MSOR connections

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

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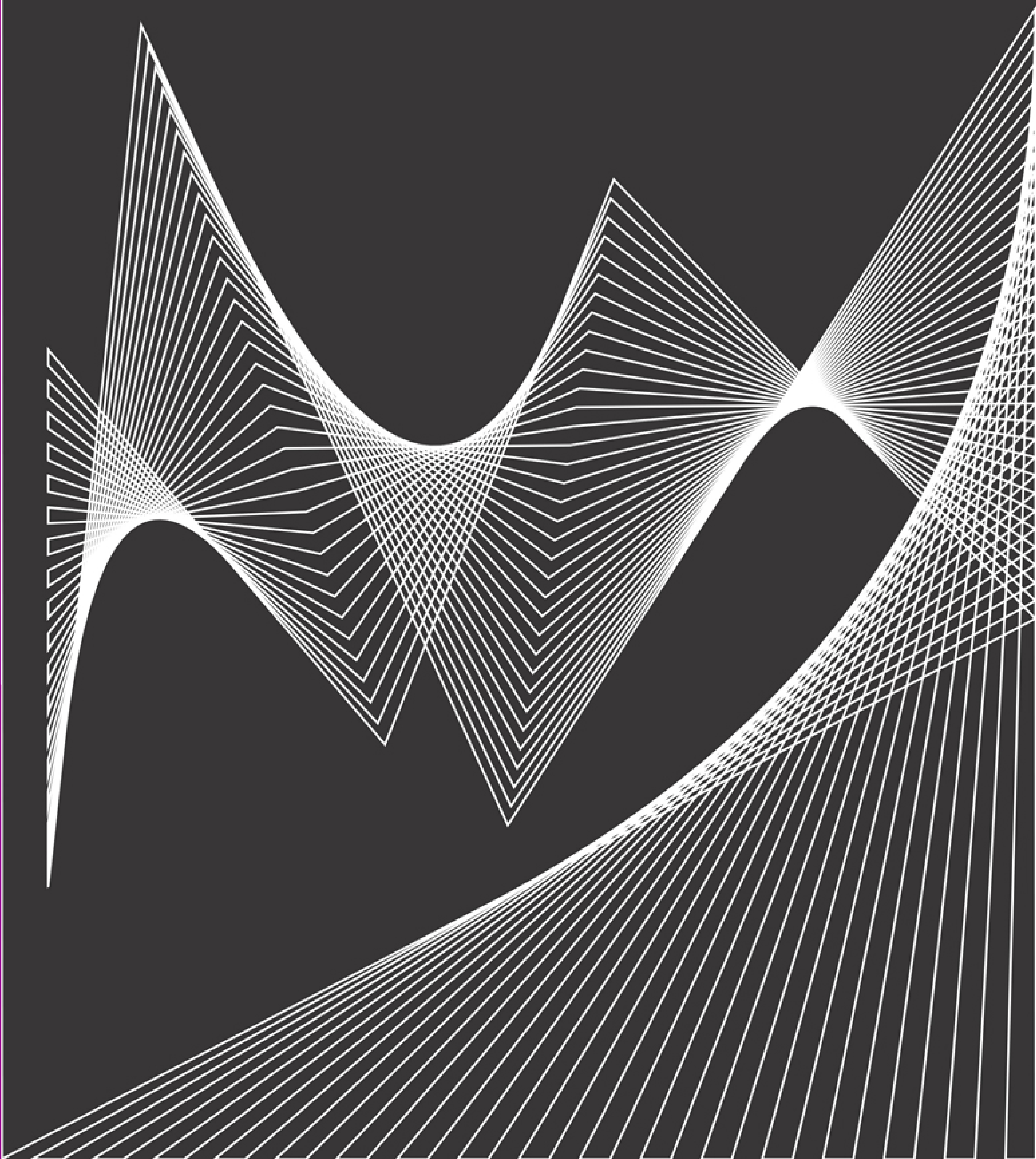

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Editorial

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This issue opens with two articles offering an insight into the mechanics of providing mathematics and statistics support in higher education. First, an article by the Scottish Mathematics Support Network reports on a detailed study of practice in institutions in Scotland, with comparison to similar practice elsewhere in the UK and Ireland. This is followed by an article from the **sigma** Centre at Coventry, giving an overview of the activities of one of the better-resourced provisions with some really interesting ideas that could work in other centres.

Following this, Crisan and Rodd provide an interesting account of designing a short course for graduate teaching assistants (GTAs) that takes account of the specific requirements to teach mathematics that can be overlooked in a generic ‘new to teaching’ course (I am trying hard not to say ‘training course’, for reasons that will become clear when you read the article).

The next paper is from Hamburg and offers an interesting insight into the mathematical preparedness of incoming STEM (in German, MINT) undergraduates. Barbas and Schramm describe attempts to test for a pre-agreed set of basic mathematical knowledge and skills and provide extra learning for students to address weaknesses diagnosed by the test. I was particularly interested to hear that attempts have been made by a group representing both sides of the school-to-university transition to agree a set of minimum assumed knowledge for the start of a STEM degree programme.

I am particularly pleased by the contribution of David Smith on his views about methods for publishing mathematics lecture notes in ways that can be more adaptable to users who don’t just want a standard PDF. I saw on Twitter a link to a blog post David had written on this topic and asked if he would be willing to adapt it for an opinion piece in *MSOR Connections*. He has been able to incorporate feedback he had received from readers of his blog post and further feedback from the peer review process, resulting in a really interesting piece. I think it is very worthwhile for practitioners to have a space like *Connections* in which to share opinions about their practice. We have always had an article category ‘Opinion’, but perhaps we haven’t received as many submissions to it as we might hope for.

The final two articles are something I am trying out, that I hope you will join in with. I attended a meeting of the **sigma** Network that discussed storage and use of legacy resources which were created by projects that are no longer operating. There is a wealth of such resources out there (I give a little history in the introduction piece), but I am not sure how likely these are to be discovered without signposting, so I propose a series in *MSOR Connections* to bring attention to favourites. To kick things off, I wrote a brief review of a resource developed under the National HE STEM Programme that aims to assist those looking to include industrial problems in the mathematics undergraduate curriculum. You are strongly encouraged to consider writing a review of a favourite legacy resource yourself.

You may be aware that the editors of *MSOR Connections* take turns to edit issues of the journal. I am particularly grateful to my fellow editor Tony Mann for arranging the anonymous review of the two submissions of mine which were included in this issue, since I could not arrange this myself.

This is the first issue of *MSOR Connections* since Noel-Ann Bradshaw left the editorial team, so I would like to take this opportunity to thank her for her substantial part in reviving the journal and finding a home for it, supported by **sigma**, at the University of Greenwich, and her work for three years as editor.

I will end with a call for assistance. *MSOR Connections* can only function if the community it serves continues to provide content, so I strongly encourage you to consider writing case studies about your practice, accounts of your research into teaching, learning, assessment and support, and your opinions on issues you face in your work.

Another important way readers can help with the functioning of the journal is by volunteering as a peer reviewer. When you register with the journal website, there is an option to tick to register as a reviewer. It is very helpful if you write something in the 'reviewing interests' box, so that when we are selecting reviewers for a paper we can know what sorts of articles you feel comfortable reviewing.

To submit an article or register as a reviewer, just go to http://journals.gre.ac.uk/ and look for *MSOR Connections*.

I hope you enjoy reading this issue as much as I have putting it together.

RESEARCH ARTICLE

The Provision of Mathematics and Statistics Support in Scottish Higher Education Institutions (2017) – A Comparative Study by the Scottish Mathematics Support Network

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Abstract

The Scottish Mathematics Support Network (SMSN) was formed in July 2008 with the aim of creating a support network for people working in Scottish universities who were involved with, or wished to be involved with, providing mathematical and/or statistical support for their students. The consensus of the SMSN is that increasingly more students need assistance with their basic mathematical and statistical skills than was the case in the past, and that consequently mathematics support is an area on which universities will need to focus on in future years. Through networking and professional development opportunities with other practitioners in the field of mathematics and statistics support, the SMSN have developed and maintained strong links with individual practitioners, and more broadly with like-minded groups such as the **sigma** Network and the Irish Mathematics Learning Support Network. With the provision of mathematics and statistics support becoming more prevalent in UK Higher Education institutions, it seemed timely to assess the current state of this provision in Scotland, and to compare with the rest of the British Isles. At the 2016 SMSN AGM, it was unanimously agreed that such a study should be carried out with the SMSN committee taking responsibility for conducting the research.

Keywords: Mathematics Support, Statistics Support, Higher Education, Scotland.

1. Introduction

While mathematics and statistics support in Higher Education (HE) across the UK and Republic of Ireland is a relatively recent development, with a little imagination, its origins can be traced back to the time of mathematicians such as Colin Maclaurin. As a Lecturer and Professor of Mathematics at the Universities of Aberdeen and Edinburgh in the early 18th Century, Maclaurin was described as being “kindly and approachable” and that the help he gave to his students “was never wanting, nor was admittance refused to any except in his teaching hours” (Chambers, 1875; O’Connor & Robertson, 2017). However, at that time, only the privileged, and some particularly gifted students, were able to attend university so that there was little or no demand for any formal mathematics support.

In recent years, HE has made itself available to the wider population, with the number of UK universities more than doubling during the 1960s. Furthermore, with the introduction of post-1992 universities there are now around 160 universities in the UK (Higher Education Statistics Agency, 2017). A consequence of this increase in degree-awarding institutions is that there has been a significant rise in student numbers. Additionally, UK governments have pledged financial support for widening access initiatives which has further contributed to the number of students in HE. In Scotland, these policies include articulation from the college sector that enables advanced entry to university, the Schools for Higher Education Programme (SHEP) which provides information, advice and guidance for schools across Scotland with traditionally low progression rates to HE, and the Widening Access and Retention fund (WARF) which is awarded to the Scottish universities that have the highest widening access intake (Hunter Blackburn et al., 2016).

Consequently, universities have witnessed increasingly more entrants who come from diverse educational, social, and cultural backgrounds. The most recent UCAS report (UCAS Analysis and Research, 2017) showed that entry rates for students from the most deprived backgrounds in Scotland have reached the highest level on record. These students have widely varying experiences and knowledge of mathematics and statistics. Furthermore, the introduction of new degree programmes, such as computer games, digital security, computer networking and audio technology, has resulted in the need for students to learn mathematical topics on their degree courses that they possibly have not been adequately prepared for in school or the college sector.

2. A Brief History of Mathematics Support in the UK and Ireland

Although it is very difficult to provide an exact date and location as to when and where formal mathematics support in HE originated in the UK, three of the main institutions responsible for instigating formal support programmes were: in England, the Universities of Coventry, Hull and Loughborough (LTSN MathsTEAM, 2003b); and, in Scotland, Edinburgh Napier University (then, Napier Technical College). The latter, through the guidance of Ann Evans, initiated MathPlus in 1988 (Evans, 2010). This was one of the country’s first mathematics drop-in centres. In England, the Mathematics and Statistics Support Service was established at Coventry University in 1991 with a grant from BP’s Engineering Education Fund, while the University of Hull launched its service in 1995. Loughborough University opened its centre in 1996, targeting first year engineering students and offering a drop-in facility. From the mid-1990s, more universities across the UK started to offer mathematics and statistics support on a formal basis.

2.1. Mathematics and Statistics Support in England & Wales

An important milestone in the development of mathematical and statistical support came in the early 2000s when the Learning and Teaching Support Network (LTSN) funded the LTSN MathsTEAM project. The project was a collaboration between four subject centres (LTSN Maths, Stats & OR Network, LTSN Engineering, LTSN Physical Sciences, and the UK Centre for Materials Education). In 2003 three comprehensive booklets (LTSN MathsTEAM, 2003a; LTSN MathsTEAM, 2003b; LTSN MathsTEAM 2003c) were produced that focussed on case studies relevant to support for engineering and science students. The aim of the project was to enable the sharing of knowledge and materials and therefore promote good practice in the mathematical and statistical teaching and support community.

In the document *Mathematics Support for Students* (LTSN MathsTEAM, 2003b), it was observed that funding had been made available for the development of *mathcentre*[*], the first UK website of

[*] http://www.mathcentre.ac.uk/

peer-reviewed mathematics support resources*. The facility came into existence in 2003 and was originally aimed at easing the transition of science and engineering students from school to university. Over the years it has grown into an extensive online resource, with well over 22,000 visitors each month (Matthews & Croft, 2011). *mathcentre* offers lecture notes, audio and visual tutorials, exercises and diagnostic tests. The Engineering Council (UK) in June 2000 recommended to all universities that students embarking on a mathematics-based degree should take a diagnostic test on entry (LTSN MathsTEAM, 2003b).

The MathsTEAM study reported that staff at over 20 institutions across the UK discussed various aspects of their work including how their centre was formed, the barriers and enablers encountered and what support was needed from the university and its staff. They also provided evidence of the level of success achieved, mainly in terms of the number of students using the facility, and offered advice on how others could establish a support network.

Lawson, Halpin & Croft (2001) noted that there was already extensive provision of mathematics support centres across the UK, with 48% of the 95 institutions who replied to their survey indicating that they had some form of mathematics support. Two further surveys undertaken in 2004 (Perkin & Croft, 2004) and 2012 (Perkin, Lawson & Croft, 2012) identified considerable growth in mathematics support in the HE sector. Table 1 summarises the findings.

Table 1: Summary of mathematics support provision across the UK in 2000, 2004 and 2012 (adapted from Lawson, Halpin & Croft, 2001; Perkin & Croft, 2004; and, Perkin, Lawson & Croft, 2012).

