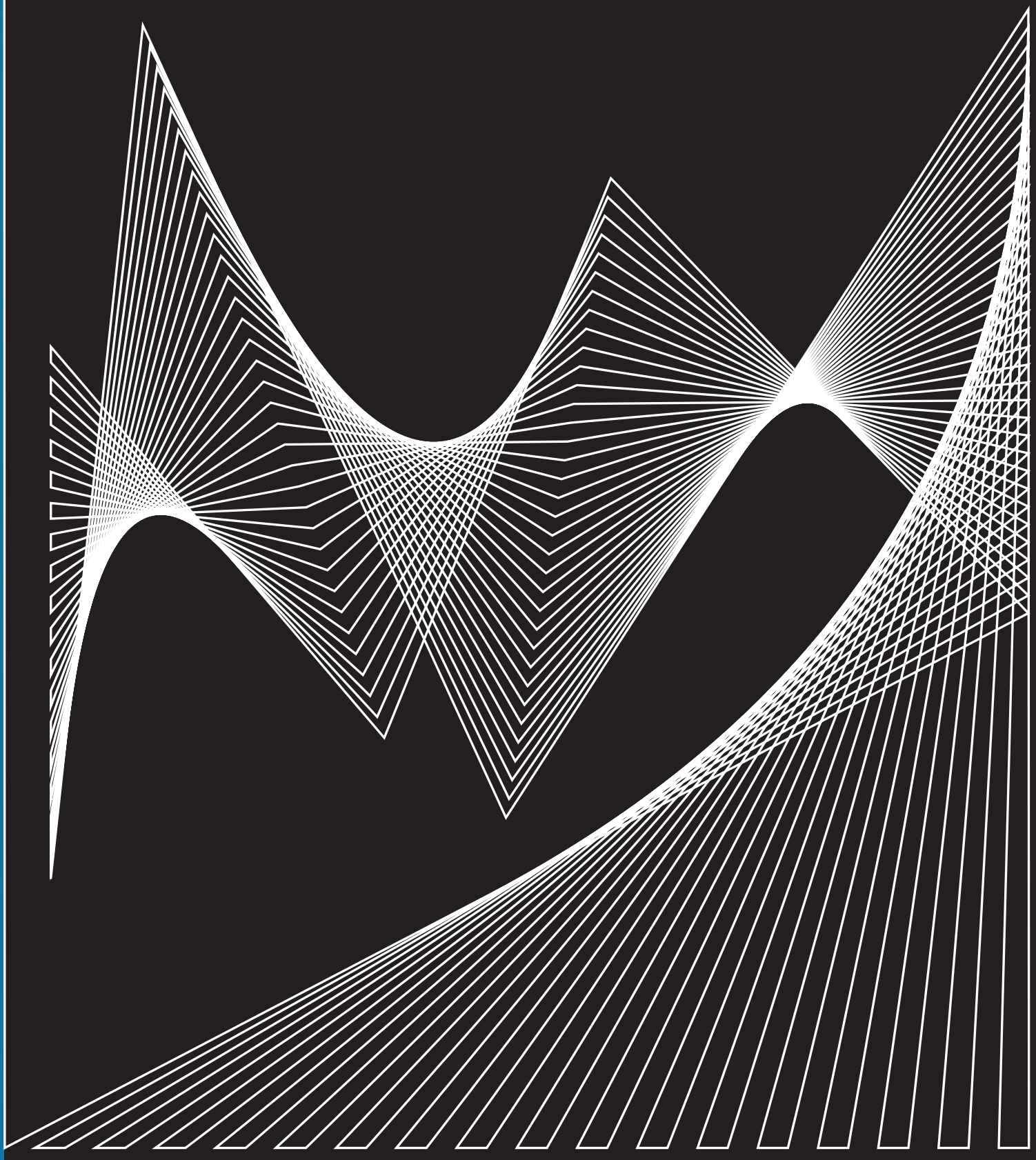
MSOR connections

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. 2



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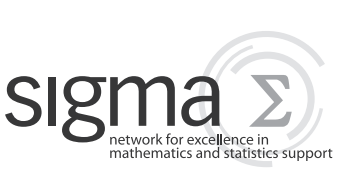

Editorial

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Welcome to this second edition of Volume 14 of *MSOR Connections*, the second edition since the re-launch of the publication last autumn. The task of editing this edition has been a joint effort between two of the editors, and we hope very much that you find the mix of research articles, workshop reports and case studies interesting and stimulating.

This edition kicks-off with two articles that consider the use of different technologies to provide remote mathematics support as an alternative to face-to-face provision. The first of these, by Hawkes and Hodds, discusses a case study piloting the use of the *HowCloud* platform, whilst the second article, by Breen, O'Sullivan and Cox, reports on the use of technologies to provide virtual support for a multi-campus institution. Both of these should be of particular interest to those of us engaged in this type of work.

This is followed up by a very interesting example of a classroom activity that teaches the often difficult to grasp concept of hypothesis testing through the use of randomisation tests, and also chocolate! On the topic of enhancing the quality of university teaching, this has moved up the agenda in recent years, with Government policy around the Teaching Excellent Framework and work on recognition from the Higher Education Academy. Paul Glaister has submitted a timely opinion piece which outlines his thoughts on a possible way of achieving better recognition and reward of good teaching. We welcome responses to Paul's proposal, in the form of further opinion articles or letters to the editors, which could be published in future issues of *MSOR Connections*.

The final three articles that complete this edition also share a common theme of stimulating interest in the study and application of mathematics. We are therefore very pleased that two of these are student-authored articles. The first is by Johnson and Mulligan, who provide a nice summary of some of the literature on good practice in mathematics outreach. The second of the student authored articles, by Wolfin, provides a case study description of the experience of taking part in an activity designed to help maths students understand how businesses operate. This edition of *MSOR Connections* is then rounded by one of our editors, Peter Rowlett, who reports on the most recent Maths Jam Conference, which took place last November.

It is especially encouraging to see students continuing to engage with developments in teaching and learning and we would like to encourage all those in the mathematics teaching, learning and support community to support their students to make submissions to *MSOR Connections*. We hope you will also consider making a submission too and share your ideas, opinions and good practice. More information on submission deadlines is available on the inside back cover.

Finally, we would like thank our fellow editors, the editorial board and a growing group of anonymous reviewers for their continued support in preparing this issue. If you would be willing to review articles for *MSOR Connections*, you can register your willingness to do so at the following website.

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

HowCloud: Round-the-Clock Maths Support

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Keywords: Mathematics support, Statistics support, online learning, HowCloud.

Among the challenges facing our students when they seek help with the mathematics or statistics in their degree courses are finding the confidence to come through the door and finding the time to visit while a question is fresh in their mind. At Coventry University, we have piloted a scheme that aims to help such students over these obstacles by offering an alternative to the face-to-face tutoring we provide on a daily basis in our drop-in centre.

Figure 1. Screen-shot of the HowCloud opening page, customized for Coventry University

HowCloud is a browser-based platform that offers students support with maths and stats off-campus and out-of-hours. A student submits a question from their computer, tablet or mobile phone. A member of Coventry's maths & stats support team is alerted and posts an online reply.

On the opening page (see Figure 1), students are offered two links, one for Mathematics support and another for Statistics support. The first time first they log on to the service students are asked to register with their name and email address and to agree to a code of conduct (see below).

After choosing between maths and stats, they are next invited to post a question or search the resource bank of previously answered questions. If they choose to post a question, they are presented with the window shown in Figure 2.

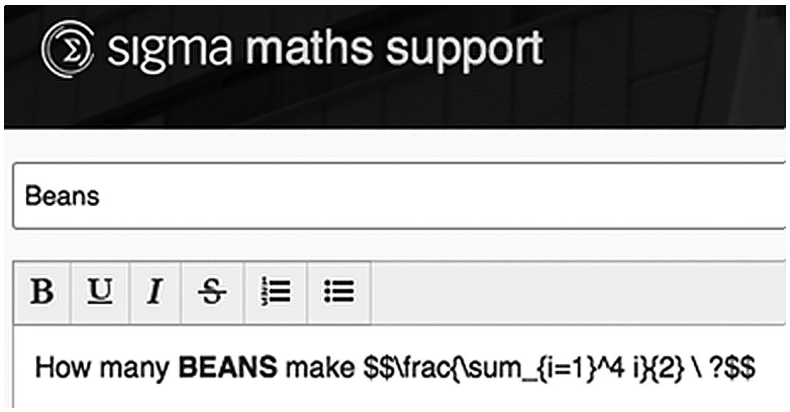

Figure 2. The window for posting questions

Questions can be typed into a text box in the browser window alongside, or separate from, an uploaded PDF, which might be a screen-grab or a scanned document.

The question window also has WYSIWYG formatting with a LaTeX option for displaying mathematical expressions.

The answers can be posted in various formats:

- as a short video of the tutor seen writing a whiteboard with voice over;
- as a typeset or handwritten static web page;
- as a static PDF to be viewed in the browser or downloaded.

To create a video, the tutor writes on a standard graphics tablet and wears a microphone headset.

The platform is the brainchild of Joseph Ros. He began its development while he was studying for an economics degree at the University of Warwick and, with some help from his contemporaries, he used it to support students in Coventry schools revising for their GCSE maths exams. Although it is several years since he graduated and left Warwick, the service has been continued by current students. Each year the questions keep coming and the answers are enthusiastically pored over by the students as the exam period approaches. Since then the platform has matured and diversified. For instance, it is now used to deliver live interactive mathematics tutorials worldwide.

We heard about HowCloud through various contacts, including *Mathematics in Education and Industry* (MEI), http://www.mei.org.uk, who used it as part of their distance-learning programme. Meanwhile, our University Library (where we in Coventry's maths/stats support team, known as **sigma,** live) had removed all the books from the top floor to make way for a new venture called the *Disruptive Media Learning Laboratory* (DMLL). Keen to encourage innovation in teaching and learning and get off to a flying start, the DMLL gave us a modest grant to try out HowCloud. As a result, since January 2015 our students have been able to fire off their questions about maths and stats at any time of the day or night from anywhere with an internet connection.

