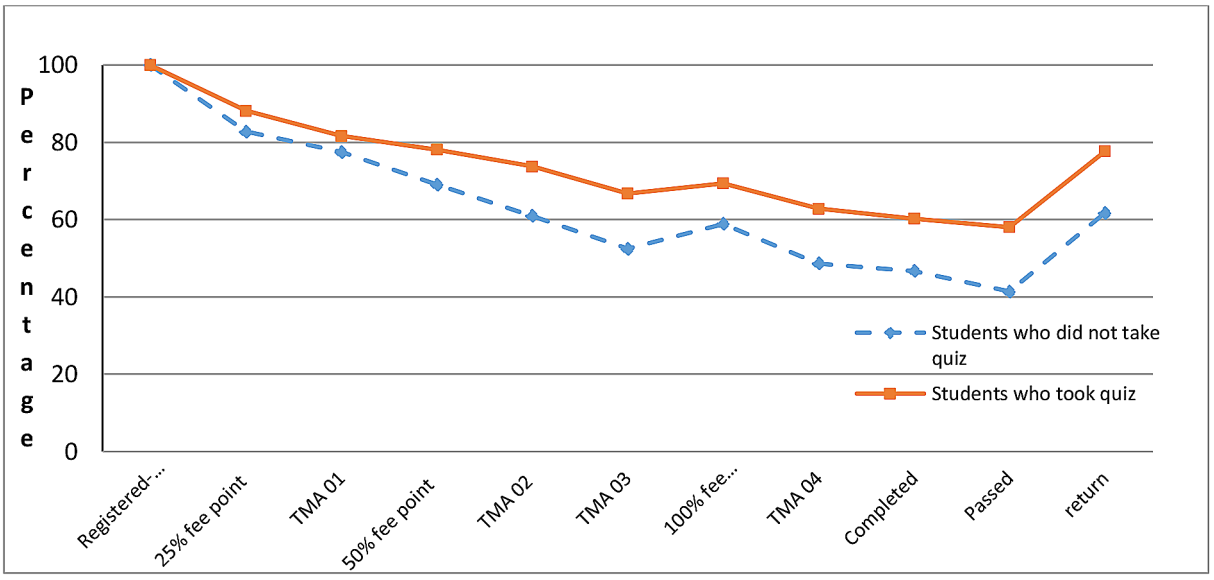


Figure 2: Percentage of registered students on October 2014 presentation of MST124 who were present at key points during the module: by those who had taken quiz and those who had not.

For presentation purposes, rather than look at the logistic regression probability outputs, it proved helpful to separately plot the paths of students who had taken the quiz and those who had not. Figure 2 shows the percentage of the original group, for those who took the quiz and those who did not in the October 2014 cohort, who were present at the fee points. In addition Figure 2 also shows the percentage of students submitting each of the four Tutor Marked Assignments (TMA). Students passively withdraw during the module and this is frequently evidenced by the student failing to submit a TMA. It is therefore typical that to see more students apparently still registered at the 100% fee point than the numbers who submitted TMA03 despite the 100% fee point being after the TMA03 due date.

4. Uptake of the diagnostic quiz

MST124 was introduced in 2014 and the MST124 diagnostic quiz is designed to help students identify areas where they may experience difficulty. Table 1 shows that only a very low percentage of students took the quiz in October 2014. Hence the first issue to be addressed was to encourage students to take the quiz so that the student could be advised accordingly.

Table 1 Numbers and percentages registered on MST124 at module start who had a quiz score (October 2014 and October 2015)

	Number students at module start	Number of those registered who had taken quiz	Percentage of those registered with quiz score
Oct 2014	2 686	199	7%
Oct 2015	2 919	606	21%

5. Getting the student to take action

The quiz is merely an initial stepping stone to getting the student better prepared for study. Students would ideally take the quiz, identify any areas of weakness, re-consider their choice of MST124 and if necessary submit a change of study. In Scotland, to prompt student action, two Associate Lecturers (tutors) were employed to contact Scottish students who had registered on the October 2015 presentation of MST124 and who had either a low, or no score on the quiz. For all other nations the central Student Support Team (SST), consisting of specialist advisory staff, contacted students with a low score or no score by either email or phone.

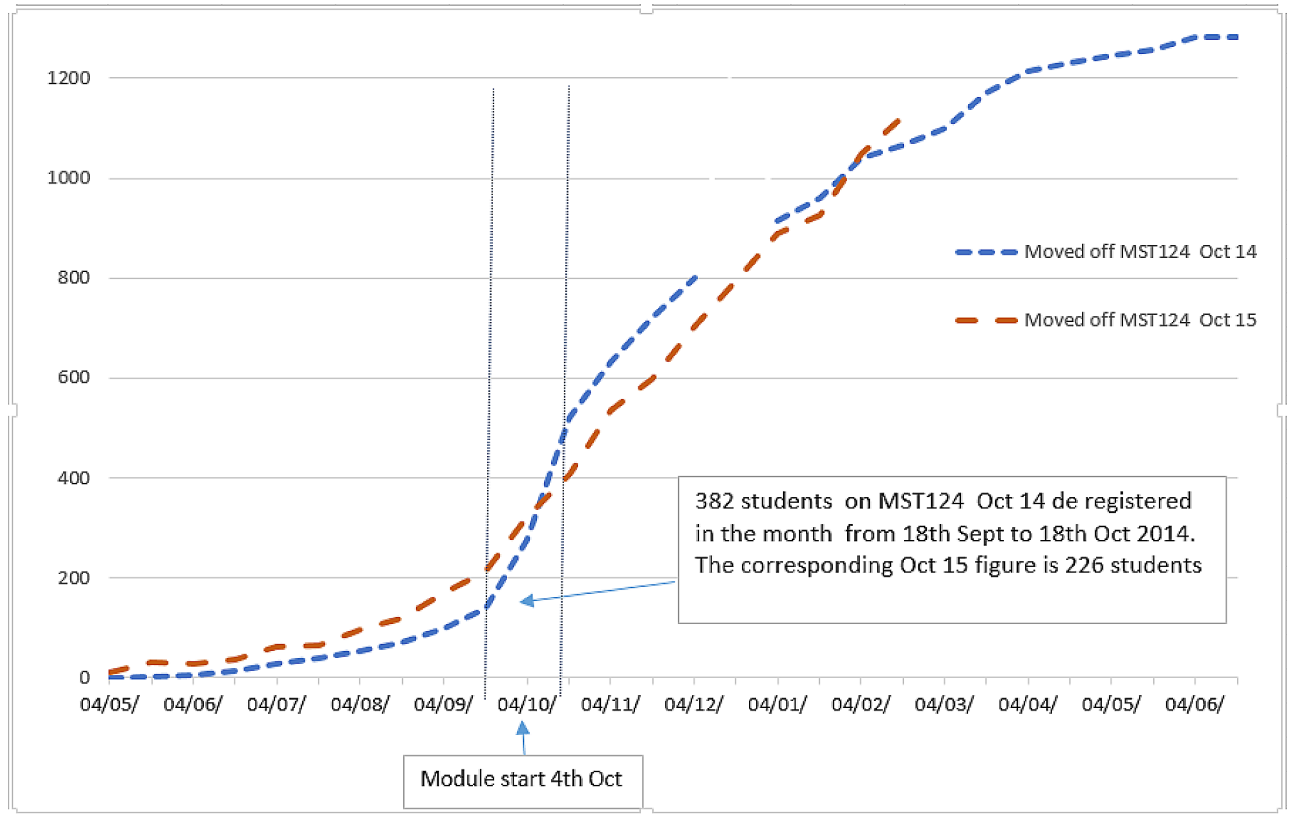


Figure 3: Numbers of students on MST124 Oct 2014 and Oct 2015 who de-register

If students had registered on MST124 and the mathematics involved was unsuitable for them we wanted to see the student withdraw from the module before module start. We also wanted the students who remained on MST124 to be better prepared and hence more likely to stay on MST124. So for October 2015 we wanted to achieve more de-registrations, initiated by the Univerisity or the student, before the 4th October module start date and fewer after that date compared to October 2014. Figure 3 indicates that we saw this effect.