Year of Survey	Number of HEIs replying to survey	Number of HEIs providing support (of respondents)	Percentage offering support (of respondents)
2000	95	46	48
2004	101	66	65
2012	103	88	85

The level of support available, as noted by Perkin, Lawson & Croft (2012), varies considerably between institutions, with some centres staffed by academics open seven days a week while others restrict opening to a few hours per week with staffing by postgraduates. The target groups also vary across universities, with some offering support to all students (and staff) while others restrict availability to first year undergraduates only.

Following a collaborative bid to the Higher Education Funding Council for England (HEFCE) in 2005, Coventry and Loughborough Universities were awarded the Centre for Excellence in Teaching and Learning (CETL) status. As a result, the **sigma** CETL project was launched to promote collaborative work in mathematics and statistics support on a national basis, and received funding from the HEFCE until 2010.

In 2010, the **sigma** CETL project became the **sigma** project and received a 2-year funding commitment from the National HE STEM programme. In 2012, the **sigma** Network was created for

* See the paper ‘Review a legacy resource: a new feature in MSOR Connections to aid discovery of hidden gems’ in this issue (p. 55) for discussion about increasing the visibility of resources from legacy projects – Ed.

those working in mathematics support in England and Wales. Further support from HEFCE between 2013 and 2016 has helped fund new mathematics support centres, run workshops and conferences and undertake various related activities (The **sigma** Network, 2013).

2.2. Mathematics and Statistics Support in the Republic of Ireland

In the Republic of Ireland, the first mathematics support centre was opened at the University of Limerick in late 2001 with funding coming from the Higher Education Academy (HEA). A form of mathematics support had however been in place at the university since 1997. This facility was created in response to concerns regarding the mathematical ability of many students entering the first year of programmes which involved an element of mathematics service teaching.

In 2008, the Centre for Excellence in Mathematics Teaching and Learning (CEMTL) undertook a comprehensive audit (Gill, O'Donoghue & Johnson, 2008) of 13 third level Irish HE institutions. The associated report was the first of its type on Irish mathematics support. It aimed to provide a summary of available resources, as well as identifying challenges faced by staff, and making recommendations for the efficient operation of mathematics support centres.

The Irish Mathematics Learning Support Network (IMLSN) was formed in 2009 and provides a forum for those in the island of Ireland as a whole who are involved in mathematics support as well as providing an avenue for collaboration with UK counterparts. An in-depth survey of mathematics support provision across the island of Ireland was carried out in 2015 (Cronin et al., 2016) and found that the level of provision compared favourably with that in the UK and Australia. A selection of the report's findings is presented in *Section 4: Comparison with UK and Ireland*.

2.3. Mathematics and Statistics Support in Scotland

The Scottish Mathematics Support Network (SMSN) was created in July 2008 with the aim of initialising a support network for people working in Scottish universities (and colleges) who were either currently providing, or would like to provide, mathematical and/or statistical support to their undergraduate and postgraduate students.

The inaugural meeting of the SMSN was funded by **sigma**, and included a presentation by Professor Tony Croft, then Director of the Mathematics Education Centre at Loughborough University. Representatives from seven Scottish institutions were in attendance. The consensus at the meeting was that more students were in need of assistance with their basic mathematical and statistical skills than in the past, and that mathematics support was an area on which universities needed to focus on in future years.

In turn, the Scottish universities that provide mathematics and/or statistics support have hosted an annual meeting, and the membership of the network has increased steadily since 2008. In addition, the SMSN have also run themed events, such as LaTeX workshops, which have been of interest to the Scottish mathematics support community as a whole.

Through these networking and professional development opportunities with other practitioners in the field of mathematics and statistics support, the SMSN have developed and maintained strong links with individual practitioners, and more broadly with like-minded groups such as the **sigma** Network and the Irish Mathematics Learning Support Network.

3. Methodology

Representatives from all Scottish universities were invited to the 2016 SMSN Annual Meeting, and the meeting was attended by delegates from eight Scottish universities: Aberdeen, Abertay, Dundee, Edinburgh Napier, Glasgow, Glasgow Caledonian, Robert Gordon and Strathclyde, alongside speakers from Loughborough University and Keele University. At this meeting, the provision of mathematics and statistics support becoming more prevalent in UK Higher Education Institutions was discussed. It was unanimously agreed that a study on the provision of mathematics and statistics support at Scottish Higher Education institutions (a list of institutions can be found in appendix A) should be implemented, with the SMSN committee taking responsibility for conducting the research. This study was aimed at accurately measuring the types of support available, how support was staffed, what facilities were in use and how the Scottish institutions compared with those of the British Isles as a whole. During the meeting, a research questionnaire was devised, based on the questionnaire used by IMLSN for their 2015 audit (Cronin et al., 2016), and ratified by attendees. The questionnaire mainly consisted of closed questions with multiple-option set responses (a copy of the questionnaire is included in appendix B). The questionnaire was then completed by a representative from each institution stated above and an online version was made available to those who were not present at the meeting. Once the results had been collated, the SMSN committee members reflected on the original questionnaire and agreed to contact the respondents who had stated that their institutions offered mathematics and/or statistics support with a follow-up questionnaire. This questionnaire focussed on the location of support sessions, the funding provided, and how the support service could be improved.

4. Summary of Findings

Responses to the questionnaire were received from all but two Scottish Higher Education Institutions. The Open University in Scotland, and Scotland's Rural College did not provide responses, although it is unclear as to whether or not mathematics and/or statistics support would be required or relevant in these institutions. In response to questions about whether mathematics and/or statistics support was provided, the data in Table 2 was collated.

From the data in Table 2, it can be seen that more than three quarters of Scottish institutions provide mathematics and/or statistics support; four institutions do not offer any support. Of those providing support, a total of 46% offer both mathematics and statistics support, 23% offer mathematics support only and 8% offer statistics support only. One institution did not indicate which area(s) support was provided for.

The data shows that the mechanisms for providing support vary between the institutions and include dedicated members of staff, graduate teaching assistants (GTAs), undergraduate teaching assistants (UGTAs) and mathematics lecturers. The equivalent FTE for each institution is shown in the final column, if this information was given. The estimated total number of hours of support provided per year across all institutions exceeds 7,644.

Various types of support are offered, including drop-in sessions, bookable one-to-one appointments, workshops and online support. These may be available for all students, undergraduate and postgraduate, or may be restricted to undergraduates, or to students in particular departments. In some cases, the support is available for staff. Support may be offered online or in dedicated space or shared space, and in some institutions support can be booked through a central booking system. A summary of provision is shown in Table 3.

From the data in Table 3, it can be seen that the most popular modes of delivery are one-to-one support and drop-in sessions, which are offered by 77% of the institutions having a support provision. Online support, which includes use of social media, is available at 62% of institutions and workshops are the least popular at 54%. Most institutions have more than one delivery mode, with only three (23%) having a single mode. Ten institutions support both undergraduate and postgraduate students, but only five of these include support for postgraduate researchers. Three institutions also support staff, but of these only one supports staff in statistics. Three institutions only support undergraduates. Attendance is recorded at nine of the institutions.

Table 2: Mathematics and/or statistics support and staffing.

Institution	**Support**	**Dedicated Staff**	**GTA[4] Available**	**Other Information**	**Total FTE**
Edinburgh Napier University	Yes	No	No	Part of Mathematics lecturers' workloads	0.5
Glasgow Caledonian University	Yes	Both[1]	No	-	1
Glasgow School of Art	No	-	-	-	-
Heriot-Watt University	No	No	No	-	-
Inverness College (University of Highlands and Islands)	Yes	Mathematics[2]	No	-	0.2
Queen Margaret University	No	No	-	-	-
Robert Gordon University	Yes	Both	No	Additional help from Mathematics lecturers	1
The Royal Conservatoire of Scotland	No	-	-	-	-
University of Aberdeen	Yes	Both	No	-	0.5
University of Abertay	Yes	Statistics[3]	Statistics	-	0.6
University of Dundee	Yes	No	No	Limited	Ad hoc
University of Edinburgh	Yes	Both	Both	-	Ad hoc
University of Glasgow	Yes	Mathematics	Statistics	-	1.08
University of St Andrews	Yes	No	Both	-	Ad hoc
University of Stirling	Yes	No	No	Provided by a lecturer	-
University of Strathclyde	Yes	Both	No	UG Teaching Assistants	1
University of the West of Scotland	Yes	No	Mathematics	Provided by Physics PGs	-

[1]**Both** means that the Institution has dedicated staff for both Mathematics and Statistics support.
[2]**Mathematics** means that dedicated staff is for Mathematics only.
[3]**Statistics** means that dedicated staff is for Statistics only.
[4]**GTA**: Graduate Teaching Assistant.

Table 3: Type of support and participants.

Institution	1-1	Drop In	Workshop	Online	UG	PGT	PGR	Staff
Edinburgh Napier University		Y		Y	Y	Y		
Glasgow Caledonian University	Y	Y	Y	Y	Y	Y	Y	Y
Glasgow School of Art								
Heriot-Watt University								
Inverness College (University of Highlands and Islands)		Y			Y	Y	Y	
Queen Margaret University								
Robert Gordon University	Y	Y	Y		Y	Y		
The Royal Conservatoire of Scotland								
University of Aberdeen	Y	Y	Y	Y	Y	Y	Y	Y
University of Abertay	Y	Y	Y	Y	Y	Y	Y	
University of Dundee	Y				Y			
University of Edinburgh	Y	Y	Y	Y	Y			
University of Glasgow	Y	Y	Y	Y	Y	Y		
University of St Andrews	Y			Y	Y	Y		
University of Stirling	Y		Y		Y	Y	Y	Y
University of Strathclyde	Y	Y		Y	Y	Y		
University of the West of Scotland		Y			Y			

Three additional questions were sent to the institutions offering mathematics and/or statistics support. These questions focussed on the location of support sessions, the funding provided, and how the support service could be improved. Overall, 62% of responses were received to these subsequent questions. It was found that there were three different types of teaching space utilised, these being: dedicated space, shared space with other discipline’s support groups, and centrally bookable rooms. The three types of location were available in equal amount across the institutions, with three institutions having access to all arrangements and one having a dedicated space for statistics only. With regards to funding, it was found that 46% of the support services were allocated funding from a central source, 15% from a departmental funding source, and a further 15% came from ad-hoc payments. All the institutions commented that improvements could be made to their services by either an increase in staff numbers, or access to dedicated space, or both. It should be noted, of course, that both of these proposed improvements would require an injection of funding for them to be realised.

The data garnered, however, does not evidence the effectiveness of such delivery modes. Evaluation of these is difficult due to the many factors which impact upon a student’s ability to succeed (Matthews et al., 2013). Therefore, anecdotal evidence aside, how one could accurately measure the effectiveness of these delivery modes remains to be seen. While there are obvious benefits of one-to-one sessions with students, there is a cost versus reward argument which would be made by both the budget holders and the student retention officers. Drop-in sessions, being the second most popular delivery mode, have the disadvantage of often being held on Wednesday afternoons, when they are in direct competition with sports clubs and/or students’ part time employment. Nevertheless, the uptake of these sessions, particularly immediately before module examinations, is evidence as to their popularity, if not their usefulness. Finally, while online support would mostly always be available, it can be argued that it is not as effective as it does not provide the intangible benefits which relate to the in-person communication available in one-to-one and drop-in sessions. In spite of the range of available delivery modes, there is still a persistent minority of students who would benefit from the available support who do not make use of it (Symonds, Lawson & Robinson, 2008).

Even though evaluation of efficacy of mathematics and statistics support is difficult, as noted above, one study has been conducted in Scotland. At Glasgow Caledonian University an attempt has been made to quantify the success of mathematics support by comparing the module performance of two groups of undergraduate students: those who engage with mathematics support and their counterparts who choose not to engage. The module marks achieved by students, across all undergraduate levels, were selected as a measure of how mathematical support impacts on student performance. Data were collected for computing and engineering students, in the School of Engineering and Built Environment, studying modules with a substantial mathematical content as part of their degree programme. The study showed (Macdonald, 2014) that there was substantial and significant difference between the average marks achieved by engaging and non-engaging students. Students who engaged with mathematical support on average showed an 8% increase in their module mark compared with those who did not engage.

A summary of the availability of mathematics and/or statistics provision in Scottish HEIs has been presented on an interactive map[*], created by the SMSN. A green tag represents institutions with both mathematics and statistics support provision, an orange tag represents institutions with either mathematics or statistics support provision, and a red tag represents institutions with neither mathematics nor statistics support provision.

5. Comparison with UK and Ireland

The most recent Irish Mathematics Learning Support Network (IMLSN) audit of mathematics support in Ireland was conducted in 2015 (Cronin et al., 2016) following a similar survey in 2008 (Gill, O'Donoghue & Johnson, 2008). Members of the National HE STEM programme conducted a UK wide survey in 2012 (Perkin, Lawson & Croft, 2012; Perkin, Lawson & Croft, 2013) and the **sigma** Network is in the process of designing and conducting a new survey in England and Wales.

The 2015 island of Ireland survey consisted of 58 questions sent to 31 institutions in Northern Ireland and the Republic of Ireland, including universities, institutes of technology, colleges of education and liberal arts, and colleges of further and higher education. Results of the survey are bracketed under six main themes: availability and practical operation of mathematics learning support, staffing and tutors, types of support available, users of the service, reporting and evaluation of activities, challenges and developments.