What the platform offers

When a student posts a question, it appears on the main page as shown in Figure 3.

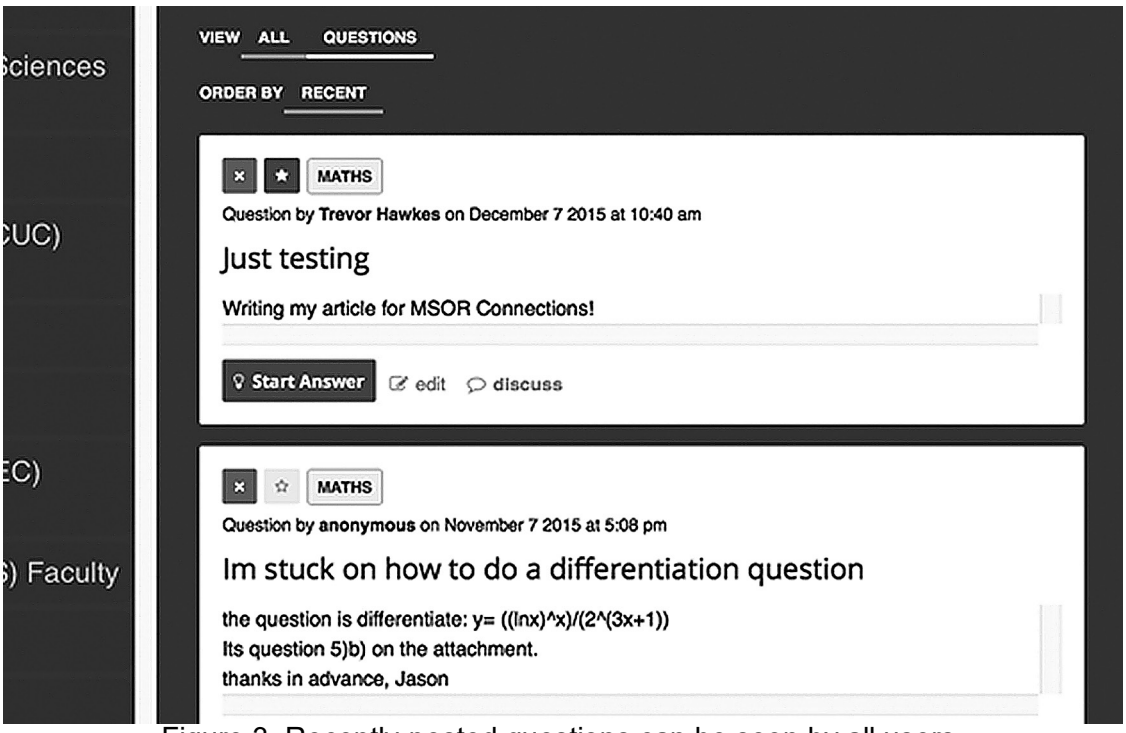

Figure 3. Recently-posted questions can be seen by all users

At the same time, an email alert containing the question is sent to the members of staff who are tasked with providing the answers. At Coventry we have currently nominated one person to handle the maths questions and another to coordinate answers to the statistics ones. In principle they will farm out the questions to the most appropriate tutor to post an answer, but in practice the traffic so far has been small enough for them to respond to all the questions themselves without calling in colleagues to help. Like Amazon Prime, we have aimed for a next-day delivery if a question cannot be answered at once, and for the maths questions at least we have mostly met this target.

There are various options for creating a post to answer a question.

- The quickest and simplest way is to write out the answer by hand, scan it as a PDF file and upload it to the answer box (see Figure 4 below). This is useful if you have little time and want to give the student an answer as soon as possible. It is perhaps the least effective method, depending on the detail provided in the answer.
- If you have more time, can type fast and are a fluent LaTeXnician, you can write your answer in elegantly formatted mathematical text using HowCloud's WYSIWYG window – again, it's less personal but can turn out to be more reliable and legible than a shaky hand.
- The voice-over video is perhaps the most user-friendly medium for your answer. Listening to someone explaining things as they write is, for most students, a more comfortable and effective way to learn. Two of the five senses are engaged and students can always replay a section if it goes by too fast.

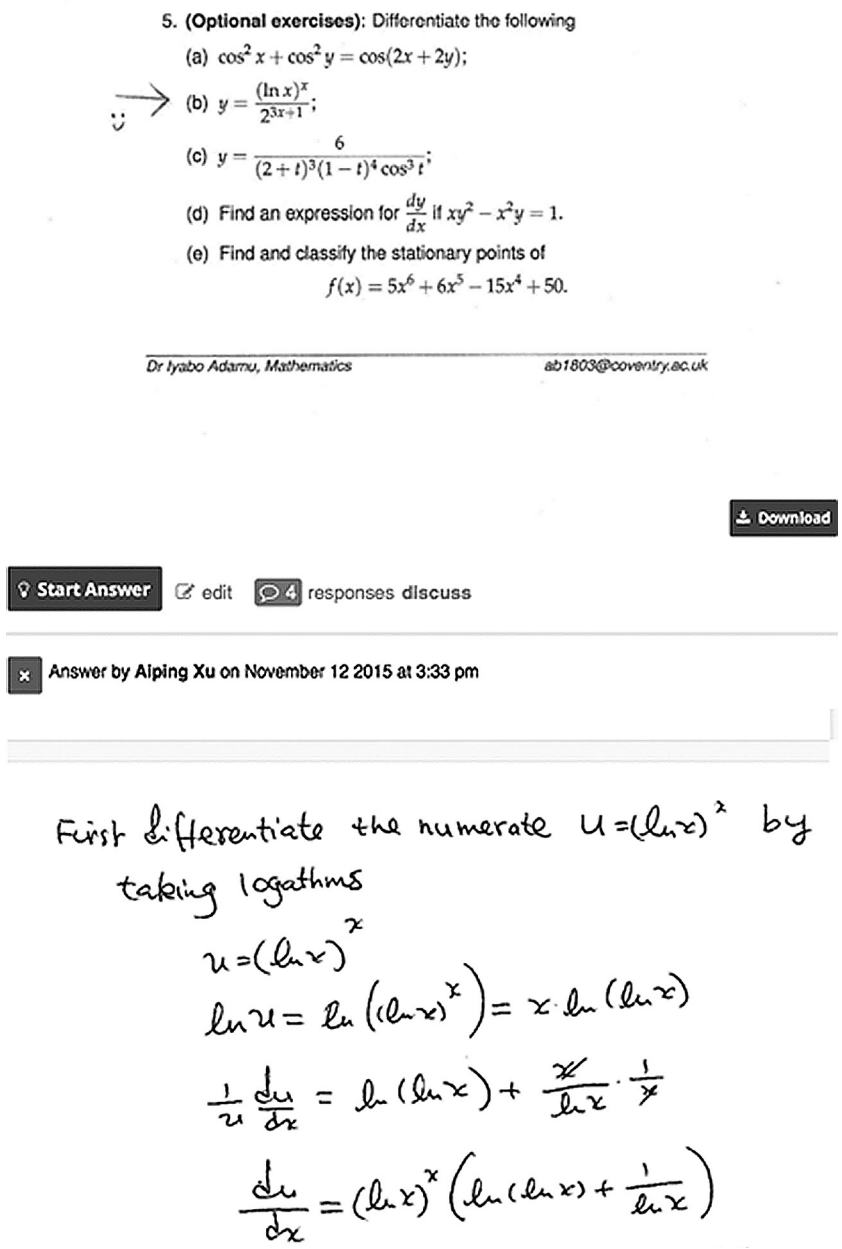

Figure 4. A question with a hand-written answer

Furthermore, if a student still doesn't understand, a thread of questions can be created with further answers provided, all linked to the original question. Indeed, the interface prompts the student by asking: "Still unsure? Post a follow-up".

To create the video, you will need a microphone and a tablet with a stylus (an outlay of around £40 for reliable equipment). If you have not used a tablet before, it may take some perseverance to learn to write legibly and at a suitable scale for the screen. Once you have plugged these devices into your laptop, found a quiet space to work where you won't be interrupted, and decided how to present your answer, it typically takes from 10-30 minutes to write, review and post a 5-10 minute clip online; you may like to upload some auxiliary material or even to prepare part of the answer ahead of recording and fill in in the missing bits of the argument as you talk – this acts as a prompt to your train of thought. The software allows you to pause and continue the recording, and if you are unhappy with part of it, you can go back and re-record over it.

The questions and answers are saved and can either be deleted or moved to the archive to be searched and re-used later. As the store of answers grows, more of the questions can be

answered with a reference to past posts. We are still working on ways to organise the archive and to prime the search engine to present helpful results. We strongly encourage students to search the previously-answered questions before posting one of their own.

The HowCloud server is strong on analytics and, with further growth in usage, knowledge of the detailed habits of our clients, such as their degree programmes, their locations, times of posting, and the devices they are use, will help us to tailor our service better to their needs.

We also have a code of conduct that students agree to when they register. If they post inappropriate questions or a question that is direct from coursework, then they are warned that they might face disciplinary action from the University. This adds some security to our service and reduces the risk of us providing answers to questions that contribute directly to degree credit.

Future Plans

Although we began the HowCloud experiment at Coventry at the beginning of 2015, it took time to bed down and for students to get into the habit. We relaunched it in October, and have had a better response, although perhaps still not enough to justify the investment; nevertheless, we are enthusiastic about its potential and intend to continue our subscription for the rest of this 2015-16 academic year.

As part of our ongoing commitment to improve and increase our services, including HowCloud, we also intend to use the live version of the site to offer maths support to our secondary campuses in London and Scarborough. Students will be able to come at a set time and get maths support from our tutors in Coventry using the live HowCloud interface.