There were just over 230 more students on the October 2015 intake for MST124 than there were in the October 2014 intake. We therefore expected there to be more de-registrations (in terms of numbers) for October 2015 and our aim is for there to be a lower percentage who fail to pass the module. The number of de-registrations was in fact lower, as seen in figure 3, until around week 16 of the module although,at that point in the module, in percentage terms it was still lower at 38% compared to 40% for the October 2014 cohort.

Additionally we would have wished to see students transfer to the alternative module MU123 if their qualification route permitted. Here we had little success with only 80 students transferring to MU123 prior to module start compared to 64 in the previous October of 2014.

6. Reluctance to action advice

The discussions with students in the early work on this study established a strong reluctance from students to engage with the University's worries about their ability to study successfully on the module. Students with low quiz scores responded to advisors with comments that they "felt confident"; "felt happy with the challenge of MST124"or "planned to get up to speed before October". Similarly students who had not taken the quiz were typically happy to have been contacted but responded along the lines of the student who was recorded as "Student will take the quiz to check any areas he needs to revise, but is confident". This is not an outcome restricted to OUUK or mathematics diagnostic tests. Batchelor (2004), in relation to new Pharmacy undergraduates using diagnostic maths quizzes, observed that "…students for whom the tests were designed, those with lower mathematical background knowledge, were not using these facilities".

The psychological phenomenon known as Cognitive Dissonance could be one explanation for students not taking the quiz, taking it and ignoring the results or not heeding advice based on quiz results. Cognitive dissonance (Freily and Kothe 2013) demonstrates that once a "difficult to make" decision is made, it becomes fixed and it is difficult to undo. The decision maker actively avoids seeking out or hearing contradictory information as this makes them very uncomfortable. Preventing a student making the wrong initial decision about which mathematics module to study in the first place, and therefore becoming resistant to information or advice, is critical.

For those students who cannot be encouraged to take the quiz and, as necessary, take on additional study to address areas of difficulty or consider a move to MU123 there is another potential intervention point with the students' tutor (Associate Lecturer). The students' quiz scores, where known, where placed into the electronic set of information available to Associate Lecturers about their students. This pack of information becomes available around 2- 4 weeks before MST14 starts. The Associate Lecturer might be able to encourage any of their students for whom there is no quiz score to take the quiz from the internal site. If any of their students have a low quiz score then the Associate Lecturer will be able to discuss, in advance of the start of MST124, additional preparatory resources to help the student succeed.

7. Conclusions

The pass rate for students who have done the "Are you ready for MST124" diagnostic quiz is around 60% whilst for those who have not done the quiz it is 40%. Taking the quiz captures a willingness on the part of student to engage early with their mathematical study; getting a good score on the quiz indicates that the student already has sufficient mathematical knowledge to be well placed for successful study of the module. The simple act of taking the quiz is statistically a much stronger predictor of success than the score.

The quiz merely represents the first step in the task of trying to ensure that students are adequately prepared for their study. For some students there is a possibility that their qualification pathway would enable them to study MU123 and this may therefore be a more appropriate choice. Some students may already have studied MU123 or their qualification may require them to study MST124 but we have a wealth of materials available to support such students not least the support all students get directly from their personal tutor.

Students welcomed the contact from advisors at an early stage but very few followed up the discussion by either taking the diagnostic quiz or moving to another module where this was available. A possibility, despite issues around ethics and creating psychological discomfort, is to design an intervention based around success rate information to jolt students into using the quiz to establish their readiness for study.

8. References

Batchelor, H., 2004. The importance of a Mathematics Diagnostic Test for Incoming Pharmacy Undergraduates. *Pharmacy Education*, 4(2), pp.69-74.

Calvert, C., 2014. Developing a model and applications for probabilities of student success: a case study of predictive analytics. *Open Learning,* 29(2), pp.160-173.

Donavan, D. and Loch, B., 2013. Closing the feedback loop: engaging students in large first-year mathematics test revision sessions using pen-enabled screens. *International Journal of Mathematical Education in Science and Technology*, 14(1), pp.1-13.

Engineering Council, 2000. Measuring the Mathematics Problem. [pdf] London: Engineering Council. Available at: http://www.engc.org.uk/engcdocuments/internet/Website/Measuring%20the%20Mathematic%20Problems.pdf [Accessed 24 March 2016]

Freijy, T. and Kothe, E., 2013. Dissonance-based interventions for health behaviour change: A systematic review. *British Journal of Health Psychology*,18(2), pp.310-337.

Lockwood, F., 1989. The evaluation of Open University preparatory packages, *Open Learning: The Journal of Open, Distance and e-Learning*, 4(2), pp.43-46.

OUUK, 2016. Maths Choices [online] Available at: http://mathschoices.open.ac.uk/are-you-ready-quizzes/mst124-quiz [Accessed: 24 March 2016]

Simpson, O., 2006. Predicting student success in open and distance learning. *Open learning*, 21(2), pp.125-138

Slade, S and Prinsloo, P., 2013. Learning analytics: ethical issues and dilemmas. *American Behavioural Scientist*, 55(10) pp.1509-1528.

CASE STUDY

Peer Assisted Study Support (PASS) and Students as Change Agents (SACA) in Mathematics at the University of Nottingham

Stephen Cox, School of Mathematical Sciences, University of Nottingham, Nottingham, UK. Email: stephen.cox@nottingham.ac.uk
Laurence Cook, School of Mathematical Sciences, University of Nottingham, Nottingham, UK.
Sam Nield, School of Mathematical Sciences, University of Nottingham, Nottingham, UK.

Abstract

In 2015-16, a Peer Assisted Study Support (PASS) scheme was introduced in Mathematics at the University of Nottingham. A distinctive feature of this PASS scheme is its intimate linking to the University's Nottingham Advantage Award (NAA) scheme, which recognises a wide range of students' extracurricular activities, including serving as a PASS Leader. Furthermore, the PASS scheme has been developed in conjunction with the NAA's Students as Change Agents and Change Leaders (SACA and SACL) programmes, which recognise student-staff partnerships that change teaching and learning practice. Essential to the success of the scheme has been its genesis through such a partnership, in particular two summer internships in 2015 to develop PASS materials, supported by the Sigma Network and the University's Teaching Transformation Programme.