Authors of the 2012 UK survey contacted 119 universities in England, Scotland, Wales and Northern Ireland with three questions that asked the extent of mathematics and/or statistics support available, whether papers are published to describe or evaluate the support provision offered, and whether the institution provides any engineering education support. The institutions that responded to the survey were categorised by their 'mission group': Russell Group, 1994 Group, University Alliance, million+, Cathedrals Group, Unaligned Universities.

[*] The map has been made available at https://drive.google.com/open?id=1TkLfxHQbVIj_WlWdwe-JphgS1c4.

The response rates of the 2016 SMSN, 2015 IMLSN and 2012 UK surveys are detailed in Table 4.

Table 4: Response rates of the 2016 SMSN, 2015 IMLSN and 2012 UK surveys.

Survey	Institutions Contacted	Institutions Responded	Percentage
SMSN	19	17	89%
IMLSN	31	30	97%
UK	119	103	87%

We compare the results of the IMLSN and UK surveys with the SMSN findings but note that there are two key differences between the three surveys. Firstly, authors of the SMSN and UK surveys contacted only universities while the results of the IMLSN survey also included data from colleges and institutes of technology. Secondly, the questions in the IMLSN survey focussed exclusively on the provision of mathematics support while the SMSN and UK studies also included questions concerning support for statistics.

Mathematics and/or statistics support existed in 13 of the 17 universities (76%) that responded to the SMSN survey. This figure compares to 85% of the universities in the UK survey and 83% of the institutions that completed the IMLSN survey. Out of the 4 Scottish institutions that did not offer mathematics and/or statistics support, two are the Glasgow School of Art and the Royal Conservatoire of Scotland. It is not expected that such institutions would offer learning support of this nature and hence if these institutions are excluded from the SMSN data, then the extent of support provision in Scotland is 87%, which is commensurate with Ireland and the UK as a whole.

Differences in the support provision offered in Scotland, Ireland and the UK are detailed in Table 5 below. It is interesting to note that drop-in support and one-to-one appointments are available in equal measure throughout institutions in Scotland, while drop-in services are much more popular in Ireland and the UK (overwhelmingly so in the latter case). Workshops or optional classes are offered in 55% of institutions in Scotland and 64% in Ireland, but only occurred in 8% of institutions in the UK in 2012. The provision of online support is highest in Scotland with 73% of institutions offering such support compared with 48% in Ireland. However, it should be noted that the 2012 UK survey did not explicitly ask if online support was available and of the 13 institutions that did not offer online learning support in Ireland, 69% were planning to implement this.

Table 5: Comparisons of learning support provision in Scotland, UK and Ireland.

	Scotland (n=13)	UK (n=103)	Ireland (n=25)
Drop-in service offered	76%	84%	88%
1-1 appointments available	76%	6%	44%
Workshops or optional classes offered	54%	8%	64%
Online Support	61%	-	48%

Out of the 13 institutions that offered mathematics and/or statistics learning support in Scotland, 9 were staffed by either full-time tutors, lecturers or dedicated teaching staff (collectively referred to as FTE staff), while 8 provided support by postgraduate students. It is quite common to find universities in Scotland using a combination of these staff profiles and a similar picture is found in Ireland where the authors of the IMLSN survey found that 48% of institutions used staff from a variety of sources. Only one university in Scotland, the University of Strathclyde, employed the use of undergraduate teaching assistants compared with 36% of institutions in Ireland. A complete breakdown of this data, together with results from the 2012 UK survey, is given in Table 6.

Table 6: Comparison of staff profiles in institutions offering learning support.

	Scotland (n=13)	UK (n=103)	Ireland (n=25)
Support offered by FTE staff	69%	86%	72%
Support offered by postgraduate students	61%	14%	48%
Support offered by undergraduate students	8%	-	36%

Fewer institutions (54%) in Scotland offered mathematics and/or statistics learning support from a dedicated space than in Ireland (80%). However, there are more cases in Ireland of this space being shared with other academic support units (63% in Ireland compared with 31% in Scotland).

In terms of funding, 54% of institutions in Ireland were funded centrally while academic departments were responsible for funding in 29% of cases. In Scotland, 46% of universities fund mathematics and/or statistics support centrally, 15% provide funding through departments or student services and 15% are funded on an ad hoc basis. We note that six institutions did not provide any information regarding their funding position. Also, some support facilities use a blended approach, with dedicated staff funded centrally and ad hoc funding for additional tutors. Funding information was not included in the 2012 UK survey.

Table 7: Funding and availability of space in Scottish and Irish learning support facilities.

	Scotland (n=13)	Ireland (n=25)
Dedicated Space	54%	80%
Shared Space	31%	63%
Centrally Funded	46%	54%
Departmental Funding	15%	29%
Ad hoc Funding	15%	-

The SMSN survey asked respondents to comment on improvements to their support facilities that they would like to see implemented. The three most common replies (in order of preference) were: an increase in staff numbers, an increase in funding for resources and equipment, and a dedicated space. It is interesting to note that these comments matched the most common improvement themes reported in the IMLSN survey. These were: location and space, support and materials, and tutors. Many institutions reported a need for dedicated and larger space, resources to provide specialised workshops, and more tutors. Two institutions in Ireland reported that dedicated staff for statistics and engineering would be desirable, matching similar comments from two institutions in Scotland.

6. Conclusions and Discussion

Since the higher education boom in the 1960s and the introduction of post-1992 universities, student numbers in the United Kingdom have increased to unprecedented levels. In addition, the introduction of policies aimed at increasing student numbers from the country's most deprived areas have meant that universities have witnessed increasingly more entrants who come from diverse educational, social, and cultural backgrounds. The current population of university students have widely varying experiences and knowledge of mathematics and statistics, and an extensive range of mathematical and statistical requirements. Consequently, the need, and use, of mathematics and statistics support provision has risen considerably.

In this paper, the strengths and weaknesses of the support provision available in Scotland are highlighted and benchmarked against the UK and the island of Ireland. It was found that there is strong provision of support for undergraduate and postgraduate students, but a perceived poor availability for postgraduate researchers and staff. The percentage of institutions offering support is comparable across the three groups, but with Scotland offering considerably more pre-arranged one-to-one support over its UK and Ireland counterparts. A comparable percentage of Scottish and Irish institutions offer workshops or specialised classes, and these numbers far exceed the percentage of UK institutions offering these options. Furthermore, the availability of online support for Scottish students slightly outperforms that of Irish institutions, with no UK data available.

It was observed that all three groups have a similar proportion of institutions which make use of FTE staff, but proportionally more Scottish institutions rely on postgraduate tutors, and proportionally more Irish institutions rely on undergraduate tutors. However, it is noted that the Irish institutions boast a significantly larger number of dedicated and shared support provision space, even though the funding avenues are not dissimilar.

The perceived issues with mathematics and statistics support in Scotland, the UK, and the island of Ireland are comparable. That is, the number of tutors, the provision available, and the space in which to avail oneself of these aforementioned factors, is paramount across the regions.

In conclusion, the Scottish institutions are certainly comparable with, and sometimes outperforming (at least in availability), the institutions of the entire UK, and the island of Ireland. However, it is clear that Scottish institutions are required to invest more in dedicated space for students who are in need of additional mathematics and statistics support. Given the recent success of the inaugural Maths Week Scotland, it is hoped that Scottish universities appreciate the breadth of mathematical and statistical applications in today's degree programmes and provide appropriate funding to support the ever-changing demands of students in Scotland.

Appendices

Appendix A – List of Institutions

University of Aberdeen
University of Abertay
University of Dundee
University of Edinburgh
Edinburgh Napier University
University of Glasgow
Glasgow Caledonian University
Glasgow School of Art
Heriot Watt University
University of Highlands & Islands (Inverness College)
Open University in Scotland
Queen Margaret University
Robert Gordon University
Royal Conservatoire of Scotland
Scotland's Rural College
University of St Andrews
University of Stirling
University of Strathclyde
University of West of Scotland

Appendix B - Mathematics and Statistics Support Provision in Scotland Questionnaire

Name:
Role:
Institution:

1. Does your institution offer Mathematics and/or Statistics support?
   YES (please go to question 3)
   NO (please go to question 2)

2. If NO, please give reason. Tick all that apply.
   Mathematics /Statistics support not required
   Lack of funding
   Lack of support from senior management
   Other – please give details overleaf

(**END OF QUESTIONNAIRE**)

3. If YES, please give details of staffing. Tick all that apply
   Dedicated staff for Mathematics & Statistics support
   Dedicated staff for Mathematics support only
   Dedicated staff for Statistics support only
   Postgraduate students (GTAs) for Mathematics support
   Postgraduate students (GTAs) for Statistics support
   Other – please give details overleaf

4.
   a) Please state total FTE for Mathematics & Statistics support
   b) Please state total FTE for Mathematics support only
   c**)** Please state total FTE for Statistics support only

5. What type of support is on offer? Tick all that apply.
   1-1 appointments
   Drop-in sessions
   Targeted lectures/workshops
   Online
   Other – please give details overleaf

6. Do you keep attendance records? Delete as appropriate.
   Yes
   No

7. Who can use the service? Tick all that apply.
   UG PGT
   PGR Staff
   Other – please give details

8. Which is the largest user group(s)?

9. Any other comments? Please give details overleaf.

(**END OF QUESTIONNAIRE**)

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CASE STUDY

Reviewing Coventry University's Mathematics Support Centre 2016-17: Ideas and Inspiration

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Abstract

The academic year 2016-17 was one of outstanding achievement for the **sigma** Mathematics Support team at Coventry University. We had a further increase in the take-up of **sigma**'s range of services by students from all faculties and our feedback has been enthusiastically positive. Above all, the team has taken some innovative approaches to support and inspire Coventry's ever-growing body of students and staff. This article aims to provide insight into our services and to provide perhaps some inspiration and ideas that other support centres can use.

Keywords: Mathematics support, Statistics support, Coventry University.

1. Introduction

Since 1991, Mathematics Support has been provided at Coventry University by the **sigma** team, which is currently composed of two mathematicians and three statisticians, all of whom are full-time, together with its part-time director. From humble beginnings in a small and difficult-to-reach room, the **sigma** Mathematics Support Centre (MSC) is now a large and welcoming room on the ground floor of the university library (see figure 1). We now have over 10,000 student and staff visits each year and indeed, this past academic year we had 13,670 visits, our highest ever. The 13,670 visits consist of 3026 individual students, therefore each student averaged around 4 repeat visits each. In this article we describe what our MSC offers, how we advertise our services, and hope to provide some ideas and inspiration for other MSCs.

Figure 1: Mathematics Support Centre in Action.

2. Our Services

We offer a range of services to our students and staff across the academic year. Our main service is our drop-in service, which we now offer for more than 50 hours, over 6 days a week in term time.

Figure 2 provides the numbers of students' drop-in visits for the last four academic years. Previously we opened for 7 days a week but found that students were hardly using the service on a Sunday. Furthermore, we found it difficult to motivate any staff members to give up some of their weekend for such low numbers of students. A PhD student currently oversees the support provision on Saturdays, but still the useage is quite low. Figure 3 shows the number of visits by day for 2016-17. Our term-time timetable, a sample of which can be found in appendix A, shows students our tutors' expertise areas, which can be particularly useful if they are looking for some specialist support in mathematical or statistical computer packages (for example). Last year we opened fully, meaning for over 50 hours a week, during the 22 teaching and 4 exam weeks. We also had reduced opening times during holidays, to support students preparing for their exams, and during the summer, for students doing resits and projects. The reduced timetable consisted of weekday support only between 11am and 3pm.

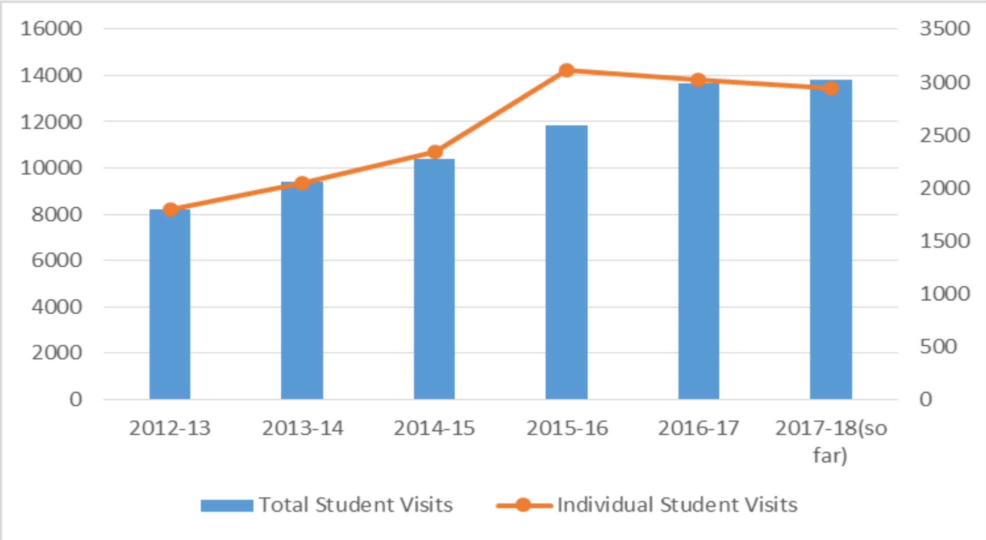


Figure 2: Numbers of student visits for the past five academic years.
The blue bars represent total student visits, using the primary axis as the scale and the orange line represents the number of individual students who visit, with the secondary axis as the scale.