Joe Ros is committed to maintaining and developing the version we use, at the same time diversifying the product in the direction of live online tutorials for secondary-level mathematics students. We are currently working with him on further improvements for the benefit of the UK maths support community. If you would like to find out more, please contact us via our emails listed above.

RESEARCH ARTICLE

Mathematics Learning Support across a Multi-Campus Institution: A Prototype of Virtual Support

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Abstract

In this paper, a study on Mathematics Learning Support (MLS) that was undertaken across three institutes intending to form the Technological University for Dublin is outlined. This study consisted of a survey that was circulated to both staff and students in each of the three institutes. The survey had two objectives. Firstly it sought to identify the students' needs for MLS in each of the three institutes. Secondly, it sought to ascertain the preferred method of provision of MLS, on a scale ranging from exclusively online, to exclusively in person. Following on the results of this survey it was decided to prototype a virtual MLS drop-in service. The operational details of the prototyping of this virtual drop-in service and the feedback obtained from the students involved are also presented in this paper.

Keywords: Mathematics-Support, Virtual Drop-in.

1. Introduction

In recent years an increasing number of students in Irish Higher Educational Institutions (HEIs) are taking courses with mathematical and statistical elements. This is in part due to the widespread recognition that mathematics underpins the STEM disciplines and the emphasis placed by the Higher Educational Authority (HEA) on producing graduates who are highly literate in mathematics (Expert Group on Future Skills Needs, 2008, and HEA, 2011). Hand in hand with this increase however has come the so called 'Maths Problem'- that is an apparent decline in the mathematical proficiency of incoming first year students across HEIs in Ireland and elsewhere (Gill et al., 2010). In fact, it is widely acknowledged that the absence of a solid foundation in mathematics can be one of the key inhibitors for student progression in higher education (HEA, 2010).

As part of the response to this problem, Maths Learning Support Centres (MLSCs), defined by Lawson et al. (2003) as 'a facility offered to students (not necessarily of mathematics) which is in addition to their regular programme of teaching through lectures, tutorials, seminars, problems classes, personal tutorials, etc.' have been set up in the majority of HEIs in Ireland (Gill et al., 2008). In fact a soon to be published study involving 32 Irish HEIs has shown that 84% of these now offer some form of MLS (Clancy et al., 2015). It is therefore clear that MLS has now become an integral part of the higher educational framework.

The prosposed merger of the three institutes intending to form the Technological University for Dublin: The Dublin Institute of Technology (DIT), The Institute of Technology Blanchardstown (ITB) and The Institute of Technology Tallaght (ITTD), represents a significant change in the Irish Higher Educational landscape. It is important that the MLS provision in each of these institutes evolves in a manner that best suits the needs of the students across the three Institutes. The work reported in this paper represents a first step in this process.

2. Methodology and Participants

The initial stage of this study consisted of a survey of both staff and students in each of the institutes. It was decided to survey staff that are involved in teaching mathematics or statistics modules and students who had engaged with some form of MLS. The survey was conducted online and consisted of three main questions:

1. Which discipline do you teach under/are you studying?
2. In your opinion, what are the three main topics that students would require MLS for?
3. Please indicate your preference for how this MLS would be delivered?

For Q3, answers were given on a five point scale, ranging from 'Exclusively Online' to 'Exclusively in Person'. A total of 45 staff responses and 118 student responses were received. The breakdown of responses per institute is given in Table 1. It should be noted here that DIT, with approximately 20,000 students enrolled, is a much larger institute than both ITB and ITTD, with approximately 4,000 students each. Table 3 gives details of the responses to Q1 of the survey.

Table 1. Breakdown of Staff and Student Responses by Institute.

Institute	DIT	ITB	ITTD	Unspecified
No. Of Staff Responses	16	18	9	2
No. Of Student Responses	34	67	16	1

Table 2. The disciplines under which the staff who responded teach mathematics and the disciplines the student respondents are studying. (Note that respondents could choose more than one option. The percentages quoted are the percentage of respondents in each group who selected each option.)

	Engineering	Mathematics	Business	Science	Computing	Other
Staff	59%	27%	20%	27%	17%	5%
Student	49%	4%	24%	6%	17%	3%

3. Results of the Survey

In this section we give the results to Q2 and Q3 of the survey. The results from staff and students are given separately and then compared.

It should be noted that the results for Q2, on the topics that students would most need MLS with, are given just in terms of number of responses, as more than one answer to this question was allowed. Many individual responses to Q2 were received, for clarity it was decided to group these responses into five main areas: Basic Algebra (e.g. logarithms, indices), Calculus, Preliminaries (e.g. fractions, basic numeracy, percentages), Probability and Statistics and an Others category. Topics that were included in the Others category include trigonometry, vectors, Fourier and Laplace transforms, geometry, financial mathematics, linear algebra, among others.

The responses to Q3, on the method of provision of MLS, are given as a percentage of total respondents.

3.1. Staff Responses

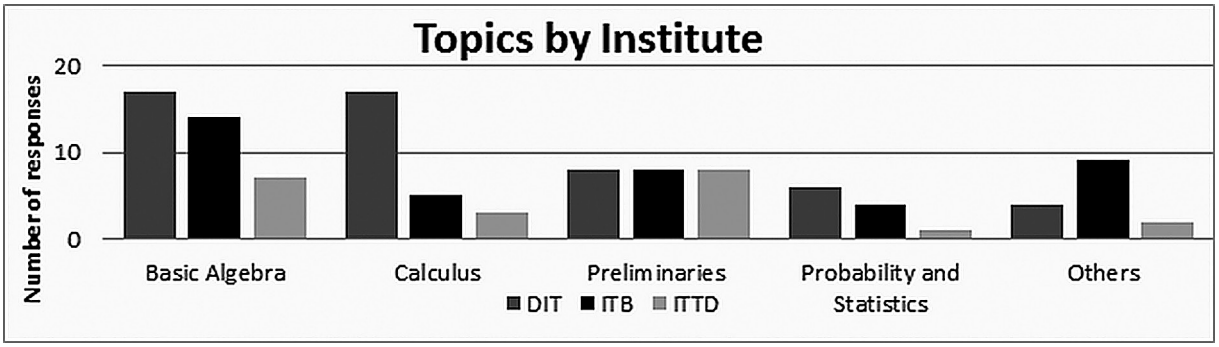

Figure 1. A breakdown of the staff responses to Q2 across each of the Institutes.

Overall the most common topic that **staff** indicated students would require extra support with was Algebra, followed by Calculus. In DIT the most common topic indicated was Calculus, in ITB it was the Others category and in ITTD the most common topic indicated was Preliminaries.

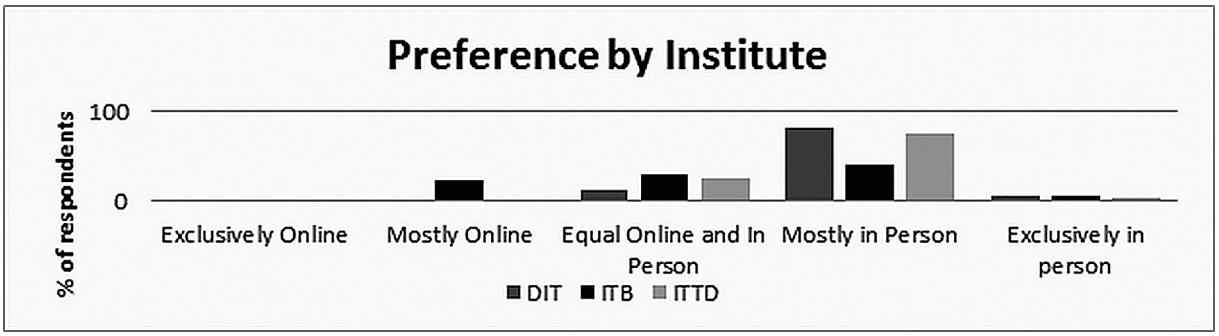

Figure 2: A breakdown of the staff responses to Q3 across each of the Institutes. Preferences are given as a percentage of total responses.

71% of total **staff** surveyed indicated their preference for the delivery of MLS to be provided either mostly or exclusively in person. This was highest in DIT, with 88% of staff indicating this preference, and lowest in ITB with 47% of staff indicating their preference to be given mostly or exclusively in person. 24% of ITB staff would prefer the MLS to be provided mostly online, while 0% of both ITTD and DIT staff opted for this option. This may be explained by the fact that in ITB some modules are delivered completely or partially online and therefore staff in ITB may be more familiar with this medium of delivery.

3.2. Students' Responses

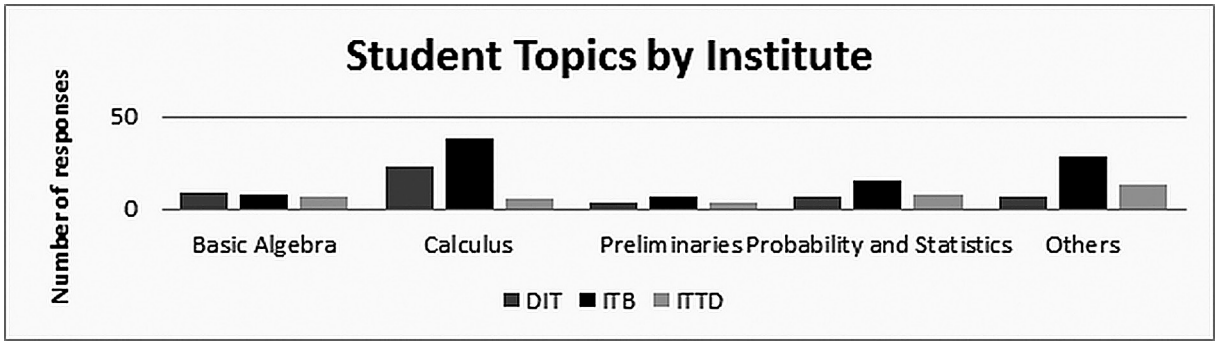

Figure 3. A breakdown of the student responses to Q2 across each of the Institutes.