Keywords: PASS, transition, student support, student-staff partnership, Nottingham Advantage Award.

1. Peer Assisted Study Support and Students as Change Agents

Peer Assisted Study Support-type schemes are nowadays fairly common in university mathematics departments. Kane and Sinka (2009) describe some wide-ranging examples, from specific module support to transition support focussed on providing an introduction to university services. Not only do PASS schemes provide support to first-year students in their transition to university mathematics, they also provide useful curriculum support, and significant CV benefits for the students involved (Hibberd and Grove (2009) discuss the challenges in developing employability skills in maths programmes). In the Nottingham incarnation, PASS groups have regular scheduled meetings consisting of around a dozen first-year students and three higher-year students (the PASS Leaders). The academic staff member responsible (PASS Director) is the first author; between him and the PASS Leaders are five Senior PASS Leaders who help administer the scheme.

The key distinctive feature of the PASS scheme at Nottingham is that it has been developed from the start as a student-staff partnership; this aspect has helped to ensure buy-in from students, and has helped us to tailor the scheme to our students and to fit it to our curriculum. We borrowed the general framework from the successful scheme at the University of Manchester (Walker, 2015) and impetus was provided through the University of Nottingham's Teaching Transformation Programme (TTP). In late 2014/early 2015, the first author collaborated with the student Mathematics Society, MathSoc, then with a focus group of interested students, to begin to shape the scheme. Some of the focus group students were pioneers on the new NAA module Students as Change Agents, which allowed their contributions to scoping and shaping the scheme to be formally recognised by the University. These SACA students went on to be the first generation of Senior PASS Leaders.

1.1. Organisational principles of PASS

We would select the PASS groups by combining pairs of first-year tutorial groups (each comprising 5-6 first years). This would have the advantage that right from the start the first years would already

know some others in their PASS group. Overall, this feature was generally reported by PASS Leaders as contributing positively to the atmosphere of PASS sessions at the start of the academic year. However, one unanticipated slight problem with this arrangement proved to be that in a small number of cases attendance at PASS sessions suffered from a "herd" effect, whereby the absence of one or two key students from one tutorial group would seem to lead to the absence of that entire tutorial group en masse.

PASS groups would meet informally at the start of the new academic year to fulfil a welcoming, mentoring role, equivalent to the Parenting Scheme historically run by MathSoc. This Parenting Scheme had involved higher-year students providing an informal introduction/welcome to the University for the first years. Unfortunately, the lifetime of the "parenting" relationship had typically been very short, often not extending beyond the induction week at the start of the year, and we were keen to improve this.

Formal PASS sessions would not begin until the third week of lectures. This would allow plenty of time for training of PASS Leaders, with some contingency, as this was the first year of operation. With hindsight, this hiatus was a mistake, as students seemed to be eager to start PASS sessions, and concerns regarding the logistics of an earlier start proved unfounded.

PASS sessions would combine some peer mentoring-type discussion with academic work. This decision was in contrast to a University move towards purer Peer Mentoring schemes, and meant that our scheme involved considerably more work to set up. To some extent, this decision to provide an obvious academic purpose to each session was made in the expectation that first-year students would readily appreciate this purpose, and hence engage well with the scheme. It would also improve buy-in from staff, who would recognise the value of the scheme in developing key mathematical skills and knowledge, both in the first-year students and also in the PASS Leaders. The ostensible academic focus of each session was also provided in the knowledge that the interpersonal skills required for effective peer mentoring are not naturally well developed in many of our mathematics students; thus the peer-mentoring aspect could take place within a "safe" mathematical context.

PASS sessions would take place fortnightly, with training sessions in the intervening weeks. This decision was made in part to limit the commitment required of PASS Leaders and in part to limit the number of session plans that needed to be completed for the first year of operation.

Bespoke academic content would be created, free from specific module "branding"; this would allow focus on areas of perceived student weakness (proof, curve sketching, use of definitions, …) and help to demodularise student thinking, with an eye on trying to address the "Mathematics Problem" (LMS 1995). In fact, somewhat predictably, even though module "branding" was not explicit, anecdotal evidence from PASS Leaders suggested that the first years did tend to assign PASS topics to specific modules, so the attempt to demodularise was only a partial success.

A bespoke Nottingham Advantage Award module would be created for PASS Leaders. This module would be optional and would be assessed through a reflective piece of writing, of 500-1000 words, for which training was provided by the University's Careers and Employability Service. Around one-third of PASS Leaders had cited the existence of this NAA module as a key factor in their decision to apply for the scheme; in the end a much greater proportion – around two-thirds – took the assessment. Even if students do not complete the full Award (which generally requires successful completion of three of its modules), individual NAA modules are recorded with their University transcript.

2. Implementation

Support for the new scheme from students has been overwhelming. Indeed, so many students volunteered to be PASS Leaders that we were able to assign three PASS Leaders to each PASS group, rather than two, as had originally been planned.

Essential to the success of the nascent scheme was the work done over summer 2015 by the present authors in writing PASS materials. Some of these materials were road-tested on other students undertaking summer projects in the School, and then further adapted as a result. The summer interns were supported by generous grants from the **sigma** Network and the University's TTP. The summer internship proved to be an intensive period of work and provided us with many different challenges each day. We had just six weeks to produce – from a nearly blank page – a comprehensive set of materials to support the PASS sessions which would start in September. We capitalised on this freedom by including topics that the students had found difficult in their own personal experience of first year mathematics, as well as topics recommended by staff and topics that we felt would prove useful in later years but traditionally tended to get rather disregarded by first-year students (noting the findings of LMS (1995)).

One particular synergy emerged among the internship team in devising the seventh PASS session of the year, which had initially been focused simply on the routine calculation of eigenvalues and eigenvectors for matrices. We realised that we were frustrated because we had in addition some unrelated, unused partial sessions written to practise use of the Cayley-Hamilton Theorem and also a bunch of ideas on false proofs left over from the early PASS sessions. Between the three of us, we combined these ideas (wisely or unwisely) into one session. This session would start with a false proof based, quite transparently, around division by zero. Then an apparently unrelated calculation would follow of the eigenvalues and eigenvectors of a matrix $\mathbf{A}$, with one of the eigenvalues turning out to be zero. Finally an attempt would be described at using the Cayley-Hamilton Theorem to calculate the inverse $\mathbf{A}^{-1}$ (which, of course, does not exist). Thus the session would link back to that attempted division by zero at the start, with the moral that division by zero (or multiplication by a non-existent inverse) may not be quite so easy to spot as one might think.

Timetabling of PASS sessions proved to be (just about) possible, even though it required coordination between timetables of all years and across single and joint honours programmes. We managed to avoid any 9am slots, and kept rooms to a civilised side of our large University Park campus. The only significant gripe expressed by first-year students regarding the scheme has concerned the timing of particular PASS sessions. Dissatisfaction has been expressed both in cases involving a long, contiguous block of contact time for the students and also in cases where the PASS session is isolated from other teaching activities in the timetable (some instances of far-from-optimal scheduling had proved unavoidable, given the complex make-up of the student body participating in the scheme). We have allowed PASS groups to request an alternative time for their sessions, provided they can agree on a better time: in some cases, PASS groups have moved and in others no better time has been found.