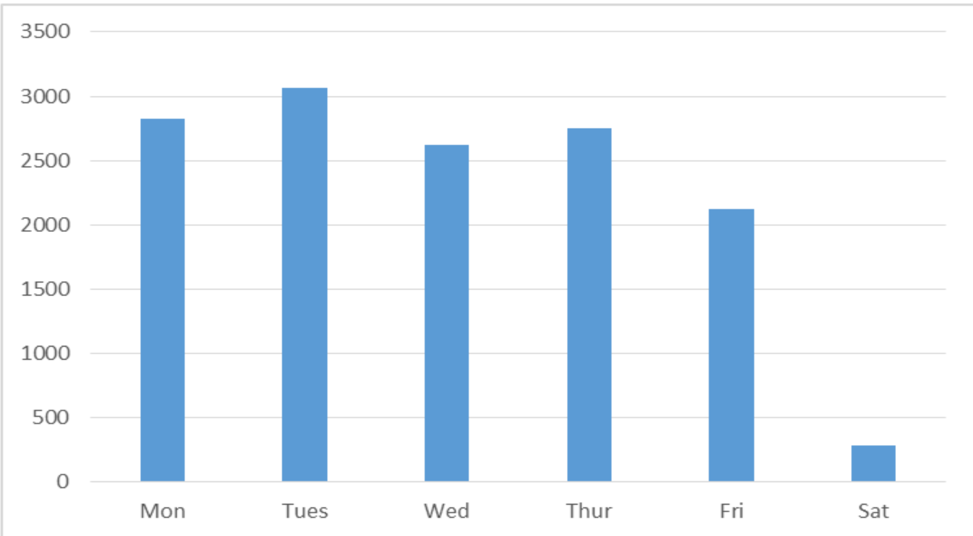


Figure 3: Number of student visits by day.

Within the centre itself, we have 18 computers, various books for reference and two touchscreen computers, which provide print-on-demand worksheets in over 10 different topic areas. To assist us in providing our 50-hour-a-week service, we had about ten undergraduate student proctors who each worked five hours a week on average. We pay our student proctors and, although we are aware that this is not an option for all mathematics support centres, we know that it does provide us with an excellent way of advertising our services to all faculties. Our student proctors attract student visits, especially from those who are perhaps a little shy since some students prefer talking to fellow students rather than lecturers. Our proctors also provide advertising through word-of-mouth which benefits us greatly. A further benefit to having student proctors is that they offer expertise in subjects, such as business and economics, where getting staff members to provide their support can be difficult. Indeed, we tend to recruit students based on demand for a subject area but also where we are lacking in support from staff in a particular subject. All student proctors are recruited subject to having good academic achievement (minimum 2:1 average up to the point they are recruited) and are trained on-the-job for 1 hour a week for the first term with us. Alongside the student proctors, we have three part-time Maths and Stats Support Assistants (MSSAs) who work between 3 and 6 hours per week, and we have two postgraduate students, who work up to 4 hours a week.

In addition, we provide one-to-one, hour-long appointments in both statistics and mathematics. One-to-one appointments are provided to students who feel they need more specialised and focused support from a tutor. We ask students to visit the centre during normal opening hours first to see whether a short intervention from one of our tutors is enough to fix the problem that they have. If they feel the need for more support after this, we direct them to our online booking system to make a one-to-one appointment. Initially these were offered just in statistics but we started offering mathematics appointments for 4 days a week at the start of the 2015-16 academic year. The uptake for this has been very positive with our three tutors hosting over 200 hours of appointments over the past academic year. One-to-one mathematics appointments take place in the MSC, usually before the centre is open for general support, whereas one-to-one statistics appointments generally take place in staff offices. Again, we feel that one-to-ones provide students who are perhaps less inclined to enter the support centre in a crowded environment an opportunity to get the support that they need. However, we have encountered several issues this year with our system for appointments. Firstly, if a student fails to turn up for their appointment, that hour is then lost in the sense that we are unable to offer it to a different student. Our system does allow for cancellations but they need to be made at least 12 hours in advance for another student to be able to take full advantage. Students who do not turn up are asked why they did not show and told about our blacklisting/three-strikes system. Although this stops repeat offenders, it does still take away opportunities for other students who could take the place of the absentee on a particular day. We also found that some students started trying to use the sessions as a free personal tutorial service and had to remind them that the service was not there for that purpose. This is a tricky situation as we want to be encouraging and friendly yet we do not want students to abuse the system at the same time. Similarly, since one-to-one mathematics sessions are held in the centre before the centre is open for general use, other students often walk straight in and expect help despite the centre being closed for drop-ins. Again, this is tricky as we cannot hold all the one-to-ones elsewhere but want to give our full attention to the person who has booked the session. We would be interested to hear from other centres on how they deal with such problems.

Another popular service that we offer is a series of workshops on a variety of topics including SPSS, introduction to statistics, numerical reasoning and preparing for the teaching numeracy skills test. These workshops are provided based on feedback that we receive from students during the year and the number of questions that we receive in a particular topic area. We open the workshops to all students who feel they need more guidance in a particular topic and work closely with the careers service in the university to advertise and recruit students. The workshops are run like mini tutorials where our full-time staff provide some teaching and theory before inviting attendees to put what they have learnt into practice whilst providing individual support and guidance. All the workshops take place in one of the library's teaching rooms. Running a workshop is pretty straightforward. Once you have done the ground-work for the first session, very little time is required to prepare for future sessions. Again, this promotes our service, who we are and what we do, and since several workshops take place in the centre, the students get to know the centre and recognise it as a friendly place where they can come and get support on mathematics and statistics.

We also provide a diagnostic test in welcome (induction/freshers') week for courses that have substantial mathematical content in order to allow students an opportunity to discover their strengths and weaknesses in mathematics. This test has three levels (Foundation, GCSE, and A-Level) taken according to the mathematical needs of their course and has remained the same for the past 25 years (see Lawson and Danks, 2003). Students take the test in a room allocated by their course lecturers and have one hour to complete the 50 questions on the test. Results are processed by an OMR (Optical Mark Reader) machine and we provide the results (an example can be found in appendix B) to the students in a separate induction talk in the MSC. The results tell the students which topic areas that they need to work on whilst the lecturers get all their individual students' actual test marks and also the marks for each topic area. The result sheets that the students receive also link each topic area to our worksheets. This allows students to come into the MSC and print off the sheets (for free) that they need to work on and receive support if needed.

The final service that we provide is outreach to various departments and schools in the university. Talking to and getting to know staff and students in departments that have courses with mathematical content is vital for running a successful MSC. The issue is that non-mathematicians often dislike mathematics; they did not choose their course to do mathematics and often suffer from anxiety due to a lack of confidence in their mathematical ability (Scarpello, 2007). By being a friendly face that approaches them first, you encourage students, who are not necessarily mathematicians, to visit your centre and realise that it is a place to get support and to enjoy mathematics. Indeed, many of our students stated in our surveys that they wished that they had visited sooner but were too afraid to, thinking that the MSC was only open for mathematics students. In our outreach, we take mini lectures and tutorials in a number of disciplines, including nursing, business, population dynamics, and engineering as well as mathematics. These are usually full lectures to around 70-100 students at a time and are designed in collaboration with the departments that we work with. For example, our nursing lectures take place during a specific 'academic skills week' for first years where the students get training in basic numeracy, literacy and library/research skills. The lectures we take cover basic numeracy skills that are required to be a qualified nurse. These topics are fractions, decimals, percentages, time, ratio, drug calculations and unit conversions. We aim to provide a less formal approach by running games, using online software called 'Socrative', showing videos and supporting students individually as much as possible. We also provide an extensive range of questions using Numbas for them to use in their own time. Feedback from these lectures shows that they are well received and have a positive impact on students' understanding and enjoyment of mathematics. Furthermore, we often see a spike in the number of students from a particular course visiting the MSC after we have run an outreach lecture.

3. Advertising

The key theme running through what we do is advertising. Getting around the university and spreading the word is crucial. We have found that a little bit of hard work and goodwill can go a long way in promoting what we do and getting our 10,000+ visits each year.

One useful method is the utilisation of social media. It has been shown that social media can really boost your MSC's profile and provide a means of communication and advertising to obtain student visits (Collins-Jones, 2016). Our Facebook and Twitter profiles provide students a means of communication and notifications via familiar channels, avoiding the need to check additional sites or applications. Although our social media pages are not currently as successful as those of other institutions (for example, MASH at Bath has 490 likes on Facebook compared to our 77 at the time of writing), feedback from previous surveys that we have operated show that they have helped us to grow and connect with our students. It is also a great way to keep up to date with what is going on in our field and interact with other centres' activities and activities around the campus. We have found that it is particularly helpful on open days to interact with the university's official social media accounts to increase interest in our service from potential new students.

Our website[*] is our main source of advertising. We have links to our website straight from the university's student and staff portals, as well as our Moodle site. On our website students can also book appointments and workshops, and view or download worksheets as PDF files to use at home. They can also see any news or competitions that we are running and view our timetable. The timetables are also displayed within the centre as well as on big screens inside and outside of the centre. These screens also display relevant information to catch students' attention and can be seen from the entrance of the library.

Another crucial advertising opportunity occurs during welcome week. We, as a team, give induction talks in the MSC to freshers who have some mathematics and/or statistics content in their courses, and we also head out to many introductory lectures to promote our service briefly. Spreading the word early on in the year to the newest students engrains our service as a positive thing to help them. We know this from the feedback that we receive from our long-established calculator surveys that we run every year. Each year we give away free scientific calculators (see figure 4) to first-year students (undergraduate and Masters) that are approved for use in exams. These calculators are funded by the university as part of the budget which is allocated to the MSC. In order to collect their device, they need to come to the MSC after they have completed a short survey on our services. Our name and logo appear on the back of the calculators to remind them of our existence throughout their time at Coventry. In return, we get some valuable questionnaire data on their knowledge of the services that we offer and on their attitudes to, and anxieties about, mathematics when they join the university. Although we tend to get similar results each year, this useful data provides us with evidence for our services that can be used to support any expansion or improvement bids that we make to the university. Furthermore, small tokens like this that have your name and logo on really help the students to remember who you are and what you do. Other examples that we use are little puzzle cubes and pens, which go down particularly well with new members of staff during the new staff induction fairs.

Team **sigma** also runs a stand in the Students' Union, called 'the Hub', on University open days, previously having a central presence there throughout the year. However, our stand for the first post-application open day was very quiet so we decided to change to the MSC, and talked to groups of visitors from the campus tours throughout the day. We believe that getting the message across that we are here to help even before students arrive at Coventry really helps to get students through not only our door, but the university's door also. Furthermore, we attend staff and research student

[*] http://sigma.coventry.ac.uk/

induction sessions which again raises awareness to new university staff members and postgraduates.

Figure 4: Our calculator

4. Evaluation of what we do

Whilst we carry out our day-to-day support activities, we ask students for formative feedback on what we do. Small verbal comments and short emails allow us to evaluate what we do as we go. However, alongside the first year calculator survey mentioned previously, we also carry out an in-depth user survey every two years. The purpose of doing the biennial survey is to obtain formal feedback and data that can be used not only to improve our service, but can also be included in reports published by ourselves, and the library where we are based, to show the university how beneficial having a maths support centre is. Students who use the centre whilst the survey is open are not forced to complete it, however they are gently reminded to take part if they receive some form of support from us. Since we do not force students to take part, we feel this gives us a fair reflection on what we do. The survey is taken either on a computer, either in the centre or at home, or on one of our iPads in the centre, using Bristol Online Surveys (BOS), and consists of around 20 questions. These questions vary somewhat depending on our activities over the previous, or upcoming, two years. Some results of the latest survey taken in 2015-16 are enclosed in appendix C. Here are some verbatim comments:

"…the only thing keeping me on this engineering course and is the only place I feel I can adequately receive help and tutoring…"

"…service is amazing, staff are very friendly. This centre had helped me a lot in my studies."

"…very valuable resource to have at our university. Has been an absolute godsend…"

and simply "Lifesaving!"

The survey shows that 93% of students (N = 78, representing 3% of total student visits) are happy or very happy with the support that they have received and 100% of students said that they were likely or very likely to return to get more support. 100% of students also stated that they were likely or very likely to recommend us to their friends and colleagues. Although this only represents 3% of our total student visits for the 2015-16 academic year, it does represent over 20% of our individual student visits during the period that the survey was available. However, we are aiming to improve this during the current academic year, and at the time of writing we have already had 130 students take this year's survey. The difference being that this year we offered a bar of chocolate as an incentive for taking part! Making sure that our students and staff are happy with our service is crucial for sustainability, so regular evaluation is important. Furthermore, it allows us to feed forward to create, implement, and evaluate new ideas.

5. Other activities that are new for this year

The **sigma** National Network: Coventry University's sigma MSC is one of the longest-standing providers of quantitative student support in the UK and its comprehensive services are held up often as an example of good practice in the field. With HEFCE funding for the **sigma** National Network having ended, we have shown our willingness to play a role in, or contribute in some way, to the newly-constituted **sigma** National Network with Dr Mark Hodds becoming a member of the new steering group and running the social media pages. Mark was also involved in creating the new **sigma** MS-MAPS document which helps fellow Maths and Stats Support practitioners gain HEA accreditation. Keeping up with what is going on nationally is vitally important for having a modern and up-to-date service.

Online: We previously offered all students a 24/7 online service called 'HowCloud' for the first time. It allowed students to post a mathematics or statistics question online at any time and then receive an answer within a day. Furthermore, this service also had a live video option that allowed us to tutor students based anywhere in real time. It also gave us the potential to support our students across all of Coventry's campuses. For further details, please refer to Hawkes and Hodds (2016). Despite the promising start, we had a very disappointing overall take-up. The reasons might be:

- Students working on a mathematics or statistics problem want a fast fix. By the next morning, when the answer has been posted on HowCloud, it is too late: they have moved on or lost interest (or missed the deadline).
- The steps that are required to post a question (fire up a device, remember the URL, formulate the problem, type it in mathematical notation) simply presented too much of an obstacle.
- The drop-in centre is easy to get to, in both time and space. Our personalised one-to-one service there takes some beating.
- We had a few technical problems, which meant the posts were not always picked up and answered.
- Students are set in their ways: it takes a long time to change their study habits and receive support.