The most common topic that **students** indicated overall that they would need extra support with was Calculus; individually Calculus was most commonly chosen in DIT and ITB, while in ITTD the most common topic category was the Others category.

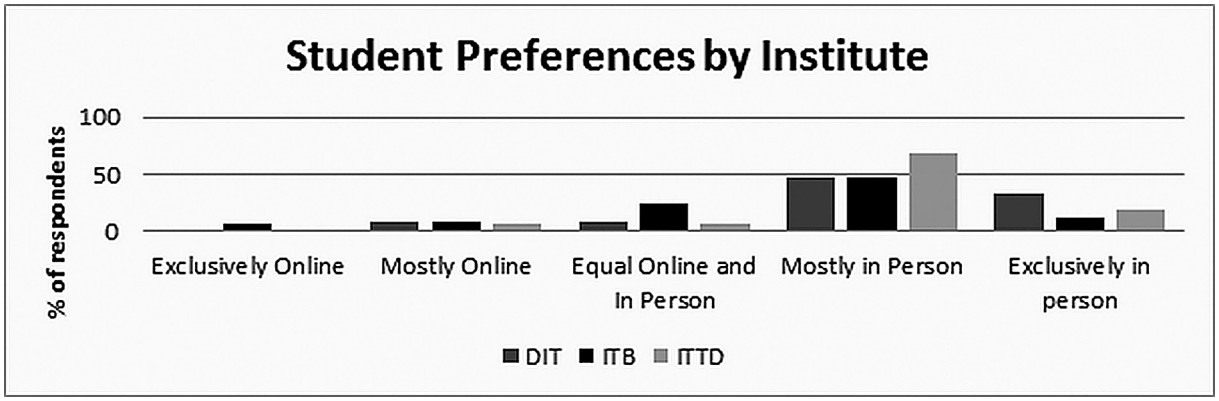

Figure 4. A breakdown of the student responses to Q3 across each of the Institutes

69% of total **students** surveyed indicated that the preference for the delivery of MLS to be provided either mostly or exclusively in person. This was highest in ITTD, with 88% of students indicating this preference, and lowest in ITB with 60% of students indicating their preference to be provided mostly or exclusively in person. Again it is worth noting that only ITB students indicated a preference for MLS to be provided exclusively online, which may again be a reflection of their familiarity with online delivery of lecture content.

Comparing the total student and staff responses, we find that the responses to Q3 are mostly in agreement. However it is interesting to note the difference in opinion between the groups in regards to Q2, the topic that they believe students would most need extra support with (see Table 3 for details).

Table 3: Comparison of the total student and staff responses to Q3

	Basic Algebra	Calculus	Preliminaries	Probability and Statistics	Other
Staff	34%	22%	19%	12%	13%
Students	13%	37%	7%	16%	26%

A result of particular note is that the most common topic chosen by students was Calculus, while Basic Algebra was the most common topic that staff chose. One possible interpretation of this is as a misconception on the students' behalf, whereby they are struggling with a module involving Calculus but the root causes for this difficulty may lie in issues with Basic Algebra.

4. Virtual Drop-in Service Prototype

While the majority of staff and students surveyed had a preference for in person support, there was some desire that some form of MLS be provided online. In a recent large scale report on student engagement with MLS in Ireland, it was found that 83% of students surveyed rated the drop-in service as worthwhile while 56% of students rated ICT facilitated support as worthwhile (O'Sullivan, et al. 2014). Inspired by this and the results of our survey, we decided to prototype a virtual drop-in service, where we would hope to replicate the in-person experience as much as possible in a virtual environment. It should also be noted that in the proposed merger both ITB and ITTD will remain in their respective campuses, therefore the development of effective ICT facilitated support, such as a virtual drop-in service, will be an important issue in any future merged entity.

In order to implement this, three Wacom Intuos Tablets were purchased (see Figure 5), one for use in each institute, and the Adobe Connect software package was used. It should be noted here that the Adobe Connect software package was chosen simply because there the institutes involved possess a licence for this package. Another equivalent package, such as Blackboard Collaborate, would also have been sufficient for our purposes. The key feature required of any particular software package is that it can be used to mimic the in-person drop-in experience as closely as possible. This includes a facility to simultaneously have a two way conversation and to share a whiteboard, upon which all participants can write. In keeping with the spirt of collaborative learning, a single Adobe Connect session is run for all students involved in each trial. This provides the opportunity for students to learn from each other as well as from the academic member of staff. With Adobe Connect, students were also able to have screenshots of the shared whiteboard sent to their email, which they could then use for their own independent learning at a later date. It is possible for the entire session to be recorded, however for this first prototype it was decided to only allow the students to take snapshots of the whiteboard.

The first trial involved staff members from each of the institutes; this was then followed by two trials involving seven students in total. The first of these involved students in ITTD receiving support from a staff member in DIT, and the second involved students in ITB and a staff member in ITTD. For these trials the use of tablet and laptops was supervised by the lecturers on each site who were participating (i.e. the three named authors). The tablets were securely stored by the authors in-between sessions.

In the event of rolling out the approach to a larger scale pilot it is envisaged that a staff member involved in learning support (but not necessarily someone capable of providing Mathematics support) would be tasked with setting up the tablet and microphones as well as ensuring their proper use. For example, an administrator at the support centre could be trained to set up the

tablet etc. and would then be on hand to ensure that any technical issues that arise during the session could be resolved in a timely manner.

After the trials were completed, feedback was sought from the students, including their opinions on the advantages and disadvantages of the virtual drop-in over the traditional experience and any suggestions they may have on improving the virtual drop-in experience.

Figure 5. An image of one of the Wacom Intuos Tablets used in this project.
An A4 page is included so the relative size of the tablet can be observed.

Overall students were positive towards the concept of the Virtual Drop-in service. However, they felt that the technical issues that arose during the trials, such as feedback and slow connection issues, would need to be addressed in order for this service to be implemented successfully. A representative selection of the feedback received from the seven students involved in the prototype is presented below.

4.1. Overall Impression

'I was very impressed, I think it's a great way to help students with Maths questions. Aside from the slow internet feed I think it has great potential and I'm definitely keen to see it up and running'

'Great idea, software was a little clunky and internet connection or lack of was a hindrance, But can easily be taught and overcome'

'It has potential but I feel unless it becomes more streamlined I could see students becoming more frustrated than helped.'

4.2. Advantages

'It will help people learn or ask questions easier who are shy or ashamed to do so in class'

'… the virtual drop-in gives a larger scope of time and geographical location.'

4.3. Disadvantages

'If the lecturer on virtual drop-in uses different techniques to solve questions as opposed to classroom lecturer, it may be confusing and take longer to help solve a problem'

'may get overloaded with students who don't bother going to class as they see this system as a substitute for class attendance'

4.4. Suggestions for Improvement

'Use external microphone and speakers or headphones to eliminate the echo effect'.

'Use a speed scanner to scan the Example questions or problem sheets faster to save time writing it on the pad'.

'Web cam/Web cast with the cameras facing whiteboards on either side of the link'

'A platform for posting question and receiving answers in a timely fashion'

5. Conclusions

In this paper we have outlined the results of a survey of staff and students in three institutions soon to form a new merged entity. The majority of staff (71%) and students (69%) surveyed would like to see MLS provided either primarily or exclusively in person. This is a recurring theme in studies undertaken in Irish Higher Education system, see for example O'Sullivan (et al. 2014) and Clancy et al. (2015), and therefore it is clear that in-person support should remain at the core of MLS provision in Irish HEIs.

However among those who participated in this survey there was some preference that a portion of MLS be delivered online. As a result of this preference among both staff and students, a prototype of a virtual drop-in service, aligned closely to the in-person experience, was developed and was tested with students and staff from the different institutes. These students were mostly positive towards the concept of virtual drop-in, but had some concerns on the technical side of the service. They also offered some useful suggestions on how this service could be improved. Indeed based on the feedback from students involved in the proto-typing, headphones and microphones have been purchased for use in future trials.

A point worth stressing is that technical difficulties, such as slow connection speed, will certainly have a negative effect on students' engagement with any initiatives such as this. In fact, it is the authors' opinion that for the case of virtual drop-in, technical difficulties such as encountered in this prototype would be fatal to the introduction of a virtual drop-in system on a wider basis. In order for this to happen, we believe that there must be a robust technical infrastructure in place, ideally with dedicated technical support on-hand should issues arise, otherwise it is highly likely that students will not engage with the support.

Finally, the issue of providing effective virtual MLS is of importance beyond the scope of the merger discussed in this paper. For instance at the Open University much work has also been done in developing a model for virtual MLS provision. The Open University model follows along similar lines to that described in this paper, using Blackboard Collaborate to offer one-to-one virtual drop-in sessions. In this model, it is envisaged that this virtual drop-in will form part of a suite of online resources, including 'screencasts, forums and dedicated context based online workshops' (Golden, 2015). In the collaborative spirt of the Mathematics Learning Support network, it is important that the sharing of ideas continues so that the best practice for the provision of virtual MLS can be established.

6. Acknowledgements

This project was funded by the DIT Learning Teaching and Technology Centre.

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CASE STUDY

Introducing the logic of hypothesis tests though randomisation tests

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Abstract

There has been a lot of interest in the use of randomisation tests as a pedagogic alternative to hypothesis tests (Zieffler, 2012), although proposals to use randomisation tests in research are far from new (e.g. Hooton, 1991) with Good (2000) being an updated classic text in this area. This article will present a classroom activity that demonstrates the randomisation tests as a means of understanding several of the concepts around hypothesis testing in a manner that is as friendly as possible for maths-phobic and indeed computer-phobic students.

Keywords: Hypothesis test, randomisation test, threshold concept.

1. Activity

1.1. Background

The activity presents the randomisation test in the context of a designed and controlled experiment. Random allocation of treatments in designed experiments is a key concept that should be introduced or reinforced early on any statistical course. Hence we can readily appreciate the importance of random allocation. In order to work within a classroom (and not a laboratory) setting, we conduct a “thought experiment”.