PASS Leaders support one another through a dedicated Facebook group, which is used to share insights into the way that sessions might be run and to promote forthcoming events. They receive PASS Leader hoodies, which many proudly wear around campus, enhancing the feeling of community. There have been numerous competitions associated with PASS, including one to generate photos that can be used to promote the scheme internally and at Open Days and Visit Days (see Figure 1).

3. Student feedback

Student feedback has, not surprisingly, been overwhelmingly positive. One important source of feedback came from a poll administered by the Senior PASS Leaders, based on a Google form, which most (137) students completed during their final PASS session before the Christmas vacation. Inter alia, students were asked whether PASS had been useful for them (over 75% felt so), what the most useful PASS topic had been ("proof", followed closely by "curve sketching") and what they felt about the level of the PASS questions. Intriguingly, over 90% of the first-year students chose "about right" (rather than "too easy" or "too hard") to describe PASS questions. Our interpretation of the last, rather striking, finding is that, even though some questions may have seemed tough at first sight, the availability of immediate help generated in the minds of the first years the perception that (perhaps with hindsight) the questions had been at the right level.

First-year students greatly value the contact with friendly, more experienced students, especially at the start of the year. They also greatly appreciate the academic support they receive, and recognise the efforts that their PASS Leaders make to help them. PASS seems to generate an enhanced community spirit in the School, perhaps aided by the fact that we are lucky enough to have our own dedicated building.

First-year students say "the best thing about PASS is the opportunity to speak to students who have already been through first year and ask them questions about student life in general as well as maths" and "the mentors can sympathise with the stuff we find hard, where a lecturer might not understand :)". PASS Leaders say "as a result of being a PASS Leader, I would now feel more comfortable and willing to take on leadership roles", "I've really enjoyed the sessions once we get down to the maths and I'm explaining a detailed point to someone. I get a great feeling explaining something to someone or showing somebody that the maths is really cool".

In their NAA reflective assessment, PASS Leaders recognised their role in supporting a diverse student body, saying "we ended up [being] very inclusive, utilising our range of personalities to cater for all", "most of our learning resulted from the ways we adapted to different students' needs", "I have tried to adjust my mentoring style depending on the group", "the biggest challenge was trying to find out the best way to learn for a particular person" and "I have learned how to alter my approach in situations to suit different students and learning styles".

One PASS Leader wrote "from the outset, there was a feeling that everyone involved in PASS is part of a team and as a result I had a real incentive to make the sessions go as well as I possibly could". An important aspect of the scheme is the employability skills that the PASS Leaders pick up – these are difficult to develop elsewhere in a mathematics course; one PASS Leader wrote "these are skills that I have been able to use in job interviews by using PASS as an example [whereas] before this year I have been struggling to find examples of [using] these qualities in real life".

Figure 1. PASS Group R won the photo competition – a PASS session in action!

4. Future developments

The PASS scheme provides benefits for students in many ways. First years get support in their transition to university, academically and personally. PASS Leaders and Senior PASS Leaders get significant CV benefits, whether or not they complete one of the associated NAA modules. PASS also allows students with a passion for mathematics to share that passion in an effective way (Duah, Croft and Inglis, 2013). But there is more to do.

With hindsight, we were too conservative deciding to start the formal PASS sessions so late in the Autumn Term; in future years we would aim to begin them earlier, in the second week of lectures. Student feedback has also consistently asked for more PASS sessions, so we aim to run ten PASS sessions in 2016-17 instead of the eight that ran in 2015-16.

As part of the NAA's Students as Change Leaders programme, this year's Senior PASS Leaders are extending and more properly defining the role of the Senior PASS Leader so that, over time, more responsibility for the running of the scheme can pass from staff to students. Such a transfer of responsibility is valuable for ensuring relevance of the scheme and for providing greater latitude for students to develop the scheme according to their own initiative.

5. Conclusion

Success of the PASS scheme at Nottingham owes itself to a number of factors. First, we had strong support both from within our institution and from outside; in particular, there was strong buy-in at all levels in the School of Mathematical Sciences. Also, we developed the scheme from the start as a student-staff partnership, rather than a "top-down" generic imposition. We also provided each session with a clear academic focus. These considerations helped to ensure that the scheme was genuinely meaningful to our students. By working closely with the Nottingham Advantage Award and with the University's Careers and Employability Service, we were able to maximise the careers benefits for those involved.

We are happy to share our experiences and our materials with colleagues in other institutions. While materials have been designed to fit the timings of the curriculum and other events in the University of Nottingham calendar, they also have quite general features that may be of interest. Interested readers should feel free to contact the first author.

6. References

Duah, F., Croft, T. and Inglis, M., 2013. Can peer assisted learning be effective in undergraduate mathematics? *Int. J. Math. Education in Science and Technology*, 45(4), pp.552-565.

Hibberd, S. and Grove, M., 2009. Developing graduate and employability skills within a mathematical sciences programme**.** *MSOR Connections*, 9(2), pp.33-39.

LMS, IMA & RSS, 1995. *Tackling the Mathematics Problem*. [pdf] London: LMS. Available at: http://www.mei.org.uk/files/pdf/Tackling_the_Mathematics_Problem.pdf [Accessed 10 April 2016].

Kane, S. and Sinka, I., 2009. Good practice in undergraduate peer support. *MSOR Connections*, 9(4), pp.11-14.

Walker, L., 2015. Enabling students to become independent learners. In M. Grove, T. Croft, J. Kyle and D. Laswon, eds. *Transitions in Undergraduate Mathematics Education*. Birmingham: University of Birmingham.

CASE STUDY

When will I ever use that? Giving students opportunity to see the direct application of modelling techniques in the real world.

Ros Porter, Dept. of Engineering and Mathematics, Sheffield Hallam University, Sheffield, UK. Email: r.porter@shu.ac.uk
Hannah Bartholomew, Dept. of Engineering and Mathematics, Sheffield Hallam University, Sheffield, UK. Email: h.bartholomew@shu.ac.uk

Abstract

Mathematical modelling is unfamiliar to many young mathematicians and can be a source of anxiety for many. Although many first year mathematics undergraduates will have used mathematical models throughout GCSE and A Level most are unaware of this. Very few understand what a mathematical model is, fewer still the concept of building a model. In our experience students are reluctant to try and build their own models and fail to see the value of modelling skills in the real world. We invited 3 speakers to attend a first year modelling lecture to talk about the models they use in their jobs with the intention that this would help students see that modelling skills and analytical thought processes are valuable tools for a maths graduate. The speakers had different employment backgrounds being from banking, research (chemistry) and transport engineering. Each spoke for approximately 10 mins. giving an outline of their field. The lecture was followed by tutorials in which students were asked to reflect on what the speakers had said and how this related to their own learning. Two of the speakers also attended the tutorials and were able to have more informal conversations with the students.

Keywords: Modelling, skills, employability, reflection.