We decided to discontinue 'HowCloud' due to the above reasons. We are however currently investigating different methods of providing remote support to our satellite campuses in Scarborough and London. We hope this method of online maths support will be available from September 2018.

YouTube: As part of our summer internship offering to students, we invited three student interns to create high quality videos for use on our very own YouTube channel. Thanks to their efforts, we have a bank of around 20 videos so far that we can use support our students further. We are yet to launch our YouTube channel but plan to do so later in the year once we have created some more videos. We would also be keen to share other centres' YouTube videos so please get in touch if you have some!

6. Looking forward

For the forthcoming academic year, we hope to offer an even better service to all Coventry University students and staff, as well as the wider mathematics support network across the UK, as we seek to meet the ever-growing demand for mathematics and statistics support in higher education. To help this, although not fully confirmed, it is highly likely that we will be getting an extension to our existing Maths Support Centre room in the next year, allowing us to increase our service and offer support to more students for longer. We also held a **sigma** national network event on statistics support in April, and hope to offer more over the coming year. We know that we are very fortunate at Coventry to have such a large team of dedicated mathematicians and statisticians, to have the full backing of our mathematics department, and the higher management of the university. We understand that not every university can have the support and resources that we have but we hope this article shows what can be achieved and provides ideas and inspiration to grow your own mathematics and statistics support service.

Appendices

Appendix A – Sample MSC timetable

Mathematics Support Centre Timetable – Spring Semester 2017

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
9.00 – 10.00					Damien Foster (201MS support)	
10:00 –11:00	Sundeep Sehmbi	Katie Baker	Sundeep Sehmbi	Sundeep Sehmbi Cristina Alexandru	Katie Baker	
11:00 – 12:00	Alex Pedecenko Dorothea Kondrat[C] Sundeep Sehmbi	Robert Low Katie Baker Lewis Johnson	Tim Sparks[P] Sundeep Sehmbi Cristina Alexandru	Aiping Xu[L,C,T] Martin Weigel Jacob Low Cristina Alexandru	Katie Baker Slim Khan Cristina Alexandru	
12:00 – 13:00	Mark Hodds[S,P,L,X,N] Dorothea Kondrat[C] Sundeep Sehmbi	Mark Hodds[S,P,L,X,N] Katie Baker Jia Shao[P,L,R,T]	Helen Busby Tim Sparks[P] Jacob Low Cristina Alexandru	Jia Shao[P,L,R,T] Sundeep Sehmbi Jacob Low	Aiping Xu[L,C,T] Katie Baker Dorothea Kondrat[C] Ji Wang	
13:00 – 14:00	Mark Hodds[S,P,L,X,N] Sundeep Sehmbi Thierry Platini	Jim Tabor[A,L,T] Jia Shao[P,L,R,T] Bogdan Teaca	Aiping Xu[L,C,T] Sundeep Sehmbi Houshang Mashhoudy[S,M,X] Ji Wang	Mark Hodds[S,P,L,X,N] Sundeep Sehmbi Jacob Low Cristina Alexandru	Dorothea Kondrat[C] Sergei Molokov Cristina Alexandru	Mark Cummings
14:00 – 15:00	Mark Hodds[S,P,L,X,N] Nikolaos Fytas	Aiping Xu[L,C,T] Jia Shao[P,L,R,T] Michal Kuczynski	Aiping Xu[L,C,T] Sundeep Sehmbi Jacob Low Ji Wang	Jim Tabor[A,L,T] Mark Hodds[S,P,L,X,N] Jia Shao[P,L,R,T]	Aiping Xu[L,C,T] Jacob Low Ji Wang	Mark Cummings
15:00 – 16:00	Jim Tabor[A,L,T] Tim Sparks[P] Cristina Alexandru	Aiping Xu[L,C,T] Tim Sparks[P] Michal Kuczynski	Mark Hodds[S,P,L,X,N] Jacob Low Cristina Alexandru	Mark Hodds[S,P,L,X,N] Jia Shao[P,L,R,T] Sundeep Sehmbi	Jia Shao[P,L,R,T] Jacob Low	Mark Cummings
16:00 – 17:00	Jim Tabor[A,L,T] Tim Sparks[P] Cristina Alexandru	Tim Sparks[P] Bill Dunn Lewis Johnson	Mark Hodds[S,P,L,X,N] Robin de Regt Michal Kuczynski	Bill Dunn Sundeep Sehmbi Cristina Alexandru	Bill Dunn Jacob Low	Mark Cummings
17:00 – 18:00	Brian MacDonald Michal Kuczynski	Bill Dunn Lewis Johnson Damien Foster (201MS support)	Jacob Low Robin de Regt Michal Kuczynski	Jia Shao[P,L,R,T] Bill Dunn	Bill Dunn Michal Kuczynski	
18:00 – 19:00	Brian MacDonald Michal Kuczynski	Bill Dunn Michal Kuczynski	Jacob Low Joseph Yose[X,Y]	Sundeep Sehmbi		
19:00 – 20:00	Brian MacDonald Michal Kuczynski	Bill Dunn Michal Kuczynski	Jacob Low Joseph Yose[X,Y]	Sundeep Sehmbi		

Key

Name in Green = Statistician Name in Purple = Engineering Specialist M = Minitab support L = LaTeX support R = "R" support Y = Python P = SPSS support
X = Excel support T = Matlab support S = Stats and Maths support A = Maple support C = Logic and sets N = Nursing Support
Please note: All tutors are able to offer support in basic mathematics for ANY subject. However, if you wish to get some more specific support then please see a tutor who is able to offer that support using the key above.

Appendix B – Our diagnostic test results sheet

sigma (Maths and Stats Support)

Mathematics Diagnostic Test Results for:

«Candidate_Name»

Arithmetic:	**«Arithmetic_Arithmetic_Grade»**
Problem Solving:	**«Problem_Solving_Problem_Solving_Grade»**
Further Arithmetic:	**«Further_Arithmetic_Further_Arithmetic_Gr»**
Algebra:	**«Algebra_Algebra_Foundation_Grade»**
Lines and Curves:	**«Lines_and_Curves_Lines_and_Curves_Grade»**

Dear «Candidate_Name»

It is very important that you are well prepared mathematically for your degree course. The Diagnostic Test shows which areas need revision to get you up to speed. Individual tutoring is freely available in **sigma**'s **Mathematics Support Centre (MSC)** on the ground floor of the University Library. The Centre is open seven days a week in term time. Just drop in and ask one of our friendly tutors for help – no appointment is necessary. We have prepared some worksheets that will help you revise. Hard copies are available in the Centre and they can also be downloaded as PDFs from our website: http://sigma.coventry.ac.uk/ The worksheets are numbered and the ones relevant to the above topics are listed at the bottom of this letter.

Throughout October we also offer first year students a **FREE Calculator**. All you need to do is complete our short survey which can be found on our website. Once you have completed the survey you need to bring your ID card to the centre **between 12pm and 2pm** on weekdays to claim your free calculator (whilst stocks last!). **Please allow 24 hours from completing the survey to collecting your calculator.**

We look forward to seeing you regularly in the Centre throughout your degree years. It's a place to come and work in a supportive atmosphere, and get help when needed. Improving your maths, even if you are already good at it, will almost certainly help you get a better degree.

Best wishes,
The **sigma** Team
Worksheets to help you catch up in the topics needing revision:

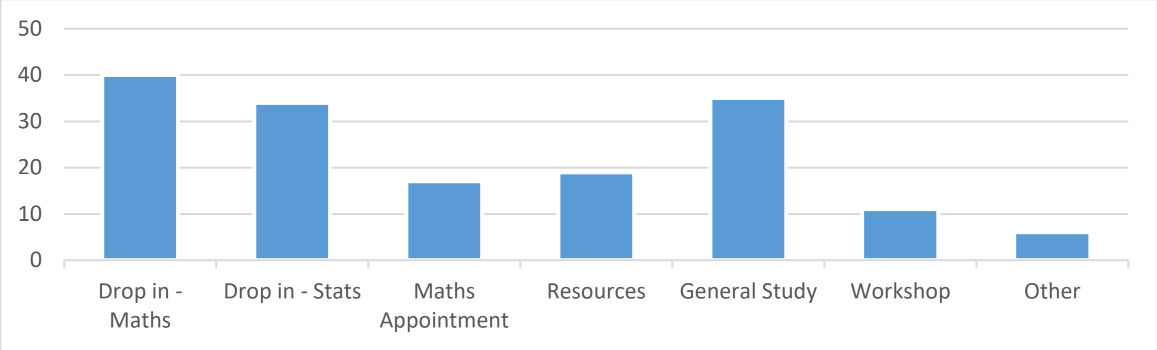
- Arithmetic — N1, N2, N3, N5
- Problem Solving — N4, N7, N8
- Further Arithmetic — N6, N13
- Algebra — A2, A3, A4, A5, A8, A9, A17
- Lines and curves — G3, G4, G5, G6, G7

Mathematics Support Centre Opening Times

Monday	**10am – 8pm**
Tuesday	**10am – 8pm**
Wednesday	**10am – 8pm**
Thursday	**10am – 8pm**
Friday	**10am – 6pm**
Saturday	**1pm – 5pm**

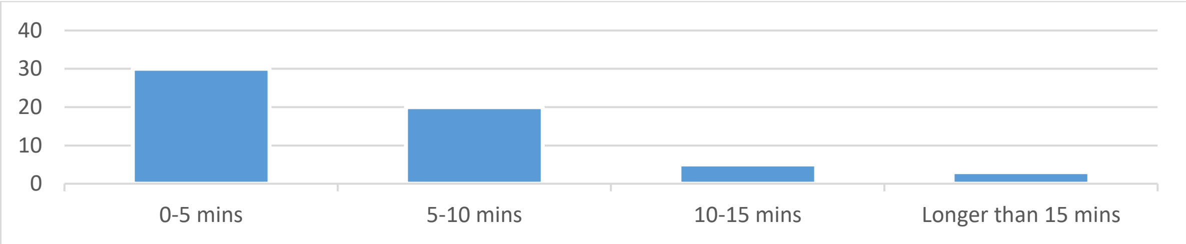
Appendix C – Some statistics from our Feedback Survey 2015-16 (N = 78)

Question 5: For which reason(s) have you visited the MSC?

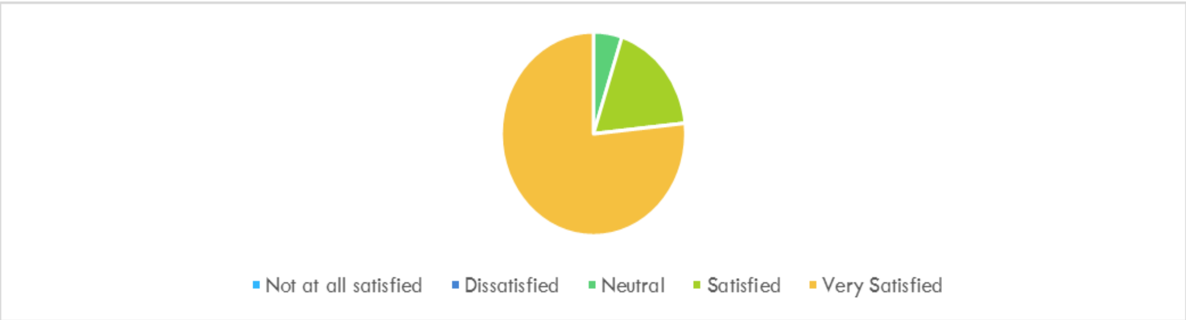


(‘Other’ corresponds to picking up leaflets and worksheets, working as a student proctor, and collecting coursework from tutors.)

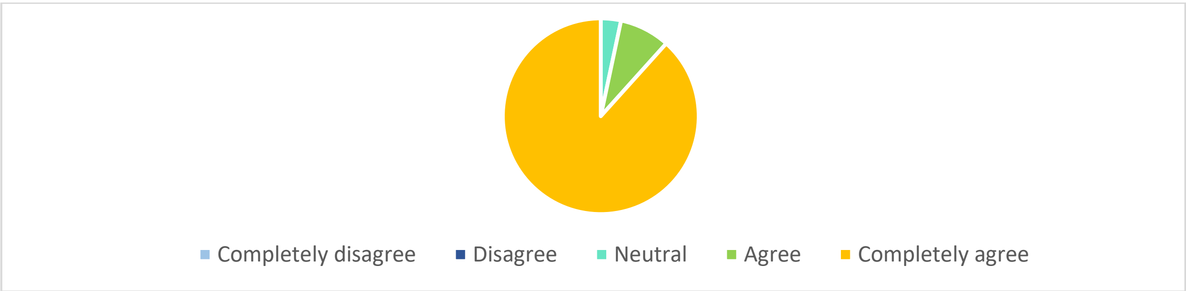
Question 6: If you received support from our drop-in service, how long did you have to wait?