1.2. Activity

The first stage in the activity is to ask a research question that could be answered with suitable human volunteers. As chocolate often serves as an inducement for volunteers to come forward we usually conduct some experiment on the stress relieving effects of chocolate (or rum truffles, or cola, or other snack). We need to discuss the ways of measuring stress (we posit a fictional biochemical test for cortisol as we can freely obtain fictional measurements and print them out). Having obtained volunteers we need to establish a working theory (that the snack has an effect) and then formulate a null hypothesis. The null hypothesis can usefully be explored in both an informal way (the snack has no effect) as well as a formal one (the population mean levels of stress measure cortisol are the same for treatment and control groups).

The student volunteers are obtained and are subsequently randomised to two groups (the treatment group receving the rum truffles or similar and the control group receiving the placebo) by means of a coin toss. We can then obtain the experimental data.

Having obtained data from both treatment group and control group we can examine the summary statistics. The fake data we have presented is as follows (Cortisol mmol l^{-1}):

Control: 4.95, 3.61, 5.15, 2.22

Treatment: 0.90, 3.16, 0.57, 0.15

Figure 1. Students are lined up on stage “wearing” their cortisol measurements.

The sample sizes are small (to make the stage production manageable in terms of explaining to non-statistians the sampling distribution of a test statistic under the null distribution) but computer animation can run the data through with larger samples later. We can first dwell on the obtained data; usually a student will notice that the data overlap (there is a value of 2.22 in the control group which is lower than the 3.16 in the treatment group. So we can make it very clear that we are looking at averages and not individuals. We can also at this stage discuss a test statistic. If our null hypothesis were true, we can usually prompt students to realise they would expect the difference in group means to be zero. At this stage we can introduce ideas of sampling error. Individuals have different levels of stress hormone (and we may introduce other errors in the testing regime). We need to know whether the difference we see is large enough that we can rule out random error. At this point we can explore designs that may block out the error.

The next step in the procedure is to introduce the idea of the randomisation test. If the null hypothesis is true, the only reason we got readings of 4.95,…2.22 mmol l^{-1} in the control group is because we allocated those individuals to the control group (because our null states that the treatment has no effect). We could therefore shuffle the subjects randomly between groups and get a fictional test statistic.

Figure 2. Students are lined up on stage having been shuffled.

To reinforce the idea that the measurements are a feature of the students the “least stressed” student has been given a surfboard and the “most stressed” student a yellow jacket. The key point is to explore the concept that if we believe our null hypothesis, we believe we would have got these data if we had allocated the students to the two groups. This is a key idea, indeed Meyer and Land (2003) give this idea of a sampling distribution as an exemplar threshold concept. Indeed, we often avoid engaging students with this concept as it is indeed rather troublesome. However, it is such a key concept underpinning many later ideas that I believe it is worth the effort of exploring carefully. So far in the classroom illustration, we are trying to convey the idea that **if our null hypothesis is true** we can use the data to give us some idea how much our test statistic can vary. The well stated advantage of randomisation tests is that we don’t need to pick our test statistic to match a theoretical distribution and need rather few assumptions about the data generating mechanism.

It is sensible at this stage to introduce ideas of the number of shuffles we might need in order to have a reasonable understanding of the distribution of the test statistic under the null. To some extent this is linked in with the discussion of the sample size of the experiment. However, it is usually straightforward to persuade students that a larger sample size is needed and that it would be helpful to have a computer doing the shuffling. We therefore move attention to a computer animation of a randomisation test of a larger dataset. Figure 3 presents one of the later stages in the animation, after we have shuffled the data 1000 times. The aim of the animation is to use the same data, but with larger datasets. We shuffle the data 1000 times and build up a histogram of values we obtain in this way.

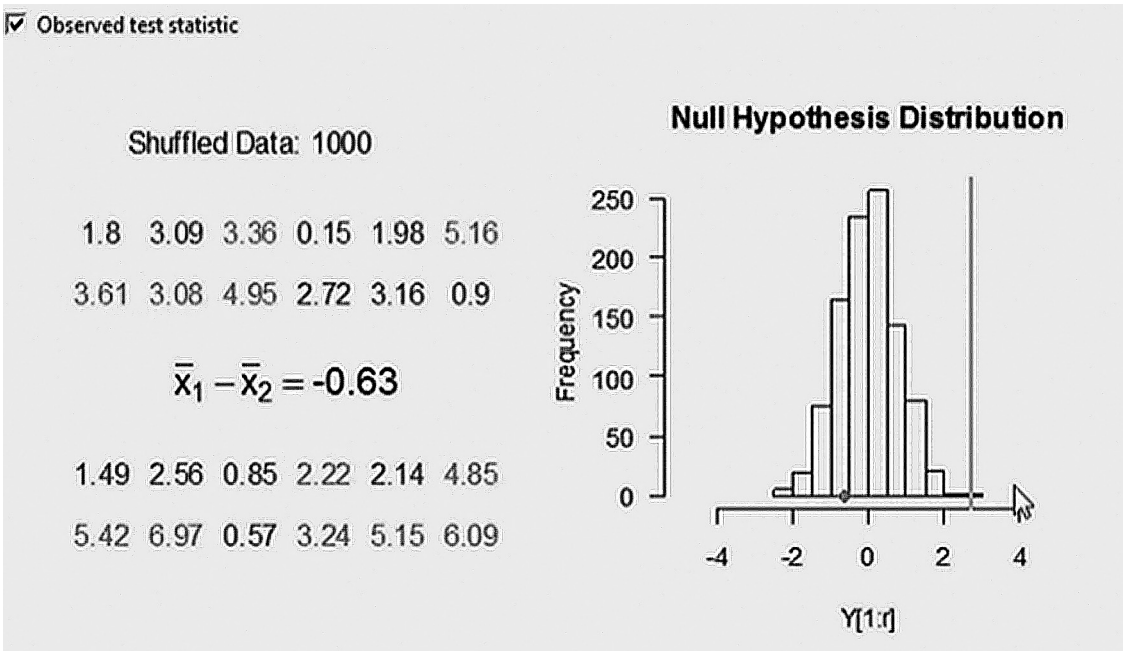

Figure 3. Computer animation of randomisation test.

The histogram therefore represents the sampling distribution of the test statistic for these data under the null hypothesis that the treatment has no effect (or more formally that both samples have been drawn from a population with the same population mean).

We can superimpose the original test statistic on these 1000 simulated values and then ask the question as to whether we believe the data we observed were indeed likely to have arisen from this null hypothesis distribution. Having hopefully rooted our students in the idea of the sampling distribution of the null we are free to explore several key ideas around hypothesis testing. Using a

simple Fisherian approach to hypothesis testing, we can approach the idea that if very few of the simulated replicates are larger than our observed test statistic, perhaps we will reject the null hypothesis. We can introduce the idea of tailedness. We can also introduce the idea that perhaps we should have used a better method for decision making and formulated an alternative hypothesis at the start of the experiment. Once using a computer simulation it is possible to consider the role of the size of the test quite carefully, and the implications for data sample size. We can explore more carefully what we mean by a p-value, and in particular, introduce the idea that if the null hypothesis is true we do indeed expect to make a decision to reject the null hypothesis incorrectly a proportion of times we are in this situation. In other words, we can contemplate simulations under scenarios we know the null hypothesis to be true and note that we will reject the null hypothesis a certain proportion of the time. We can also see that this approach to inference focuses attention on rejecting a null hypothesis and explain the logic behind non-statistically significant results only "failing to reject" the null.

1.3. Discussion

Nuzzo (2014) is just one of many papers that highlight the problems working professional scientists have with hypothesis testing. Responses to this paper vary from the suggestion we abandon hypothesis altogether (using either confidence intervals or Bayesian approaches). Inertia seems likely to prevent much movement in either direction for the foreseeable future. More conservative proposals suggest we focus on better education. The goal of this activity is to help to set out a sound conceptual framework for understanding hypothesis testing. It is hoped that this activity can at least make students clear that a p-value is something to do with the probability of data given hypothesis rather than the inverse, and highlight the way it is conditional on the sampling distribution of the very null hypothesis we wish to reject.

A YouTube clip of an early attempt to use this activity can be found here: https://www.youtube.com/watch?v=ESP0huKsKD0

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OPINION

University Teaching - recognition and reward

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Keywords: University teaching; recognition, reward

Teaching in universities has increased in importance in recent years which, in part, is a consequence of the change in funding of universities from block grants to student tuition fees. More support for the development of early career and established staff has been provided by the Higher Education Academy (HEA) through workshops, including one for those new to teaching, as well as the introduction and development of the UK Professional Standards Framework (UKPSF). While this has all served to raise the profile of teaching and give it greater recognition, it is also important that teaching is recognised even more fully and widely, and crucially that it is rewarded accordingly.

We believe that one way of achieving this would be to establish a fair, robust, transparent and objective mechanism for recognising and rewarding university teaching that is based on a review process that is supported by documented evidence. To achieve this we propose a mechanism whose outcomes can be fed into performance and development reviews, and used to inform decisions about reward and promotion, as well as the review of probationary status where appropriate.

We identify eight key ‘themes’ we believe should be addressed when developing and reviewing teaching, together with associated ‘points to consider’ and ‘key evidence’ to be provided. Crucially, each ‘theme’ has ‘observation of teaching sessions’ as one of, or the main item of ‘key evidence’ that should be used to inform the review.

Coupled with this would be a record of each teaching session that is observed to be included as ‘key evidence’ as part of the review. A teaching session observation scheme to achieve this should include written statements comprising:

1. feedback and review on the content and presentation, with positive features highlighted;
2. a statement on each of the ‘themes’, where appropriate, including examples of evidence that inform the review of that ‘theme’;
3. areas for further development related to 1. and 2.

Such observations are common practice in universities, and used extensively to support the development of staff and share good practice, but little use is made of these to make cases for reward and promotion.