1. Introduction

Sheffield Hallam University (SHU) has a strong reputation for embedding employability within its Maths degree (Robinson, Challis and Thomlinson, 2010; Pegg et al., 2012). One of the modules that contributes to the development of graduate skills is Modelling 1, the first year modelling 20 credit core module. The first year cohort is approximately 100 students from a variety of backgrounds. Most students are within a year or two of completing A levels, some are direct entry from the Extended degree (Prep year) in Engineering and Maths and a few are mature students. In 2014-2015 the students on Modelling 1 received a 1 hour lecture to the whole cohort followed by a 1 hour tutorial in groups of approximately 25 students.

The module aims to develop students' modelling skills by giving them opportunity to work on different problems. The problems come from diverse areas such as engineering, population growth, management science and diffusion.

1.1. Project Outline

The project funded by an internal University Teaching Enhancement Fund invited 3 external speakers to one lecture. Each speaker was asked to present for approximately 10 minutes allowing 5 minutes for questions. The speakers were briefed to talk about how they used Modelling in their jobs and how they dealt with uncertainty in real situations. The speakers were from banking, transport engineering and chemistry research. Two of the speakers were SHU BSc Maths alumni.

The lecture was followed by lunch and then 2 hours of tutorials (with 2 tutorial groups in each hour). During the tutorials students were asked to consider questions in groups with their responses

recorded through the freely available Socrative software app. Two of the speakers were able to stay to the tutorials and talk more informally with the students in small groups.

The project was evaluated through an informal discussion with the speakers over lunch, the results of the Socrative quiz, student feedback in their online progress files and personal reflection.

1.2. Rationale

Hibberd (2002) and Savage and Grove (2015) discuss the importance of key skills that can be developed through the modelling process although Hibberd (2002) acknowledges that the skills themselves are not easy to teach but can be enhanced by learning activities. We feel that alongside these activities it is also necessary to encourage reflection to enable students to see the skills they are developing.

The Mathematics, Statistics and Operational Research benchmark statement (QAA, 2015) outlines the importance of Modelling in its own right. In addition it is expected that 'Graduates have an understanding of the importance of assumptions and an awareness of where they are used and of possible consequences of their violation.' (Section 3.12, p.15, QAA, 2015)

The vast majority of students beginning the Maths degree at SHU have little or no previous experience of mathematical modelling and do not know what it entails. This echoes the findings of Grove (2012). The students at SHU are asked to reflect on their progress in each module every week in an online progress file. The form is accessed through the SHUMaths website. Students can see and edit their own comments but do not have access to other students' entries. All staff teaching the BSc Mathematics modules can view and respond to comments left by students. The progress file is marked fortnightly throughout the first year of the degree. Marks for engagement contribute a small percentage of marks towards another first year module. Comments from the first week of Modelling 1 include, "*I have never done maths like it before*", "*Not clearly understood what modelling is exactly*" and "*I have an understanding of basic modelling, am yet to understand the concept behind it*". Some students are even afraid of the module commenting "*this was the one that I was scared off*".

For many the lack of certainty is a concern; with comments such as "*was slightly confusing, prefer things with one fixed answer*" and *"I found modelling difficult because it's like nothing I've ever done before*". Other students are more positive, "*This helped me see maths in a different way*," although some still have misgivings; *"I like the idea of solving real world problems, however knowing that there is several answers to a particular question, or not fully understanding what the question is may frustrate me*", "*modelling isn't my idea of maths as I like the fact with maths there is always an answer but it will help in the long run to see the bigger picture*".

We wanted students to leave behind their fears and insecurities and help them to appreciate the importance of modelling skills. Dealing with uncertainty is a difficult thing to do, especially when you are so used to there being just one correct answer. We want our students to know that there are ways to deal with it and by solving one modelling problem you will develop skills to help you solve another one even though the mathematical techniques may be different. Nyman and Berry (2002) discuss developing a Modelling course with these generic skills in mind and acknowledge that "to the employer of our graduates these skills are often more important than the actual mathematics they have learnt".

Inglis, Croft and Matthews (2012) found that "applying mathematics to the real world" was the skill that most students felt they would have liked to have developed but were not given the opportunity to do so. The inclusion of 3 very different examples from industry should allow students to see that they are being given the opportunity here at Sheffield Hallam and are building up a set of transferable

skills that can be applied in different contexts. These skills are important and will enhance their employability.

We also wanted to address the students discomfort with there not being 'one fixed answer' by asking our speakers to show how they address this issue in real life models.

2. In Practice

We began our search for speakers by initially putting out a call through the LinkedIn group of SHUMaths Alumni and asking all of our final year students who had been on placement if they would be willing to talk about what they did on placement. This method yielded two speakers from the Alumni group. The third speaker was a personal contact.

The experience of the speakers varied; both in the amount of time working in their field and in giving presentations.

Overall the sessions were successful. The speakers felt the talks had gone well and we received much positive feedback from the students. Our own reflections were that it had gone well and that we would like to repeat something similar next year. However, there were areas we would like to improve next time.

The speakers were all positive about the lecture session and had enjoyed the experience. However, the two that attended the tutorial sessions felt that this was an easier platform in which to convey what their job entailed. Perhaps this was due to students feeling more comfortable to ask questions in small groups but also possibly due to the fact they had time in the lunch break in which to reflect on what they seen and to think of questions.

As the main purpose of the session was to improve students' perceptions of the importance of modelling we also wanted to find out what they got from the session. We received feedback from students primarily in two forms; the responses to the Socrative quiz completed in class and from their progress files completed individually in their own time up to 14 days after the event. It is interesting to note that the emphasis of the feedback varies depending on the form it took.

During the tutorial sessions students were encouraged to chat in small groups about the speakers and what they gained from it. There were given specific questions to answer which guided the discussions. After a short while discussing each question the group submitted their answers via the Socrative app. The class as a whole could see the comments of others and a summary was presented by the tutor with further comment from individual where appropriate. The Socrative quiz responses addressed both the modelling skills aspect of the session as well employability. When asked "*What was the key benefit from today?*" the majority of the comments involved seeing the 'real life' applications of modelling. Some focussed solely on improved knowledge of job opportunities but many covered both aspects. The feedback from the quiz questions was inevitably influenced not just by the wording of the questions themselves but also by us as their tutors as we directed the in-class discussions.

The main focus of the comments made in students' progress files was on employability issues, with comments such as "*showed me some areas I could go into*", "*I hadn't even realised the job existed*" and "*made me reconsider what I wish to do in the future*". Only one comment noting the sessions provided "*some time to reflect on the module*" could be interpreted as concerning the modelling skills.

Although students can write in their progress files at any time very few do so immediately after a session. As they are marked fortnightly it is not uncommon for students to make entries up to 14

days after a taught session, although many students fill them in weekly or ad hoc throughout the week. The vast majority of the comments written in the progress files were at least a day or more after the lecture session. The fact that students are focussing on this after the event could be an indication that this is the main influence that the session had on them and that the application of modelling skills was less important.

We also asked the students for suggested improvements. Some suggested the use of examples more specific to models they were studying, some more variety and some fewer examples but more in depth.