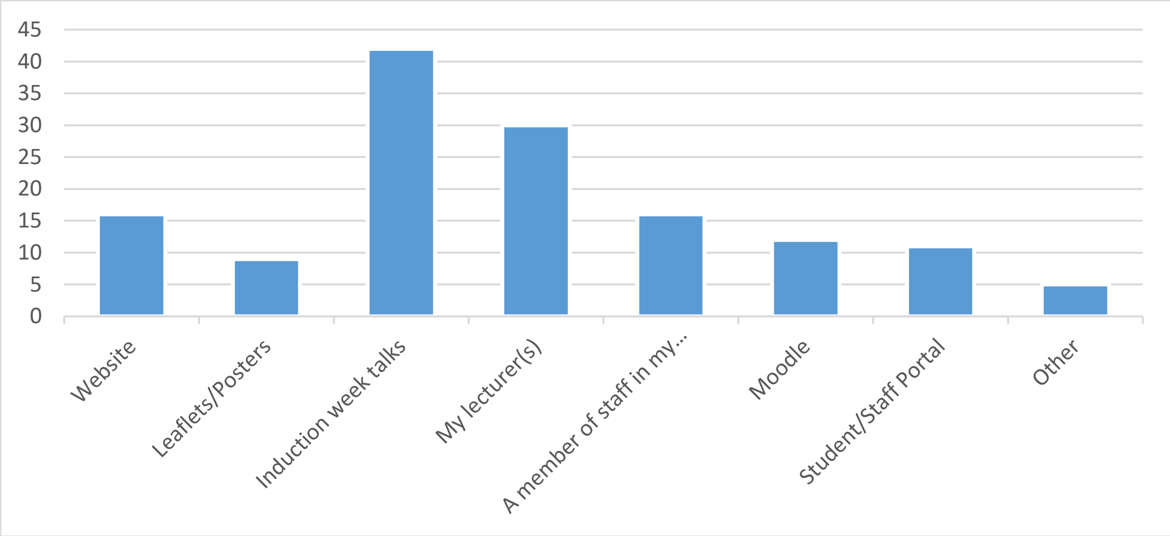
Question 8: I am satisfied with the support I received



Question 14: The staff on duty are friendly and helpful



Question 17: Where did you learn about the MSC (tick all that apply)



('Other' corresponds to Social Media and Open Day talks.)

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CASE STUDY

Designing a short course for graduate teaching assistants (GTAs) in mathematics: principles and practice

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Abstract

Graduate Teaching Assistants (GTAs) are postgraduate research students who contribute to the teaching of undergraduates while they pursue their own doctoral research. This paper reports on a mathematics-specific 10 learning hour introduction to teaching for postgraduate mathematics research student GTAs. The principles that guided the design of the course are discussed and results from our practitioner research are presented. We found that 'training' could not be delivered in such a short course yet, paradoxically perhaps, education could be achieved, given the qualities of our GTA participants.

Keywords: postgraduates, teaching assistants, GTA, undergraduate mathematics, training course.

1. Introduction

Nowadays, at many research intensive UK universities, postgraduates in mathematics departments are 'graduate teaching assistants' (GTAs), contributing to the teaching of their departments' undergraduates; this has long been the standard situation in universities in North America (Park, 2005). The UK Higher Education Academy has in the past run workshops for mathematics GTAs but cuts in public expenditure led to the demise of this specialist mathematics provision. However, a local initiative, 'the UCL-IoE* strategic partnership' in 2014-15, supported designing and running a mathematics-specific teaching course for postgraduate research students which was to take approximately ten hours of their time. This short course was designed through a collaboration between mathematicians (colleagues in the UCL Mathematics Department) and the authors of this paper, both mathematics educators working at UCL Institute of Education (UCL Institute of Education). This course has continued in the subsequent academic years and is now part of postgraduate provision in the Department of Mathematics at UCL.

The course for GTAs focused on three key aspects of university mathematics teaching: marking, tutoring and lecturing and we present results from our analysis of qualitative data that pertain to the fundamental practitioner research question: what did our course participants learn? A brief outline of the paper is as follows: the first part is an introduction to the context; firstly, some background is given to post-graduate student preparation for university teaching, then a description of the course is presented together with some illustrative data and we address the issue raised above 'what did the GTAs learn?'. The final part of the paper is discussion of what 'should' feature in a 10-hour preparation for GTAs contributing to the teaching of undergraduate mathematics leading to our claim

* University College London (UCL) merged with the Institute of Education (IoE) on 2 December 2014.

that GTAs cannot be ‘trained’ in 10 hours, but ‘education’ – the nature of which shall be discussed briefly below – is possible.

2. Context

World-wide, potential students seek to enrol in undergraduate degree programmes and, in many educational jurisdictions, pay high fees for the privilege; the issue of ‘who might be teaching me then?’ asked when fees for the majority of home students increased (Cox and Mond, 2010) continues to be relevant. When choosing their programme, these potential undergraduates will get information from universities’ websites and other publicity which, amongst other things, promotes the reputation of that university’s academics. For example, a promotional video for potential UCL mathematics undergraduates broadcasts that “anyone teaching you is a cutting edge researcher of modern mathematics, which is true for all our permanent staff” and also “all of them [faculty] are research active and all of them teach” (UCL, 2015). While the issue of the relationship between research expertise and teaching expertise is not addressed in this paper, it is the case that potential undergraduates are likely to have some tutorials (and possibly lectures as well) given by GTAs. The GTAs have not yet become experts in their research area, though they are supervised by experts, who do also teach. If a distributed expertise (UCL, 2015) can be said to come from the parent mathematics department, not only in research but also in teaching, then inducting these postgraduates into university teaching as part of departmental practice is consonant with a notion of undergraduate experience given by the promotional video.

2.1. On GTA training

In 2012, in the UK, NUS (National Union of Students) collected and analysed the responses of around 1,500 postgraduate students who teach at their institutions. The survey asked a mixture of quantitative and qualitative questions on a number of aspects of their teaching experience. There were six main areas of focus for the survey: motivations for teaching, the application process, pay and conditions, representation, training and professional development, and feedback. These data provide an overview of how postgraduate teachers are treated in the UK, and in their report, Wenstone and Burrett (2013) were able to capture a detailed picture of what the postgraduates experience when they take on teaching responsibilities at their institution. They recognised that the pressures of doctoral study make time a precious resource for postgraduate research students and the report revealed that much of the hard work of postgraduates is undervalued and underpaid by their institutions, hence highlighting the need for them to be appropriately supported and fairly compensated for it.

In the North American context, where GTA contribution to teaching is standard and includes lecture courses as well as tutorials, the issue of their preparation for teaching has been discussed for some decades (e.g., Border, Speer and Murphy, 2009; Carroll, 1980). Border et al. (2009) classifies the models that have used to describe the GTAs induction as: “orientation”, “transitional” or “recurring” programmes (pp. 26-27). Orientation programmes, generally held prior to the GTA starting to teach, induct the graduate student to the ways of the department, including the syllabus of the course s/he is to teach; transitional programmes, lasting longer and typically meeting throughout a semester, included input on teaching styles, yet rarely on subject specific pedagogy; recurring programmes offered on-going support over the years of the GTA’s graduate study.

2.2. On subject specific training

In November 2005, the Education Committee of the London Mathematical Society carried out a survey of staff training in mathematics departments at UK universities. As reported in Cox and Mond (2010), the responses received from 25 higher education institutions in the UK, with a majority of the providers offering single-subject mathematics degrees, indicated that the training of new staff was almost entirely generic. Two providers reported satisfaction with this generic training, while the remainder were critical, some extremely so, inasmuch as the taught part of the generic training courses was considered irrelevant to preparing their GTAs.

While generic courses for GTAs may be increasingly sensitive to disciplinary differences, problems can arise if these courses do not offer contextual support needed by GTAs. Cox and Mond proposed that preparation for teaching at higher education level should contain both generic and discipline-based components. As they found that often participants in generic preparation for teaching courses felt that many of the issues central to their teaching are peculiar to mathematics and cannot be addressed in a generic programme aimed at practitioners of all subjects. Based in part on their experience of running such a scheme in the Mathematics and Statistics Departments at the University of Warwick, UK, where it has been successful both in training new staff, and as a means of focussing departmental interest in teaching, they produced a booklet which aims to guide UK mathematics departments in providing training for new lecturers. At our institution, University College London (UCL), not only new lecturers, but also 'Teaching Assistants' – usually postgraduate research students (GTAs) – are required to be 'trained'. The training is offered through 'Gateway workshops' designed to prepare postgraduate students with no prior experience for their teaching responsibilities by introducing approaches to teaching and learning. Our mathematics-specific course discussed in this paper is in lieu of the generic 'gateway workshop'. While we recognize that the training needs of GTAs are different to those of new lecturers, the literature reviewed above was influential in the design of our short course.

Suggestions for how to best approach the training and the professional development of university mathematics teachers have been made by mathematicians (as above), but also by mathematics educators. Our short course benefitted from the collaboration between the mathematician colleagues (see acknowledgements) and the mathematics educators (the authors of this paper). Influential in this respect was the work of Alcock and Simpson (2009), aimed at providing mathematicians with an accessible introduction to some ideas from mathematics education research. Hence, influential in the design of our short course was our awareness of and familiarity with the considerable body of research on learning to teach mathematics to undergraduates. Key sources include: the notion of concept image (Tall and Vinner, 1981); promotion of undergraduates' active engagement with mathematics beyond mere applications of techniques (Mason, 2002); recent work on how young people transition to learning university mathematics (Grove, Croft, Kyle and Lawson, 2015); investigations in to tertiary mathematics teaching and learning (Nardi, Jaworski and Hegedus, 2005). All these sources, as well as others offered insight into the problems of assisting students to learn mathematics that we could interpret and use for inducting GTAs into teaching undergraduates.

3. Our short course for mathematics GTAs: Design Principles

Research, such as referenced above, informed the subject- and phase-specific pedagogy of the course discussed in this paper. This background was employed to design and deliver a course for postgraduate or postdoctoral researchers from a range of mathematical disciplines; this was a considerable challenge especially as the course was intended to take less than 10 hours of their time.

GTAs in the UCL Mathematics Department have one of three different roles: (1) the GTA is the tutor for a small group (five to seven) of first year undergraduates; (2) the GTA marks weekly homework sheets (set by the module's lecturer) for students attending a particular module; (3) occasionally, a GTA gives a lecture in his/her specialism for advanced undergraduates. GTAs are entitled to have access to lecture notes and problem sheets with solutions in advance (although this is not always the case). Such resources are usually designed by the module leader, a member of staff in the mathematics department.

In designing our short course so that it is a learning experience, there are a number of aspects we considered to be fundamental: 1) opportunities for *practicing* marking and lecturing with peer feedback and tutor guidance (as in Nardi, Jaworski and Hegedus, 2005); 2) opportunities for *reflection* on their practice (as in Kahn and Kyle, 2002) both in their mini-lectures (see below) and their tutorial opportunities; 3) a safe environment to try out ideas; 4) skilled tutor input within discussions to pin down and possibly offer a conceptual framework for their thinking (as in Tall and Vinner, 1981). These four principles are adapted from both generic and subject-specific literature on good practice of training design we drawn on from the literature we reviewed.

3.1. The course we ran

What we saw can be achieved in 10 hours was a lively collegiate atmosphere of postgraduates engaging with teaching undergraduates mathematics through addressing key areas of marking, tutoring and lecturing. The course was thus oriented around these types of teaching task, from which observational data and reflections were collected. The course is held annually during the Autumn term with, on average, 14 participants.

3.1.1. Marking

As the initial focus of the conversations about marking would be on the mathematics itself, we would thus start by tapping into the GTAs' strength, namely their subject knowledge. While initially the intention was to let participants choose whether to focus on teaching real analysis, number theory or mathematical methods, in practice it was not possible to give this amount of choice. So the course used real analysis – a foundational area of undergraduate mathematics with which all participants were familiar – as the content area from which to develop teaching.

From past years' Real Analysis 1 exam scripts, parts of students' answers to a few questions were cut and pasted onto a large sheet so several students' answers could be compared. The GTAs were invited to work through a selection of undergraduates' solutions to past exam questions and mark them, while engaging with the marking scheme at the same time. The marks given by GTAs to each question were then compared and a lively discussion and justification followed for the rest of the session. With mathematics problems as the starting point, a variety of aspects of teaching and learning cropped up from the discussion about: solutions, the range of possible answers, how many marks each step in the solution would score, accuracy of written language, formative feedback, etc.

3.1.2. Tutoring

The purpose of this session was to encourage a conversation amongst the GTAs, voicing their opinions and views on how to best run tutorials, mainly based on their own experiences as undergraduates on how they benefitted from attending those sessions and, on reflection, on what they would have liked to experience. Throughout the session, the GTAs views were backed up by tutors sharing their own experience and disseminating principle of researched good practice.

3.1.3. Lecturing

Participants were asked to prepare a mini-lecture (5-10 minutes) either on a topic that arose from the marking session (e.g., Rolle's theorem, or a fiendish counter-example to an intuitive 'truth') or another early undergraduate topic, to peers and tutors. After each mini-lecture there was a discussion on the content and presentation. Data were of the form of notes and photos from the presentations and notes of points of discussion.

4 Our short course for mathematics GTAs: What happened in practice

4.1 Sources of data

Towards the end of the Autumn term, the GTAs fill in a pro-forma (see appendix) aimed at helping them reflect on their experience of giving tutorials. Their responses (100% response rate, due to the small size of the group) contributed to the design of the last session of each of these courses, with an aim of drawing together some general principles for ‘good practice’ in undergraduate tuition.

In the following we present examples of GTAs comments taken from their responses to the pro-forma questions, together with the data we collected throughout the delivery of the courses over the past three years (our reflective notes after each session, photographs of GTAs’ board notes and scripts they marked, our notes of GTAs’ comments and contributions in sessions).