Prior to any performance and development review, evidence would be collated by the member of staff, including the documentary evidence indicated below, as well as records of teaching observations carried out by experienced staff who are excellent practitioners themselves, and who command respect for their knowledge and experience in high-quality teaching.

For each of the eight ‘themes’ below the following are included:

- the ‘Points to consider’ for the member of staff and reviewer;
- the ‘Key evidence’ which would support the review;

as follows:

1 Set high expectations which inspire, motivate and challenge students • set goals that stretch and challenge students of all backgrounds, abilities and dispositions.	
Points to consider	• How do you set about the task of inspiring, motivating and challenging students? • How do you ensure that your teaching is inclusive? • How do you use information from assessment in your teaching? • What in your practice is influenced by Departmental and University policies?
Key evidence	• Observation of teaching sessions • Planning • Module results and student progression data • Consistently working within Departmental and University policies

2 Promote good progress and outcomes by students • be accountable for students' attainment, progress and outcomes in conjunction with any staff supporting their teaching; • be aware of students' capabilities and their prior knowledge, and plan teaching to build on these; • guide students to reflect on the progress they have made and their emerging needs; • demonstrate knowledge and understanding of how students learn and how this impacts on teaching; • encourage students to take a responsible and conscientious attitude to their own work and study.	
Points to consider	• How do you monitor the progress of students? • What do you do to establish students' prior knowledge and capabilities in order to build upon this in your planning? • How do you give feedback in a positive, accurate and constructive way? • How do you promote the skills necessary for learners to be able to identify the progress they have made? • What do learners know about the standards of attainment expected of them in the next stage of learning? • How do you effectively use feedback in your teaching sessions? • What professional development opportunities have you undertaken to improve the effectiveness of your teaching? • How do you evaluate the impact of your teaching? • What strategies do you use to develop independent learning? • How do you plan and provide for learners to co-operate and collaborate?
Key evidence	• Observation of teaching sessions • Communication with colleagues • Feedback from colleagues • Evidence of student progress

3 Demonstrate good subject knowledge • have a secure knowledge of the relevant subject areas, foster and maintain students' interest in the subject, and address misunderstandings; • demonstrate a critical understanding of developments in the subject, and promote the value of scholarship; • demonstrate an understanding of and take responsibility for promoting high standards of the correct use of standard English.	
Points to consider	• What do you do to develop your subject knowledge? • Can you talk about ways in which you have adapted your practice in response to developments in your subject areas? • What approaches have you found successful in fostering and maintaining student interest in your subject? • How do you keep up to date with the latest developments in education? • How are Departmental and University approaches effectively reflected in your work?
Key evidence	• Observation of teaching sessions • Self-review of teaching • Contribution to setting of learning outcomes • Range of professional development opportunities undertaken • Response to feedback from colleagues, including observation of teaching sessions • Student response/engagement (e.g. observation, formative and summative assessment evidence)

4 Plan and deliver well-structured teaching sessions • impart knowledge and develop understanding through effective use of teaching session time; • promote a passion for learning and students' intellectual curiosity; • set formative (and, where relevant, summative) coursework, and guide students to engage in other independent learning activities outside teaching sessions to consolidate and extend the knowledge and understanding they have acquired; • reflect systematically on the effectiveness of teaching sessions and approaches to teaching ; • contribute to the design and provision of an engaging curriculum.	
Points to consider	• How do you demonstrate good planning? • How do you ensure that coursework is relevant to, and marked to learner's needs? • Do you apply constructive criticism to new ideas, research and approaches and contribute to change and innovation in your Department? • Are you proactive in seeking, listening to and acting upon advice, including: mentoring, professional dialogue or other professional development activities? • What contributions do you make to, for example, departmental/staff, team, planning or other meetings? • What do you do to extend your students' learning outside teaching sessions?
Key evidence	• Observation of teaching sessions • Planning of sessions • Samples of formative and summative coursework • Differentiated tasks • CPD • Presentations to staff

5 Adapt teaching to respond to the strengths and needs of all students • know when and how to differentiate appropriately, using approaches which enable students to be taught effectively; • have a secure understanding of how a range of factors can inhibit students' ability to learn, and how best to overcome these; • have a clear understanding of the needs of all students, including those with special educational needs; those of high ability; those with English as an additional language; those with disabilities; and be able to use and evaluate distinctive teaching approaches to engage and support them.	
Points to consider	• How do you support and guide learners so that they can reflect on their learning, identify the progress they have made, set positive targets for improvement and become successful independent learners? • How do you make effective use of an appropriate range of observation and assessment strategies as a basis for setting challenging learning objectives and monitoring learners' progress and levels of attainment? • How can you show that you have taken account of specific needs of individual/groups of students within your teaching? • How do you demonstrate differentiation in your planning and practice?
Key evidence	• Observation of teaching sessions • Planning • Assessment records • Samples of formative and summative coursework • Involvement in CPD opportunities

6 Make accurate and productive use of assessment • know and understand how to assess the relevant subject areas effectively; • make use of formative and summative assessment to secure students' progress; • use relevant data to monitor learning and plan subsequent teaching sessions; • give students regular feedback, both orally and through accurate marking, and encourage students to respond to the feedback.	
Points to consider	• How do you use information from assessment in your planning and teaching? • How is the Departmental assessment policy/practice evidenced in your planning? • How does your planning and teaching show progression towards appropriate levels and/or examinations? • How do you assess achievement both within lessons and in students' work? • How do you use assessment as part of your teaching to diagnose learners' needs, set realistic and challenging targets for improvement and plan future teaching? • How do you work with relevant colleagues to access and use local data? • When, where and how do you use formative and summative assessment in your teaching? • How can you show that data informs your planning? • How do you give feedback in a positive, accurate and constructive way?
Key evidence	• Observation of teaching sessions • Planning • CPD • Samples of formative and summative coursework • Assessment records

7 Manage an effective learning environment • manage teaching sessions effectively, using approaches which are appropriate to students' needs in order to involve and motivate them ; • maintain good relationships with students and exercise appropriate authority.	
Points to consider	• What factors in the learning environment enable students to feel confident? • How effectively do you establish and build relationships with students and colleagues?
Key evidence	• Teaching observations

8 Fulfil wider professional responsibilities • develop effective professional relationships with colleagues, knowing how and when to draw on advice and specialist support; • deploy administrative and teaching support staff effectively; • take responsibility for improving teaching through appropriate professional development, responding to advice and feedback from colleagues; • take advantage of continuing professional development opportunities, both locally and nationally, and to incorporate best practice in their teaching.	
Points to consider	• How do colleagues e.g. Demonstrators/Tutorial teaching staff, know what you want them to do in order for learners to achieve learning outcomes? • How can you demonstrate that you are able to collaborate and cooperate effectively with colleagues and other professionals? • How do you involve them in planning and the assessment and recording of student progress? • How do you liaise with relevant colleagues to assist in supporting the range of learning and development needs? • How do you know that you fully utilise the skills and expertise of your support staff? • How can you demonstrate that contributions from colleagues impact on your teaching? • What do you think other team members value about your contributions?
Key evidence	• Observation of teaching sessions • Deployment of Demonstrator/Tutorial teaching staff support • CPD • Communication with colleagues • Feedback from colleagues

Any review should include:

- a commentary on the actual evidence addressing the 'theme';
- the reviewer's comments;
- areas for further development.

All eight 'themes' should form the basis of any review of teaching and common to all university teaching. It is also essential that a strong focus is placed on the actual teaching and learning that takes place, with evidence taken from the observation of teaching sessions.

It goes without saying that any scheme which is designed to recognise and reward teaching should not become a 'tick-box' exercise, whether it is one based on the framework above or something else entirely. To reap maximum benefit from any scheme of this kind it is essential that colleagues engage in the spirit in which it is intended - as a developmental tool which supports colleagues to enhance their teaching.

Finally, we note that 'university teaching' is about to undergo a revolution following the publication of the Green Paper in November 2015: 'Fulfilling our potential: teaching excellence, social mobility and student choice'[1]. As Jo Johnson, Minister of State for Universities and Science stated in his speech to Universities UK: 'There must be recognition of excellent teaching – and clear incentives to make "good" teaching even better'[2]. The Government has decided to 'drive up teaching quality' by introducing a Teaching Excellence Framework (TEF) across the sector. The TEF is expected to be based on a set of outcome-focused criteria and metrics, such as scores in the National Student Survey (NSS), drop-out rates, graduate employment rates, and even the proportion of 'good' degrees (a first or 2.1).

We believe that a framework based on these criteria and metrics bears little relation to what we would describe as 'teaching' excellence as exemplified by the themes outlined above. We also believe that the TEF as currently forumulated is unlikely to value the actual teaching that takes place in any meaningful way, and it will not enhance the quality of that teaching. Among a number of other salient and salutary points, Anthony Seldon argues in his article[3] that: 'Professional development of teaching needs to be embedded in universities, along with regular observation and feedback.'

[1]https://www.gov.uk/government/consultations/higher-education-teaching-excellence-social-mobility-and-student-choice

[2] https://www.gov.uk/government/speeches/teaching-at-the-heart-of-the-system

[3] http://www.thetimes.co.uk/tto/opinion/columnists/article4607170.ece

RESEARCH ARTICLE – STUDENT AUTHORED

What makes a successful outreach kit?

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Abstract

The research has been carried out in order to create an effective portable maths outreach kit, using readily available sources and collating the information. The report explores the types of outreach and their benefits. Our findings indicate that an outreach session should be interactive with a range of activities. Research also showed that most young people do not see mathematics as a career option so for maths outreach to be effective there should be a strong focus on linking the activities to careers. The research highlighted the importance of avoiding stereotypical views regarding gender, age and ethnicity within mathematics and other STEM careers, encouraging young people to consider a STEM career.

Keywords: Outreach, Student Project, Mathematics, Careers.