Comments in both formats were overwhelmingly positive and included a "*THANK You*" (their emphasis). With many comments about how helpful and insightful it had been. Students commented that the tutorial sessions which gave the opportunity for 1-1 and small group discussions were particularly valuable. One student also mentioned the value in seeing where ex-students are now employed.

3. Conclusion

From our own perspective the lecture and tutorial session were well worth doing. The students found them to be of value and they evidently helped students see the wide variety of jobs in which modelling can be applied. It became apparent that the more informal discussions in the tutorials were felt to be of most benefit to several students.

However, we do not feel that all our aims have been met. Although asked to talk about uncertainty none of the speakers did so in the way we had hoped for. This suggests that in future the intended outcomes of the talks need to be more clearly communicated to the speakers.

The tutorial sessions were poorly attended; anecdotal evidence would suggest this was partly due to a coursework deadline and a lack of understanding in what we would be doing in these sessions. One student felt that the Socrative quiz could have been completed individually in their own time and didn't need a whole hour's tutorial devoted to it. This is an interesting comment and highlights that we need to spend more time and thought planning the reflective exercise and communicating this to students. Although students could reflect on their own we believe there is value to a shared reflective experience. This is something we need to make sure students understand in the future.

We have secured funding to run a similar session this year. We would like to build in more opportunity to have small group discussions. We will also devote time to planning a more structured discussion to enable students to highlight the transferable skills they are gaining and that the speakers are using.

We also hope to give more guidance to the speakers; making our aims clearer and asking for one example of developing a problem. We would like them within this to discuss the assumptions they make and how they deal with uncertainty.

In summary, it was a well-received way of giving students an authentic insight in to how and where models are applied in the real world. However, it was also a learning experience for us and we hope to deliver a more focussed session next year that meets more of our aims.

Perhaps we should give the last word to one of our students, although we cannot claim that the session with the speaker is the sole driver for the change of heart, we do think it helped. The student who began the year thinking "*modelling isn't my idea of maths as I like the fact with maths there is always an answer*" ended the year thinking "*Modelling is one of my favourite modules as it used the pure maths to fix everyday problems and it's much more relatable.*"

4. References

Grove, M., 2012. The Mathematical Transition: A Multi-Stage Problem? *MSOR Connections* 12 (1) pp. 15-18. Available at: https://www.heacademy.ac.uk/sites/default/files/msor.12.1.d.pdf [Accessed: 10 April 2016].

Hibberd, S., 2002. Mathematical modelling skills. In P. Kahn and J. Kyle, eds. *Effective learning and teaching in Mathematics & its applications*. London: Kogan Page, pp.158-174.

Inglis, M., Croft, T., and Matthews, J., 2012. Graduates' Views on the Undergraduate Mathematics Curriculum. National HE STEM Programme and MSOR Network. Available at: http://www.mathcentre.ac.uk/resources/uploaded/gradviews.pdf [Accessed 10 April 2016].

Nyman,M. and Berry, J., 2002. Developing transferable skills in undergraduate mathematics students through mathematical modelling. *Teaching Mathematics and Its Applications* 21(1) pp.29-45. Available at: http://teamat.oxfordjournals.org/content/21/1/29.abstract [Accessed: 10 April 2016].

Pegg, A., Waldock, J., Hendy-Isaac, S. and Lawton, R., 2012. Pedagogy for employability, HEA. [pdf] Available at: https://www.heacademy.ac.uk/sites/default/files/pedagogy_for_employability_update_2012.pdf [Accessed 10 April 2016].

QAA, 2015. Subject Benchmark Statement: Mathematics, Statistics and Operational Research. [pdf] Available at: http://www.qaa.ac.uk/en/Publications/Documents/SBS-Mathematics-15.pdf [Accessed 10 April 2016].

Robinson, M, Challis, N and Thomlinson, M., eds., 2010. *Maths at University: Reflections on experience, practice and provision*, Birmingham: More Maths Grads.

Savage, M and Grove, M., 2015. Mathematical modelling and problem solving in real-world physical situations. In: Grove, M, Croft, T, Kyle, J and Lawson, D., eds., *Transitions in Undergraduate Mathematics Education*, Birmingham: University of Birmingham, pp.115-128.

CASE STUDY

ENISTEM: Using Emotional Nerve Intelligence in Science, Technology, Engineering and Mathematics

Makhan Singh, Institute for Sustainable Futures, Enterprise Innovation and Business Engagement, Birmingham City University, Birmingham, UK. makhan.singh@bcu.ac.uk
Edmund Chadwick, Mathematics, School of Computing, Science and Engineering, University of Salford, Salford, UK. e.a.chadwick@salford.ac.uk

"The art of being myself is something only I can ever find out" (Singh, 2000)

Abstract

An Emotional Nerve Intelligence module for second year mathematics undergraduates is presented. This is a new concept that extends Emotional Intelligence by including psychotherapy practices used to control nerves (anxiety and stress). This is delivered within a mathematics STEM setting with the aim of releasing the undergraduates' potential. Results show development in self-awareness of the students by capturing pre- and post-comments, and anecdotal observations indicating the success in students developing their ability to think for themselves are also given.

Keywords: Emotional Intelligence, soft skills, curriculum innovation.

1. Introduction

What will the world look like in 2065? The global population is anticipated to exceed 10 billion, nearly every person on the planet will be connected to the internet, a fifth of the world's population will be over the age of 60; and energy, food and water will be a serious challenge – particularly as most of us will be living in (smart) cities. The need for innovation is therefore of critical importance. The Nomura Institute in Japan has gone one step further by stating that we are now living in the Innovation age – the information era has been surpassed. Boosting innovation is therefore crucial at regional, national and global levels – for the planet to survive we will need a new generation of leaders that can innovate. More than ever before, Science, Technology, Engineering and Mathematics (STEM) will play a key role in the 21st century, and it is essential therefore that a new breed of STEM graduates is 'born' – graduates who are not only highly skilled in their STEM discipline but who are also able to tap into their creative, innovative and more artistic sides.

The timing of this paper is perfectly synchronised with the recent Higher Education Green Paper, *Fulfilling our Potential: Teaching Excellence, Social Mobility and Student Choice*, a consultative review published on 6 November, 2015 by the Department for Business, Innovation and Skills (DBIS). The Green Paper states the government's vision for the future of higher education in England, with a wide variety of proposals ranging from raising teaching standards to facilitating a greater focus on graduate employability. Student fees, league tables, graduate destination data and greater demand to develop employability skills – these are just some of the serious challenges facing the University sector. It is therefore no surprise that HEIs (Higher Education Institutions) are exploring various avenues and strategies that will not only increase academic achievement but will also progress students' learning experience to become employable on graduation. If we put ourselves in the shoes of a typical student – we will be graduating with a debt in excess of £30,000.