4.2 Samples of data

4.2.1 Marking

Excerpts from students’ exam scripts provided a fruitful starting point of a rich discussion about many aspects related to understanding, learning and teaching mathematics. Some of the GTAs expected a high level of precision of how undergraduates employed the mathematical notations and symbols: for instance, the absence of quantifiers was thought by the GTAs to be sanctioned. Another example, paraphrased from notes: one of the participants, GTA1, argued that an undergraduate examinee should be penalised for not stating explicitly that ‘N’ should be an integer when using ‘N’ in a certain definition. The other participants and tutors, had a discussion about implicit meaning, given the practice (i.e. use of notation of the lecturer) and the pressure of an exam; the consensus was that GTA1’s judgment was tough on the student.

The importance of and awarding of partial marks was discussed at great length during the session, with the aim of raising GTAs’ awareness about striking a balance between awarding marks for the correct reasoning and validity of the argument put forward and penalizing presentations of written solutions which were not accurate or rigorously presently.

4.2.2 Tutoring

The GTAs found the tutorial a very useful session. They learned from listening to others sharing their experiences about how to interact with students, learning about the subject-specific pedagogical aspects of preparing and conducting a tutorial, what they tried and how it worked, why or why not. The discussion challenged the GTAs’ initial view about tutorials *being more than just teaching mathematics, but also about supporting students and understanding what they need help with* (GTA2), while the following aspects were raised through discussions as aims for tutorials: establish a friendly environment; help the students prepare and practice; encourage discussion about a specific mathematics topic; offer explanations so they understand – rather than just present an answer; provide feedback on the students’ work; be prepared to answer all sorts of questions.

In the following, we illustrate how some of the GTAs reflected on efforts to implement these aspects in their tutorials.

Encourage discussion about the mathematics: “We discuss and collaborate on the problems we solve and I encourage them to explain their work to each other”, said GTA3. Others expressed their concerns about not being very successful in using discussions to the benefit of all of their students, as reflected in GTA4’s comment: “the discussion was mainly on the part of the students who understood the topics completely, and were therefore confident talking about it. The students who had any doubts preferred to remain quiet mostly”. GTAs expressed frustrations with students’ preoccupation with the correct answer and admitted that “in so far as is possible I have tried to; however most of the students are focused on the correct answer and nothing else”; GTA5 encourages students to answer questions and not being afraid of being incorrect, which he identifies as a common issue amongst undergraduates, while GTA6 “would like to learn how to get the students to converse more with each other”.

Be prepared to answer all sorts of questions: As a pre-requisite to preparation for tutorials, the GTAs’ comments highlighted the need to have access to lecture notes in order to appropriately support students’ learning: “however, both courses I was supporting changed this year so I was not always clear on what they had covered in class until I had seen their notes” (GTA7), while another, GTA8, found it very useful to have access to the module resources: “we’ve discussed homework problems, proofs and examples in their lectures, textbook recommendations and online resources”.

This short course raised an awareness amongst the GTAs that familiarity with the subject matter content of the modules and being able to solve the weekly problems set does not suffice as preparation for tutorials. Unpacking their own understanding, reflecting on the reasoning involved at each step prepares them better for tackling students’ various questions: “I feel I could have been a bit more prepared for some of the questions they gave me, some of the nuances that are not directly relevant to solving equations were sometimes lost on me” (GTA9). Another student commented that the subject matter of the course studied by her students was very easy and that most of the time students’ questions were very easy, although on occasions, when harder questions were asked by the students, she wished she could anticipate those. GTA10 soon realised that “if you just present an answer on the tutorial, instead of doing the things mention above, the tutorial becomes boring and you are just repeating the things they already saw in lecture and you are not doing anything relevant to help them”.

On reflection, through whole group discussion, the GTAs came up with a number of suggestions that would benefit their preparation for tutorials: work through the problem sheet thoroughly, discuss potential problems undergraduates might have with other tutors and in this respect, cultivate a community of tutors for supporting each other.

Feedback on students’ work: The mathematical dimension of tutorials was of a high interest to the GTAs. The issues they raised were related to the standard of precision, logic and use of new concepts is different for those who need support, those who are getting along and those who are really good. The importance of developing questioning skills was also discussed, to support students’ understanding, particularly for those students who breeze through the problem sheets in order to challenge them on points of detail.

4.2.3 Lecturing

Samples of board work are shown in figures 1 and 2.

It was satisfying to have been immersed in details of undergraduate mathematics with the participants, all of whom are potential university lecturers in mathematics, who contributed to group discussions lead by the project team enthusiastically and perceptively. In particular, their presentations embodied some of the challenges involved in giving mathematics lectures. Examples raised included: coordinating board writing with talking to students, positioning themselves at the board to allow for clear visibility of the board notes by all students in the room, erasing board notes as a result of mathematical simplification was realized to not be helpful to students, splitting the work area of large boards and the ‘flow of the board work’ in general to make it easy to follow, pace of tutor’s handwriting versus students’ handwriting, and use of different colour pens to emphasise main points (as in figure 1) also emerged as important issues to consider in teaching.

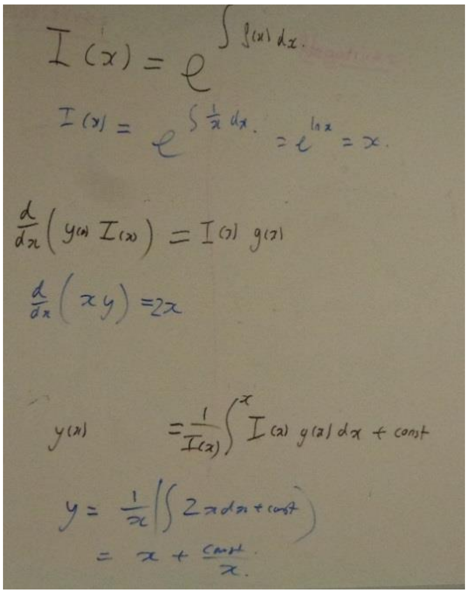

Figure 1: Emphasising main points.

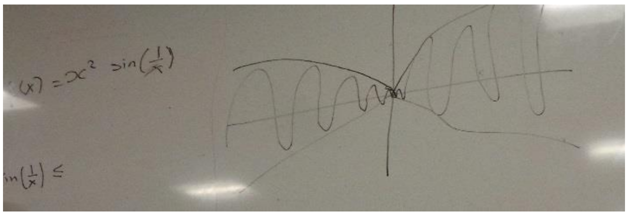

Figure 2: Lack of accuracy when using visualization.

Discussion about the use of diagrams to support explanations or illustration of mathematics results also arose naturally during the presentations. While visualization is to be encouraged, one instance where a diagram was used (figure 2) led to a debate about how the lack some level of accuracy does not support understanding, and how an explicit link to its symbolic representation is also required.

Consideration of suitable notation and being explicit about the oral language associated with symbolic reasoning became apparent by sitting in each other's lecture. Mathematical notation received yet again a particular attention: being explicit about how to read a particular new notation introduced and not taking for granted mathematical terminology that undergrads might not be aware of (such as: lemma, corollary, etc.). Similarly, the GTAs presentations alerted them to the conventions of mathematics which undergraduate might find it challenging: such as the need of assumptions and conventions to be made explicit.

The atmosphere of the feedback sessions was very collegial, which is a good environment for the mutually supportive and insightful peer comments to be taken in.

5 Discussion: education versus training

We were struck when we[*] started on this project how casually the word 'training' was used within the mathematics department for the induction into teaching we were planning for their postgraduates, yet the observation was a prompt to consider differences between education and training that were relevant to this context and lead to the claim ('not enough time for training') proposed above. It is worth noting that in all teacher preparation courses there are aspects that are more akin to training and other aspects deemed education. For example, in a year long postgraduate teacher preparation course (PGCE), based in a university with school practicum, the pre-service teacher could be said to be trained to take a register, know the content and progression of the National Curriculum, the current statutory requirements for 'special needs' etc. On the other hand, pre-service teachers on such a PGCE course could be said to be educated into ways of thinking about students through

[*] Authors together with colleagues named in the acknowledgements.

being asked to interrogate different theories of learning within their school experience, and also educated into developing a reflective practice that includes personal and academic writing, reflection on literature and dialogue with peers and tutors that widen their views on relevant issues (such as what mathematics should be in the curriculum). It seems ironic, given the relative demands of training and education, as illustrated above, to say that we do not have enough time to train the GTAs, though we have an opportunity to educate. However, for our GTAs, we aim to explain why, firstly, by considering the meanings of the two key terms, then considering the participants and data from the course.

There is frequent confounding of education and training in common parlance; a quick internet search brings up a host of ‘education & training’ websites, for instance. This lack of discrimination between the terms ‘education’ and ‘training’ concerned Robert Dearden in the context of ‘vocational education and training’ schemes being set up in the 1980s.

> Training typically involves instruction and practice aimed at reaching a particular level of competence or operative efficiency. As a result of training we are able to respond adequately and appropriately to some expected and typical situation. … in every case what is aimed at is an improved level of performance … brought about by learning. (Dearden, 1984; p. 58-59)
>
> [Education] is very much a matter of conceptual insight, explanatory principle, justificatory or interpretative framework and revealing comparison. It also involves a degree of critical reflectiveness and hence autonomy of judgement, … Being concerned with understanding does not exclude from education any concern for feeling and desire, attitude, action or activity, but they will not be fostered apart from understanding. … A necessary condition of understanding many things is participation in them or experience of them. Education is not a purely intellectual affair. (p. 62)

Dearden’s clarifications of the respective terms, training and education, can be applied to the case of our course for GTAs together with the observation that assessment or evaluation is also a part of a training cycle, which can be expressed as: find out the training needs, plan training, deliver training and assess whether participants have achieved the desired outcome. If not, adapt and try again.

So a ‘training’ has not been achieved on the course because there was not opportunity to check performance and response in typical teaching situations and ‘try again’ if the performance was wanting. For example, the Marking session of the course aimed to prepare a GTA to mark and to respond to undergraduates’ written work by giving participants a range of undergraduate responses to some of last year’s exam to mark. There was a great range in many of the marks given by participants and a lively discussion ensued justifying the marks given. This debate constituted (part of) the GTAs education, as it involved interpreting, developing autonomy of judgement and justification. But it was not a training, as there was no opportunity to have the participants mark another batch of exam questions and check that they had followed the principles which came from the discussion in the session and which conformed to international mathematical community represented by the mathematics department.

On the other hand, Dearden’s characterisation of education suggests that understanding – in this case, how GTAs understand teaching mathematics to undergraduates – includes experience as well as affects like feeling and attitude. At this point a brief introduction to the course participants is appropriate: each of them has won a place at a prestigious mathematics department to do mathematics research, every one of the participants communicated within our sessions a genuine interest in teaching undergraduates mathematics, each one of them prepared thoroughly for a mini-lecture in front of peers and tutors in which all of them contributed supportive insightful comments. They were an exceptionally well-motivated group of people who came together with a common interest in mathematics and all of whom had studied undergraduate mathematics. Returning to

Deardon's characterisation of education, the GTAs experience of participating in mathematical culture and their current career trajectory, positioned them to have, for instance, conceptual insight in the mathematics education domain. An example of this occurred following GTA11's mini-lecture on integrating factors (illustrated in figure 1) when the notion was raised that a set of suitably designed problems could get students to discover/invent the integrating factor formula without the lecturer 'giving it'. This insight is in the spirit of Bob Burn's (2013) investigative approach to first year analysis and illustrates that our course provided an opportunity for this insight to be realised thus educating them about different forms of mathematical instruction in context. Another aspect of education offered by the course was in post-discussion consolidation. In the feedback session we summarized points from the sessions of the course and offered some general principles, for instance, on different roles of examples in mathematics learning. Thus education might well have taken place as the participants had a contextual entry to general principles, but training did not as performance was not monitored.

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Appendix

Mathematics postgraduate research student TA
pro-forma on tutorials

Your feedback on this form will contribute to this last session, so please fill in the form below and return it by email to ___ as soon as you possibly can.
Thanks.

1. General info

1. Your name:
2. What is your research area?
3. Were you a maths undergraduate in the UK? **Yes/No**
    - If **Yes**: at UCL? Yes/No.
    - If **No**, which country?
4. Did you have your own tutorial group throughout this term?
   Yes/No
    - If **Yes**, please omit item A ('no Autumn term tutorial group') and fill in item B.
    - If **No**, please omit item B and fill in item A.

2. Item A (on Autumn term tutorial group)

Did you take a tutorial group at least once this term?
Yes/No

- If **Yes:**

Who is the usual tutor for this tutor group? Is s/he your PhD supervisor? Which course(s) did the tutorial support? In which week of the course did you take the tutorial? What topic(s) did you plan to address? Roughly, for how many hours did you prepare for each tutorial?

If **No**, please explain, briefly, why this did not happen and whether you can arrange to take a tutorial session next term.

3. Item B (you had your own tutorial group in the Autumn term 2016)

Which course(s) did the tutorial support? Did you take the tutorials every week this term? If not, can you please briefly explain why not? Roughly, for how many hours did you prepare for each tutorial?

4. Aims for tutorials

The following points were raised by yourselves at the initial 'TUMIPS tutorial session'. Please fill in the right hand column.

Aim for tutorials raised at the initial 'TUMIPS tutorial' session at the beginning of term. I aim to:	*Your appraisal* with some exemplification *of whether or not this was achieved, and, if applicable, what you'd like in terms of support or instruction.*
1. Establish a friendly environment;	
2. Explain so they understand - rather than just present an answer - at a pace the students are comfortable with;	

3. Feedback on the students' work;	
4. Encourage discussion about the mathematics;	
5. Get the students to develop their own strategies for problem-solving which includes understanding what it is to prove something;	
6. Be prepared to answer all sorts of questions;	
7. Support students going up to the board to explain their solutions;	
8. Be enthusiastic about mathematics;	
9. Help the students prepare and practice.	