1. Introduction

If done well, outreach in maths can be an effective tool to enthuse young people about the subject outside of school lessons. Not only does it increase and expand learning techniques, it can be used to help students gain confidence and develop a positive attitude towards the subject area. There are various forms of outreach such as day events, industry speakers, university visits and block programs. For this report we have focused our research on a portable outreach kit that can be adapted to a variety of situations at short notice.

The main purpose of this project is to improve what Nottingham Trent University (NTU) has to offer in regards to mathematical outreach. This research was undertaken to identify the key requirements of effective outreach and put the knowledge gained into practice to develop 3 outreach kits. These kits, of varying sizes, should then be able to be transported and used by any member of staff or student ambassador. These kits will be used by NTU in the future, improving the current mathematical outreach on offer.

The research will look at effective types of activities and games, career information required, sterotyping and safeguarding children using available publications.

2. What Makes Effective Outreach?

There are many things to consider when putting together a maths outreach kit that leaves a lasting effect on the participating students. It is important that the activity matches to a mathematical objective and the goal is clear (Way, 2011). Outreach is common at day events such as science fairs and within designated time slots at school. This means that interaction time with the students can be short; therefore the activity shouldn't be too complicated and can be picked up quickly. One way of doing this is to create a series of games with a similar structure that the students rotate between. An effective outreach kit is usually interactive- with solo and multiplayer activities. It can be a good idea to keep multiplayer games to a maximum of 4 players to avoid long waits between turns and hence losing interest (Way, 2011). Depending on the age group, using objects varying in size, material and colour will make the student feel less like they are doing maths, and more like

they are having fun. If the participants are enjoying themselves, it may lead to motivation to get more involved in maths. Developing activities with direct links to the National Curriculum can assist the students' learning outside of the classroom. Within schools, outreach sessions can provide teachers with an informal method of assessing the levels at which pupils are working (Way, 2011).

An outreach kit that is portable can be used at multiple venues and should be able reach a large target audience that includes a range of age groups. In most cases a limited amount of information will be known about the participants in advance so creating a combination of activities, games and puzzles that cover a wide range of interests is key. Additionally, it is important that the activities appeal to both girls and boys (Centre for Science Education, 2015). As the audience will be largely unplanned, the activities should be able to be adjusted to suit different age and ability levels. This will also create the chance for students with different strengths to help each other out. Including games with an element of chance will allow less able students a chance to win and therefore build their confidence with mathematics (Way, 2011). Including multiplayer games and activities based on team work maths outreach provides students with a chance to engage in discussion and develop both their problem solving and social skills. Strategic puzzles will encourage students to use their initiative and develop creativity (Way, 2011).

Hewson (2011) writes that there is a lack of interest amongst students within mathematics. He also suggests it is not uncommon for young people to have a negative attitude towards mathematics, preventing them from giving it a fair chance and therefore limiting their ability to develop a fascination within the subject. They may not be aware of how many aspects of everyday life are based on maths. Putting a strong focus on linking the activities to real life situations will help the students realise the many career opportunities within the field of mathematics. Eaton and Morton (2012) say that the key to effective outreach is "long term impact to compliment short term effects of an outreach activity".

3. Linking Activities with Careers

"The world of work, can make a strong contribution to the motivation of young people towards a career and a lifetime in STEM" (National Science Learning Centre, 2008).

Outreach has an important impact on raising a student's aspiration to university, resulting in an increase of students partaking in higher education (More Maths Grads, 2009). The More Maths Grads project outlined that "making students aware of the range and interest of jobs which use mathematics is at least as important as enriching the mathematics these students know" (p. 9).To some extent, outreach can help bridge the gap between the mathematics taught in schools, the everyday use of mathematics in life and the careers it offers. This will help shift the attitude "I could never see myself ever using [mathematics] in my day-to-day life" (Rodd et al., 2014).

Outlining how students' understanding of key aspects of mathematics can be applied in a real-world context is key. It may not be enough for the students to just be interested in mathematics as the More Maths Grads Project identified in their good practice guide "many school students (and a large number of teachers) are only vaguely aware of the range of career opportunities available to a mathematical graduate". They also stated this can be a "great inhibition to those that enjoy mathematics but may feel their career options are limited" (More Maths Grads, 2009).

The STEM careers awareness leaflet (Centre for Science Education, 2009) suggests that young peoples' career choices are heavily influenced by their families. This is supported by the UK Engineering report 2009 (EngineeringUK, 2009) in which 73% of those surveyed agreed with this response. It is therefore important to engage all audiences in outreach and "it is important that the role of parents should not be underestimated" (EngineeringUK, 2015). The ASPIRES project

(ASPIRES, 2013) found that “families exert a considerable influence on students’ aspirations” (p. 3) and that “that most young people and their parents have a narrow view of where science can lead”. Outreach can be a useful tool in changing families’ views on STEM careers; for example at The Big Bang Fair 2015, EngineeringUK found perceptions on engineering can be improved with 68% and 70% of parents and teachers saying they were more likely to recommend a career in engineering to an accompanying young person.

Some outreach activities may directly link to potential career paths such as industry speakers or Higher Education visits (to demonstrate the research). Others however may not have such a strong link and may be lost on participants of the activity.

Eaton and Morton (2012) highlighted that even if it is unfeasible to adapt an activity explicitly to include careers advice, “a short summary handout of the careers linked to the task or for those who deliver the activity to explain how they got to do their job” can “make the activity more meaningful and open up opportunities that young people may not have considered”.

Another way is to use role models and ambassadors (a representative of a career or university course), who can be a great way to break down stereotypical views on Mathematics and STEM careers in general. They can provide a “link to young people that helps make STEM real and interesting” (Eaton and Morton, 2012). The More Maths Grads Good Practice Guide (More Maths Grads, 2009) outlined HE students can be effective as ambassadors as the young person can often relate to the HE student. The Maths Outreach report (Institute of Mathematics and its Applications, 2011) showed that of the universities mathematics departments they surveyed, many universities run a Student Ambassador scheme and they all utilise students for some form of outreach activity.

It is also important when demonstrating careers to visitors to highlight the vast number of career pathways open in STEM so that visitors are able to “explore the really wide range of roles available beyond this immediate experience” (Eaton and Morton, 2012). This can be done by explicitly providing detailed information about a select few jobs and by linking to the skills that a certain activity demonstrates. An alternative is to provide an overview to demonstrate the wide range of roles available and signpost places which can offer more information such as Maths Careers or Futuremorph.

One of the things that was repeated in the literature was the importance of imparting career information to young people and their families, showing the breadth of jobs open to them and challenging the stereotypical view that mathematics careers are limited to being an accountant or a teacher.

4. Equality and Diversity

One problem that an effective outreach kit should attempt to overcome is the continuing gender stereotype that girls are less interested in STEM subjects than boys. A survey carried out by the Department of Education and Professional Studies Kings College London showed that among 12-13 year old students, 18% of boys and 12% of girls aspire to become scientists – in comparison, 64% of girls aspire to careers in the arts (ASPIRES, 2013). Outreach talks and activities can relate STEM learning to the real world and give it a meaningful context relevant to girls’ lives. The survey also revealed that “a student is most likely to express science aspirations if he is male, Asian, has high/very high levels of cultural capital, is in the top set for science and has a family member who works in science or a STEM related job” (ASPIRES, 2013).

One way to deal with these stereotypes is by managing who is being reached. Only in certain situations it is possible, but contacting the schools/teacher/advisors prior to the outreach session can ensure that the group of students involved will be diverse, with a balance of genders, backgrounds and ethnicity. Images and any fictional characters that are used within activities shouldn't impose these stereotypes, but include a range of ages, gender and ethnicities (Centre for Science Education, 2015).

Another benefit to activity-led outreach can be that once the students are familiar with the structure of the games, any language barrier becomes unimportant (NRICH, 2011a).

In order to create suitable activities for any participants with visual, hearing or learning disabilities measures can be taken. Large handouts, bright colours and a range of textures are all examples of techniques that can be helpful. By liaising with the school or organisation in advance, an outreach kit can be adapted to suits the needs of those using it (Centre for Science Education, 2015).

5. Safe-guarding Children

Safeguarding will be important in particular in outreach as in general you are likely to be in contact with vulnerable groups. It is therefore important to adhere to the guidelines and legislation set out to protect these vulnerable groups. In general organisations will normally have their own safeguarding policy but if this is not in place it is worth reading the government legislation on the issue (HM Government, 2015).

A DBS check can be required if either someone will be left alone with a child, or if they will get to know the student over a period of time. This may apply to ambassadors on defined programmes but may not apply to ambassadors assisting on open days and at 'one-off-events'. DBS Checks can take several weeks to have arranged and if required should be sought as early as possible. If the outreach is taking place in a school it can be useful to consult them for best advice (More Maths Grads, 2009).

6. Discussion

Outreach can be a key tool in changing the attitudes towards STEM careers; not only amongst young people but those of any age group. There is a common misconception that there are limited career opportunities within the field of mathematics, and STEM in general. Research indicates that young people do not relate the maths material they are learning in school to real life situations and potential career paths. If used effectively outreach can be used as a tool in correcting this disposition.

This research highlights the importance to avoid perpetuating stereotypes within mathematics. The subject is often stigmatised for being male dominated, thus putting females off. Informing the participants and breaking this stereotypical opinion should be one of the aims when planning outreach. An effective outreach kit should contain activities that can be enjoyed by all individuals and does not discriminate in any way.

The outreach is unlikely to have a lasting impact unless the participants are engaged by the activities. One method of motivating the participants is through the use of games, puzzles and challenges. By interacting with both the activities and each other they can enjoy working with mathematics outside of the school environment. By linking the activities with the National Curriculum, pupils can advance on their current knowledge and extend it to its practical applications. It seems there are a high number of young individuals that have not given maths a fair chance; successful outreach can change this negative attitude towards mathematics. Outreach

can be used to build confidence as it gives participants a chance to experience the sense of satisfaction that persisting with maths can bring in an informal situation.