Employability skills include the soft skills based around communication, and this is of utmost importance for employers to access the highly technical and specialised disciplines in the STEM

(Science, Technology, Engineering, Mathematics) sector. This has been noted upon by Toland (2011) who reflects on the importance of a T-shaped skills set, where the depth of the technical knowledge is enhanced by the horizontal ability to apply knowledge, and this ability is increasingly being seen as of critical importance for the STEM disciplines. This sentiment is also supported by the UK Commission for Employment & Skills UKCES (2010), which highlights an existing and anticipated future demand for the provision of higher level skills for managers and professionals. Considerable strides have been made by HEIs to incorporate development of these soft skills into their courses, with support from government initiatives such as the National HE STEM Programme and also from the professional bodies, in the case of mathematics the IMA (Institute of Mathematics and its Applications). For example, through this support Chadwick et al. (2011; 2012a) developed a novel Business and Industrial Mathematics module for the undergraduate mathematics degree programme at the University of Salford, which aims to develop and assess working practices for mathematicians and tackle such issues as soft skills communication, careers and EI (Emotional Intelligence). A booklet of good practice edited by Chadwick and Singh (2012) details HEI good practice and how to implement it in the area of employability skills in the mathematical sciences, and similarly a more academic study is given by Waldock and Rowlett (2012).

Savoley and Mayer (1990) describe EI as "*the subset of social intelligence that involves the ability to monitor one's own and others' feelings and emotions, to discriminate among them and to use this information to guide one's thinking and actions*". In recent years, studies have examined the role of Emotional Intelligence in education. The results of these suggest that low Emotional Intelligence has a relationship to a higher level of unauthorised absences and lateness in secondary school children (Petrides et al., 2004). In both school and HEI students a relationship has been established between academic achievement and ability and Emotional Intelligence by Qualter, Gardner and Whiteley (2007). They further state that EI is essential in the development of students at their HEI through their Personal Development Plan (PDP). Emotional intelligence is in essence the ability to understand and manage emotions - it can be learnt and developed. Self-motivation, communicating effectively, empathizing with others, overcoming challenges and defusing conflict are key attributes of good emotional intelligence.

2. An Emotional Intelligence module for mathematics 2013/14

Although the incorporation of soft skills within the curriculum for HE STEM disciplines including mathematics is well under way in the UK, and student ability in this area is generally being attributed to good EI, there is little curriculum development on the use of EI in STEM courses. With this in mind, and using his skills and experiences as a psychotherapist and from his time in industry as an engineering manager, as well as working for the IMA, Singh developed an EI module specifically aimed at Mathematics (and STEM) undergraduates for raising employability skills. In this module, Singh emphasised those aspects of EI useful for mathematicians. These were identified from his work in the HEI mathematics community over the past 6 years, and from the CBI report (2010), where employers surveyed identified generic 'employability skills' as a non-discipline specific priority for business when recruiting graduates and indicated that STEM graduates in particular were not 'demonstrating' these at recruitment. These generic skills as defined by the CBI include self-management, team working, communication and literacy. At Salford, there is a dedicated module for the development of these generic skills. Having a dedicated module enables the trailing of new practices, which can then be developed and integrated into other modules. Examples include the development of teamwork and modelling which were first trialled in this module and are now integrated into many modules in the degree programme. Emotional Intelligence was trialled in a component of this module in 2013/14 by Singh and Chadwick (2015) with particular emphasis on the following module student outcomes:

- Develop a self-awareness of the inner self
- Learn to engage in self reflection

This component was run over one full day per week over a period of 3 weeks, and consisted of three sessions of group work each lasting four hours, as well as coursework, further study and examination making up 40 hours. The group sessions were held them in flat rooms, with the lecture room set up with chairs in a circle for a class size of 20, creating a room more traditionally associated with counselling studies.

The method of assessment for the EI component was structured around a 20 minute class test (20%); one coursework assignment (40%) and a reflective journal (40%). The class test assignment was themed around the students writing their own obituary – the purpose of which was to engage the students to develop their self-awareness and self-reflection, as well as developing their ability to articulate thoughts and ideas in a small period of time. The coursework assignment was titled 'Conversation with Self', where students were tasked with engaging with themselves through written 'self-conversation' - this is a technique from Gestalt therapy given in Perls (1973), an existential/experiential form of psychotherapy that emphasizes personal responsibility, and that focuses upon the individual's experience in the present moment. The final assessment was a reflective journal – designed to capture the learning process the student has been through over the past three weeks; again developing the student's ability to engage in self-reflection. As Emotional Intelligence is a soft (rather than hard) skill, the marking was more akin to arts rather than sciences (i.e. no actual 'correct' answer).

2.1 Results and observations

Each week the attendance numbers increased – week one saw 12 students attending; week two saw 14 students and the final week saw a full house of 20 students. The module evaluation feedback had very positive feedback from the staff and students, although this evidence is qualitative. However, a longitudinal study shall be attempted later to see the impact of this module to actual student grades versus predicted grades – and to see if the module has had any major impact, as well as looking in the future to student destination data. To give an indication of the feedback, one positive and one negative comment is given below:

'*This was an excellent module – I would definitely choose to do this module if it were an option in my final year*'

'*Can't understand why we had to do this module – I signed up for a maths degree – not feelings and emotions*'.

As the module was held over a short space of time, it is difficult to assess long term impact evaluation - however Singh did devise an *Emotional Shift Measurement* ie pre-entry question and a post exit question to assess what shift or change had occurred in the students in terms of developing emotional intelligence. The students were asked at the beginning of the first lecture and again at the very end of the module the following question:

"Who am I?"

Abstracts from the following selection student responses illustrate that there was a positive shift in developing emotional intelligence:

Student 'A':

Who am I – statement written at first lecture: *I am 20 years old. Currently in the second year of my maths degree. I am a football enthusiast. I eat, sleep, drink and think football.*

Who am I – statement written at end of module: *I am a confident, motivated person. I'm not afraid to speak up when something affects my religious morals. I have realised that emotions are meant to be controlled, not blocked out. I have a better understanding of my inner emotions and how to cope with them.*

Student 'B':

Who am I – statement written at first lecture: *I'm (age), born and raised in (country). I speak French. I have been living in Manchester for almost 4 years.*

Who am I – statement written at end of module: *I am easily distracted. I am a positive person, I am a friendly person who enjoys meeting new people. I take my university studies seriously.*

Student 'C':

Who am I – statement written at first lecture: *I am 21 years old. In the future I am wanting to be a maths teacher. I enjoy drawing and baking cakes, but don't have much time to enjoy these pleasures. I also enjoy doing exercise but only sport based.*

Who am I – statement written at end of module: *Kind of torn between where I want to be in a few years, life is going too fast and I'm not ready to grow up. The responsibility commitment is a scary thought, but it's going to happen regardless of how I feel about it. I have a short attention span so I zone out a lot and try to get myself back in the room – especially in lectures.*

Student 'D':

Who am I – statement written at first lecture: *Blue eyes. 6ft 1 in. Terribly dressed. Massive Man City fan. Good friend.*

Who am I – statement written at end of module: *Confident – apparently cocky. Good listener. Love football. Know what I want to do in life. Like giving compliments. Like watching other people learn. Love family. Ambitious. Approachable.*

The above abstracts do evidence a shift in maturity and emotional intelligence – each student (statement) has shown a heightened level of self-awareness following the completion of the module, highlighting both strengths and areas of self-improvement for themselves. Each student has evidenced in their statements a deeper understanding of their inner self.