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CASE STUDY – STUDENT AUTHORED

IMA Business Game at University of Greenwich

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Abstract

This article, written by a second year maths student from the University of Greenwich, describes a workshop designed to increase maths students' awareness of how businesses operate. The motivation for this activity came from collaboration between the University of Greenwich and the Institute of Mathematics and its Applications.

Keywords: Business Awareness, Employability.

1. Introduction

Employers often say that they want graduates or placement students to have 'business awareness' but, as asked by Ramesh et al. (2013), how can students learn how companies function? To help students at Greenwich understand how businesses operate, staff developed a Business Game activity for second year maths students with the help of the Institute of Mathematics and its Applications (IMA) (Bradshaw, 2013). They have run this activity for the last four years and report that student feedback has always been extremely positive. The IMA are keen to help other universities run similar activities; so do contact Erica Tyson (IMA University Liaison Officer) for more details if you are interested.

2. Business Game

About 60 students gathered one afternoon at Greenwich to take part in this activity, which we were told was going to be in the style of 'The Apprentice'. Thankfully neither Lord Alan Sugar nor Claude Litner were present to give us all a good roasting at the end.

We were split into three equal 'packaging companies', with 20 staff each, and given a brief which outlined the departments that a company might need (i.e. marketing, production, finance etc.). We were also provided with a synopsis of the rules of the game and what staff in each department should be doing. A list of different materials and their costs was also included. Each team then chose their company name and CEO, who asked for 2 volunteers each to act as finance, marketing and purchasing staff. The rest of the team were split in half into design and production staff members. There wasn't an opportunity to change roles as the exercise only lasted for around 2 hours.

One of the lecturers took the role of the customer and another became the supplier. Other lecturers observed us as we went about our business. Only the marketing staff were permitted to communicate with the customer and only the purchasing staff with the supplier.

Our first task was to design, produce and sell a box to contain a small container. The marketing staff immediately went to see the customer to ascertain his requirements and obtain an estimate of what price he would be prepared to pay together with the volume of boxes required. In the meantime, the finance staff started to work on the costs of the materials and staff, although this was only an initial estimate as the design and volume were not as yet decided.

As soon as the marketing staff returned, the design team started working on the prototype while the finance team tried to calculate the unit cost. At the same time the purchasing staff went to the

supplier to buy the initial materials required. There were different types of the same sort of material, for example, masking tape, clear tape, or double-sided invisible tape, at different prices. We therefore had to decide whether to spend money on high-end materials thus improving the quality of our designs, or save money and buy at the cheaper end of the range and make more profit, but risk the client rejecting our design.

However, it soon became clear how difficult it is to coordinate all of the different requirements and how the flow of the supply chain has a serious impact on 'the business'.

The finance team could not calculate the unit cost until the purchasing staff were back from negotiating with the suppliers over material costs, and the design team could not make the prototype until the materials were bought. One delay occurred because there was a queue at the supplier; this showed us that choosing a potential supplier was not just about cost; efficient service and speed of delivery are also vital.

Once the prototype had been made it was taken to the customer for his approval before production commenced. We did not feel that we could purchase the rest of the materials or start production until the customer had approved the model in case he rejected it or required modifications.

This then led to a delay in purchasing materials and hence a delay in production. It also revealed that if one is too prudent over spending on machinery, there is insufficient capacity in production thus slowing delivery. It is very difficult to get the right balance between spending on hardware, profit and staff availability. Up until this point, the production staff hadn't had work to process, resulting in a waste of staff resource and cost. Once production started, we soon found that these staff were under immense pressure to get products out on time, although the delays had occurred higher up the supply chain.

We then went on to design and produce more products to keep the chain going. The second product was a type of 'horse box' which needed to have sides sufficiently high to stop the animal escaping but also allowing easy loading and unloading. At the end of the game we gave a brief presentation of our gross and net profits, what troubles we had encountered and what we had learned from the process. One of the problems we encountered that we had not anticipated was a queue at the suppliers, as other 'companies' were taking time to negotiate over prices.

The 'customer' and 'supplier' commented on each team's performance. The 'customer' noted how well or not we had kept to the promised deadlines and specifications, and why he had paid a much higher price than he originally intended for the 'animal box' as he was under time pressures. The supplier commented on each team's different approach to buying supplies, in terms of volumes and price negotiations. He also let us know that one team had successfully sold their leftover materials back to him at the end of production, thus increasing their profit.

Overall, it was an excellent and clear lesson in how hard it is to run a successful business and how much juggling is required to keep all of one's staff productive. It also highlighted how different personalities would affect the running of a business and how problematic it is to be a manager who encourages and praises their staff but also is tough when necessary. For example, a member of staff with a laidback personality can often need motivating to ensure that work is produced to the necessary timescale, and this can sometimes be frustrating.

3. Final Thoughts

But actually the best bit of the afternoon was that it was tremendous fun to play! The students were all very competitive even though we were told it wasn't about the winning but the experience! I cannot think of any group of people who would not benefit from such an experience and I would suggest that even existing companies should take part in similar activities with staff playing roles which are the opposite to those that they hold. I think this would increase the understanding of all staff for their colleagues in different departments and stop the friction between, say, floor operators and management, as they would appreciate the problems that each other faced. I believe it would also improve the cohesiveness of a company and help staff to realise that they were all in it together, and that each area has a valuable contribution to make to the overall success of a company.

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WORKSHOP REPORT

MathsJam Conference 2015

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The MathsJam weekend is an annual recreational maths conference convened by Colin Wright and held in Staffordshire in the U.K. since November 2010. This is related to the monthly MathsJam meetings, which take place in pubs in over thirty locations around the world and, since starting in 2008 in London, has provided an opportunity for “like-minded self-confessed maths enthusiasts to share puzzles, games, problems or anything else they thought was cool or interesting” (Rowlett et al., 2012). The conference offers a more structured format with the same ethos.

The 2015 conference started with lunch on Saturday 7 November 2015 and ended at lunch on Sunday 8 November 2015. The format is based around five-minute talks, with more than fifty presented in a single strand of six sessions over the two days. This format offers not enough time to give a lot of detail, but just enough to show something interesting or ask a question to provoke further discussion. After a block of around 7 talks there is a break, during which speakers make themselves available for further discussion with anyone who wishes to learn more. As a speaker, I can confirm that discussion carries on well beyond this as well. This format avoids audience members feeling they are sitting through long talks that don't interest them or are missing something in a parallel strand, while promoting an ethos of ‘sharing interesting ideas’.

The conference is specifically not an 'education' meeting. Indeed, many of the attendees have no role in education. Nevertheless, there is potentially great value in attending the series for those involved in education, and many attendees are school teachers, university lecturers and in related roles. The format means the conference was dense with a variety of potentially useful ideas.

In 2015, there were talks on recreational maths staples (for example, Matt Parker discussed the construction of magic squares) and, as you might expect from a recreational maths meeting, talks on related topics such as number theory (Matthew Scroggs, discussing forming a 'crossnumber' puzzle for Chalkdust Magazine, told us that every positive integer greater than 77 is a finite sum of distinct integers greater than 1 such than the sum of their reciprocals equals 1), geometry (John Bibby showed geometric patterns in African textiles) and probability (Martin Whitworth spoke about Penney's game, which involves two players tossing a fair coin until one wins when their particular sequence of heads and tails occurs).

Attendees are encouraged to present talks on topics that interest them, leading to some variety. There were talks about history, including Pedro J. Freitas showing the geometry of Portuguese artist José de Almada Negreiros (1893-1970) and Nicholas Jackson giving a potted biography of Émilie du Châtelet (1706-1749).

Although education was not the focus, there were some talks with an educational slant. Ken McKelvie discussed a variant on the 'Hannah's sweets' problem (Bellos, 2015), and Rob Eastaway covered an interesting solution to the 'Crocodile' question (Kennedy, 2015), both having been reported as 'difficult' exam questions this year in England and Scotland, respectively. Talks about how to explain mathematical concepts included Colin Wright's attempt to find an intuitive explanation why two sine waves sum to give a third sine wave, and Rob Eastaway's attempt to explain the construction of a deck of cards for the game Dobble (Spot It! in the USA) to students (actually, his children) who don't know about projective planes.

There were talks on mathematical modelling and other applied topics, including some by engineers and computer scientists. For example, Neal Harwood spoke about traffic modelling under the title 'Motorway Traffic: Shockwaves, Flow Breakdown and the problem of Hysteresis', Ben Sparks described how conic sections are used to track aeroplanes by triangulating radio signals, and Dan Hagon discussed the sophisticated geometry that must be understood in order to determine whether a mesh can be 3D-printed or not.

Outside of the formal sessions, there was a baking competition (in which attendees compete for prizes 'best cake', 'best presentation' and 'best maths') and a competition competition (in which attendees enter competitions they have invented for prizes including 'best competition', 'most (genuine) entries' and 'best attempt at circumvention of the rules while still strictly sticking to the rules'). An informal, semi-structured evening session included groups learning board games, card magic and mathematical knitting.

For me, professionally, the most valuable aspect from attending this conference over six years has been in collecting and sharing puzzles and games that might be useful for our Maths Arcade activity (see Bradshaw and Rowlett, 2012). For example, this year I gave a talk 'Nim-like games' covering Solomon's Stones (a game used at our Maths Arcade) and Wythoff's Game. This meant that a number of other attendees told me about interesting Nim variants, which might be useful in future Maths Arcade activities or when running this topic as a final year undergraduate project. I also discovered interesting new (to me) games; for example, this year Kathryn Taylor gave a talk about Hnefatafl, an apparently unbalanced ancient game of pure strategy that would be perfect for the Maths Arcade. I'm sure many other attendees who teach maths at university have found value specifically relevant to the areas they teach.

Otherwise, it is enjoyable to see people enthusing about mathematics, and interesting to see different ways people in a variety of occupations find to apply and take interest in maths – in formal work settings and recreationally. This can be useful when describing to students areas of employment in which they may use maths. It's also a lot of fun. I recommend the conference series wholeheartedly.

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