3. Emotional Nerve Intelligence (2014/15)

This is an on-going trial and based on the first year experiences and feedback, new changes were made to the module in 2014/15. Singh developed this module as *Emotional Nerve Intelligence*, as he believes that important attributes for student and workplace success not only require self-awareness in emotional intelligence but also understanding and controlling exam nerves, anxiety and stress. This development particularly focuses on learning outcomes:

- Learn to cope with stress
- Develop strategies to overcome challenges
- Learn to defuse conflict

The changes made for this academic year included three particular points discussed below.

1. Singh's current research has led him to look at the links between emotional intelligence and dealing with nerves, and how a human being can cultivate being in a state of optimal performance. This current research led Singh to examine the module and incorporate some body work and meditation within the teaching framework of the 2014/15 module. These new interventions were very well received by the students, with several students commenting how the body work interventions had empowered them to alleviate stress and anxiety.

The idea was that these initial Emotional Intelligence Nerve activities then help the students become more responsive and take initiative in follow-on discipline focused activities which were:

2. A discipline focussed team project assessment was introduced which was centred on a real life industrial mathematics topic. Students were tasked with identifying a company which uses mathematics in its operations; to coordinate a company visit and to give a group presentation. Student feedback was extremely positive and Chadwick observed a greater maturity developing in his students following this project including the development of leadership and teamwork skills.

3. Introducing more specific mathematics careers talks, using the maths careers website (mathscareers, 2016). There was very positive feedback from the students, as this intervention was an enabler for students to understand the wide variety of career choices with a maths degree.

Anecdotally Chadwick has reported a personal change in a majority of students following the completion of the module – of which some students have made significant steps forward in conquering fears such as speaking with more confidence in lectures, being more engaged in lectures, and students not being struck by exam anxiety.

3.1 Reflections and Future Developments

The student comments demonstrate clear *Emotional Shift Measurement* in self-awareness. In terms of managing nerves, anecdotally a change is perceived. Also, the students responded well to the follow-up activities. However, these are again anecdotal rather than evidential. So Chadwick and Singh are now examining the evaluation tools to provide clearer evidence in assessing the shift of students' emotional nerve intelligence, before and after the module, and this is an on-going development. This module is aimed at second and final year students, and the self-awareness, reflection and stress-relief techniques developed in the initial assessments prepared them to take on teamwork and self-motivation challenges in the latter discipline focussed industrial mathematics assessments. The assessments move the students along the path towards thinking for themselves and acting on their own initiative. The initial course content is generic, but then directs towards discipline-focussed issues towards the end. Singh is currently developing a further 'Advanced Emotional Nerve Intelligence' module aimed at MSc students with a further assessment that develops and brings out the students' ability to innovate in an applied mathematics problem.

Teaching Emotional Intelligence in HEIs is still a fairly new area, particularly within the STEM subjects. It is highly likely that this is the first time an Emotional Intelligence module has been delivered within a taught Mathematics/STEM degree in the United Kingdom. This module impacts on student experience, both in terms of raising student employability skills, but perhaps more crucially, developing a skill set within students which will equip them for an increased quality of life and self-confidence, which ever career they choose to follow. One particular area for future

development not looked at here is the use of these techniques to help students with learning difficulties achieve their potential.

"*And now here is my secret, a very simple secret: It is only with the heart that one can see rightly; what is essential is invisible to the eye"*. (de Saint-Exupéry, 1943)

4. Acknowledgements

The authors would like to acknowledge funding for this project from a CPD grant from the NWUA and National HESTEM Programme.

5. References

de Saint-Exupéry, A., 1943. *The Little Prince*. Translated from French by I. Testot-Ferry. London : Bibliophile Books.

Chadwick, E., Sandiford K. and Percy, D., 2011. Assessing student teams developing mathematical models applied to business and industrial mathematics, *MSOR Connections*, 11(3), pp.22–24.

Chadwick, E. and Radu O., 2012. Evaluating assessment practices in a business and industrial mathematics module. In P. Iannone and A. Simpson, eds. *University Assessment Practices*. University of East Anglia, pp.75–82.

Chadwick, E. and Singh, M. eds., 2012. *Employer Engagement: Case Studies for Adoption in HE Mathematical Sciences*, The National HE STEM Programme, University of Birmingham.

Maths Careers, 2016. Graduates. [online] Available at: http://www.mathscareers.org.uk/ [Accessed 24 March 2016].

Perls, F., 1973. *The Gestalt Approach & Eye Witness to Therapy*. New York: Bantam Books.

Petrides, K.V., Fredrickson, N. and Furnham, A., 2004. The role of trait emotional intelligence in academic performance and deviant behavior at school, *Personality and Individual Differences*, vol. 36, pp.277–293, Available at: http://www.psychometriclab.com/admins/files/paid%20(2004)%20-%20t_ei.pdf [Accessed: 24 March 2016].

Qualter, P., Gardner, K. and Whiteley, H., 2007. Emotional Intelligence: Review of Research and Educational Implications, *Pastoral Care in Education.* 25(1) pp.11-20. Available at: http://onlinelibrary.wiley.com/doi/10.1111/j.1468-0122.2007.00395.x/epdf [Accessed: 01 April 2016].

Savoley, P. and Meyer, J.D., 1990. Emotional intelligence, *Imagination Cognition and Personality*, 9(3) pp. 185-211. Available at: http://ica.sagepub.com/content/9/3/185 [Accessed: 24 March 2016].
Singh, M., 2000. *The Journey: Where Seagulls Dare to Fly.* Leicester: Book Guild Publishing Ltd.
Singh, M. and Chadwick, E., 2015. Emotional Intelligence in STEM, *Mathematics Today*, Institute of Mathematics and its Applications. 51(2), pp.75-77.

Toland, A., 2011. *HE STEM Employability Skills Review*. [pdf] Birmingham: The National HE STEM Programme. Available at: http://www.hestem.ac.uk/sites/default/files/employability_skills_review.pdf [Accessed: 24 March 2016].

UKCES, 2010. *Skills for Jobs: Today and Tomorrow*. London: UKCES. Available at: https://www.gov.uk/government/publications/skills-for-jobs-today-and-tomorrow. [Accessed: 24 March 2016].

Waldock, J. and Rowlett, P. eds., 2012. *Employer Engagement in Undergraduate Mathematics*. [pdf] Birmingham: The National HE STEM Programme. Available at: http://www.mathcentre.ac.uk/resources/uploaded/EmployerEngagement.pdf [Accessed: 24 March 2016].

Future Issues

MSOR Connections is a peer-reviewed journal that aims to promote, encourage, enhance and disseminate research, good practice and innovation in all aspects of Mathematics, Statistics and OR learning, teaching and support in Higher Education. Article submissions are welcomed at any point, with three issues published on-line each year. Indicative schedule:

A January issue will be drawn from submissions received by mid-November;

An April issue will be drawn from submissions received by mid-February;

A September issue will be drawn from submissions received by mid-July.

To register for future issues and further information regarding submissions please visit https://journals.gre.ac.uk/index.php/msor