5. *Lastly, please tick in the appropriate box:*

	Strongly Disagree	Disagree	Agree	Strongly agree
a. The tutorial session(s) seemed to go quickly.				
b. Giving (a) tutorial(s) is a waste of my time.				
c. I now understand better why some students find their mathematics courses difficult.				
d. The students were not adequately prepared for the tutorial.				
e. I used what the students said or wrote to help explain to them.				

CASE STUDY

The Hamburg Online Math Test MINTFIT for Prospective Students of STEM Degree Programmes

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Abstract

MINTFIT is a joint project of the HafenCity University Hamburg (HCU), Hamburg University of Applied Sciences HAW), Hamburg University of Technology (TUHH) and Universität Hamburg (UHH) together with the Hamburg Ministry of Science, Research and Equalities (Behörde für Wissenschaft, Forschung und Gleichstellung, BWFG) to support high school students and others interested in STEM studies. The MINTFIT Math Test is a diagnostic online test which gives its participants the opportunity to check if their math skills are sufficient for a successful start into the first terms of a STEM degree programme.

Keywords: STEM study preparation, math skills diagnostic, first year problems.

1. Introduction

Many first-year students of STEM degree programmes have difficulties with mathematics at a university level. Mathematics is a common reason why students drop out of university in the first semesters. Daily experience shows that many first-year students lack basic skills regarding high school mathematics and that their problems with the new content are due to this fact. It is important to note that these students often do not lack only competencies from the upper secondary (see ISCED 1997, International Standard Classification of Education) level 3 but also from the lower level 2 and even from primary education. In order to point out this problem to them as soon as possible – before they start with the first semester – and to help them to close their gaps, a concept of a diagnostic online test (the MINTFIT Math Test) and online mathematics bridging courses (OMB+ and viaMINT) has been developed at and with the support of universities of Hamburg within the scope of the MINTFIT project.

2. Academics and Pedagogical Background

At least in Germany the school pedagogics changed in many ways over more than twenty years. At first it changed from an input- to an output-oriented teaching. This means a change from the description of what is taught to what is learnt. Second, it turned from the transmission of knowledge to the acquisition of competencies of certain levels. In Bloom's Taxonomy (see Bloom, 1956) we find for the cognitive domain: knowing, applying, analyzing, synthesizing and evaluating as elementary levels of competencies. However, it is often criticised that "knowing" comes a little short in actual classrooms at schools and the sustainability of these competencies are not in their focus. At the universities we can just state that the freshmen often do not have the competency to work e.g. with fractions, quadratic equations or right triangles at any level. As some reasons we identify the early and exclusive use of the pocket calculator for even easy calculations, that not enough time is spent for basic practice and that the basic competencies are not used at higher grades any more so that they can be forgotten or spilled (compare Risse et al., 2008). Although administrations have already recognised these problems and some actions are under way, the mathematical competencies of freshmen are still decreasing. There are few studies published, but one study which supports this view has been done over ten years of testing the mathematical knowledge of freshmen at German Fachhochschulen (polytechnics) in the federal state of North Rhine-Westphalia (see Knospe, 2017). The overriding impression is that the objective of mathematics at schools is not the preparation for a STEM degree programme, at least not with high priority.

3. The Transition from High School to University (cosh-Katalog)

In Germany, the subject matters taught in high school differ between the federal estates. Additionally, there is a huge variety of ways to achieve a university entrance qualification. Consequently, the level of knowledge of the students in a math course at a university varies broadly. As a lecturer, it is difficult to identify which subjects can be assumed to be known. The fact that students come with different backgrounds in mathematics because they got their university entrance qualification in different ways and in different parts of the country is one more reason for the problems that arise at university.

In 2014, a group of high school teachers, professional school teachers and university professors of institutions in the German federal state Baden-Württemberg published a paper which caused quite a stir at the community of math teaching university staff. This group, which calls themselves “cosh” (short for “**Co**operation **S**chule-**H**ochschule”, in English “cooperation high school-university”) defined a set of competencies and associated problems that should be taught at high schools in Baden-Württemberg and which has been accepted as a minimum of assumed knowledge at the start of a STEM degree programme, see Cooperation Schule-Hochschule (2014). Therefore, if a high school student or a person with another educational background decides to begin a STEM degree programme in Baden-Württemberg, he or she knows which subjects have to be mastered – and especially where he or she has to put some efforts before the first semester starts.

Shortly after the publication of this cosh catalogue, many universities in Germany decided to follow this compromise originally made only for a part of Germany and to assume the knowledge defined in the cosh catalogue for the students of the first semester of their STEM degree programmes. For example, the universities of the group TU9 (a group of nine big technical universities in Germany) now accept this cosh catalogue, and each of the universities in Hamburg which offer a STEM degree programme. These are the HafenCity University Hamburg, the Hamburg University of Applied Sciences, the Hamburg University of Technology and the Universität Hamburg. For the history of the cosh group and the cosh catalogue, see also Dürrschnabel and Wurth (2015). For an alternative overview compare also Schramm (2015).

The mathematical knowledge and competencies defined in the cosh catalogue covers a wide range of topics: elementary algebra, geometry/trigonometry, calculus, linear algebra and stochastics. Each topic is divided in further subtopics: e.g. for calculus, it is divided into functions, differential calculus and integral calculus. For a subtopic like differential calculus, a list of skills the freshmen should possess are defined:

- they should have a propaedeutic knowledge of limits,
- understand the derivative as the slope of a tangent to a curve as well as a rate of change,
- know how a function and its derivative relate and
- can conclude the graph of the derivative of a function from the function itself (and the other way),
- know the derivatives of elementary functions,
- can use the basic rules of differentiation,
- use the derivative to analyze a function regarding monotonicity and extrema,
- and know how to use differentiation to solve optimization problems.

Each skill in the list comes with a few problems which freshmen should be able to solve – they must be viewed as a mean to define the level and should not be understood as an all-embracing definition of problems that should be mastered.

4. The MINTFIT Math Test

MINT in German is an abbreviation of “Mathematik, Informatik, Naturwissenschaften, Technik” which translates to “mathematics, computer sciences, natural sciences, technology”. It is an equivalent of STEM.

The MINTFIT Math Test is a free diagnostic online test for high school students and those interested in STEM degree programmes. After finishing the test, the participants instantly get a feedback in which subjects of high school mathematics they should still put some efforts before beginning their university studies. Furthermore, two online learning platforms with mathematics bridging courses – the OMB+ and viaMINT – are presented, the recommended chapters in both courses are highlighted. The OMB+ was developed with the support of the HCU, TUHH and the UHH. viaMINT is a product of the HAW.

The questions asked in the MINTFIT Math test are mathematically based on the mathematics knowledge competencies defined in the cosh catalogue (see above).

The MINTFIT Math Test is originally in German, but is now available also in English since 2017. It is accessible via www.mintfit.hamburg.

5. The Structure of the MINTFIT Math Test

The MINTFIT Math Test consists of the two separate tests Basic Skills I and Basic Skills II. Basic Skills I includes questions dealing with fractions and exponents and is based loosely on the subject matters taught in junior high school. Basic Skills II tests the skills in more advanced areas such as differential and integral calculus. It is based loosely on the subject matters of senior high school. Together, the two tests cover the subject matters defined by the cosh group in the cosh catalogue. Each of the separate tests should be finished in 45 minutes. This is just a recommendation, because there is no time limit. The test results and the suggestions which skill areas to review do not take the time consumed into account.

Basic Skills I consists of 22 questions, Basic Skills II of 14 questions. For each area such as fractions or differential calculus, two questions are randomly drawn out of a pool of questions. The test runs on the free and open source software course and learning management system Moodle. Many questions are written using the Moodle plug-in STACK. This plug-in allows random generation of a huge variety of versions of one only question within structured templates.

All questions were developed so that they can and should be solved by doing the calculations on paper and sometimes also by mental arithmetic. It is pointed out in the information that neither a calculator nor a formulary should be used. Since the test is designed as a test which can be taken at home, participants are only committed to themselves to honesty. Participants can choose the order and the times when they want to complete the tests. Before starting with the first of the two separate tests, they have to complete a short preparatory section consisting of four tasks. These serve to show how to enter mathematical expressions. The tasks in the tests themselves are designed such that the input is as simple as possible. During the entire tests, a symbol key is available on the edge of the page displaying how to input mathematical expressions.

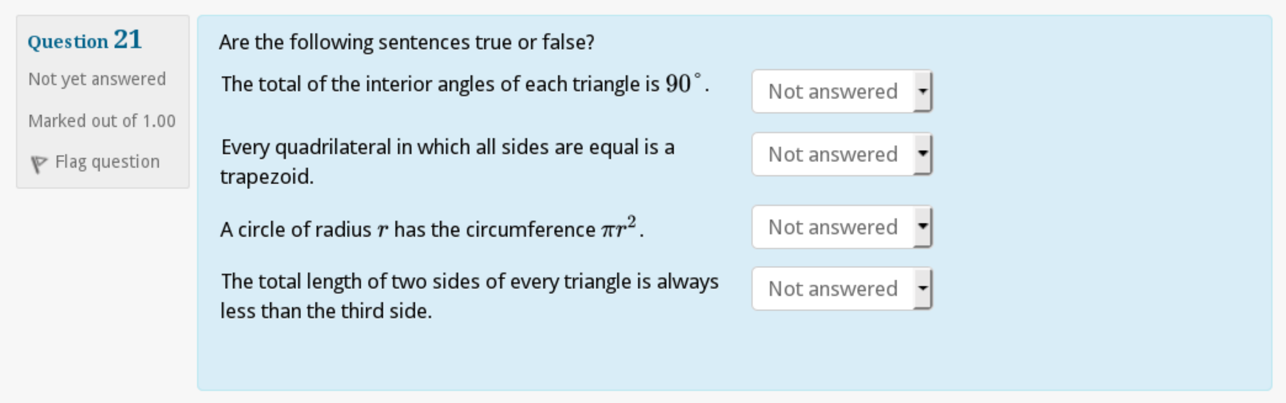

Figure 1. Questions from the test Basic Skills I

In both tests, there are different types of questions (compare e.g. figure 1 to figure 3a). There are arithmetic problems, where the capacity to do calculations is tested. There are also multiple choice and true or false questions, and as well questions where rules or laws such as the laws of logarithm shall be put in. The used question types are from a set of possibilities defined by the IMS QTI specification (compare IMS GLOBAL).

6. The Feedback for the Participants

The results of a test are displayed immediately after participants complete this test. At the top of the results page, a medal is shown which expresses a feedback in a visual way. The medal is available in gold, silver, bronze and blue (figure 2). It is a face either smiling or with a neutral expression, depending on how good the result was. This medal is called “Plietschi”, “plietsch” meaning “clever” in Low German language which is typically spoken in Northern Germany.

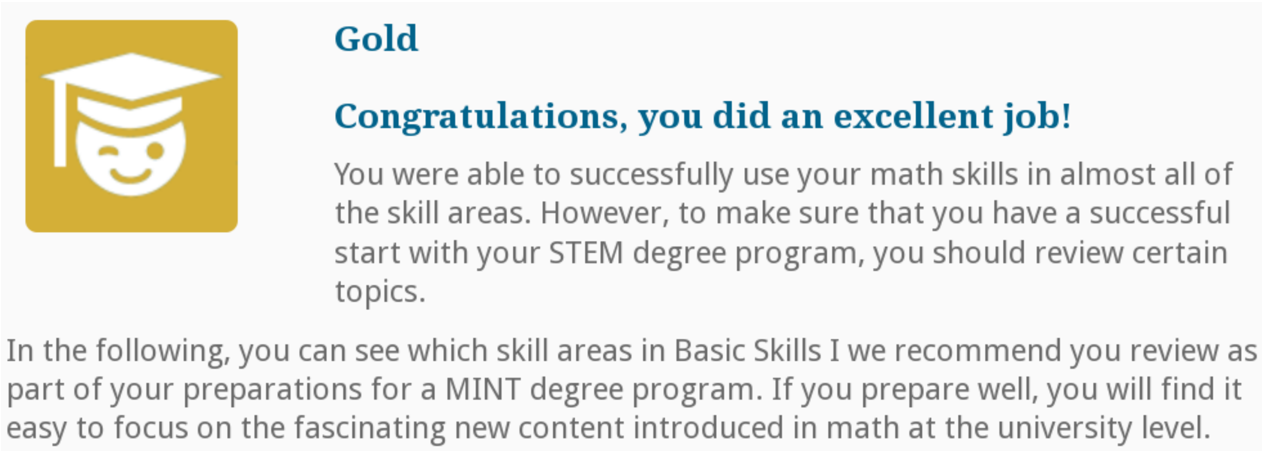

Figure 2. General feedback for test results that are between 33% and 66% (Silver) and between 66% and 99.9% (Gold) of the maximum result.

A text describes the result and suggests how much effort participants should put in their study of mathematical basics. The score in the form of a percentage of maximum available points is not displayed, because it had a discouraging effect on the participants at an early stage of the development of the test. For each question, there is a standard solution shown as well as the solution that the participant gave. Additionally, if it is mathematically and technically possible, there is a specific feedback for wrong solutions indicating which mistakes were made. With the help of decision trees, the system gives these specific feedbacks as well as partial points for partially correct answers or consequential errors (figure 3a and figure 3b).

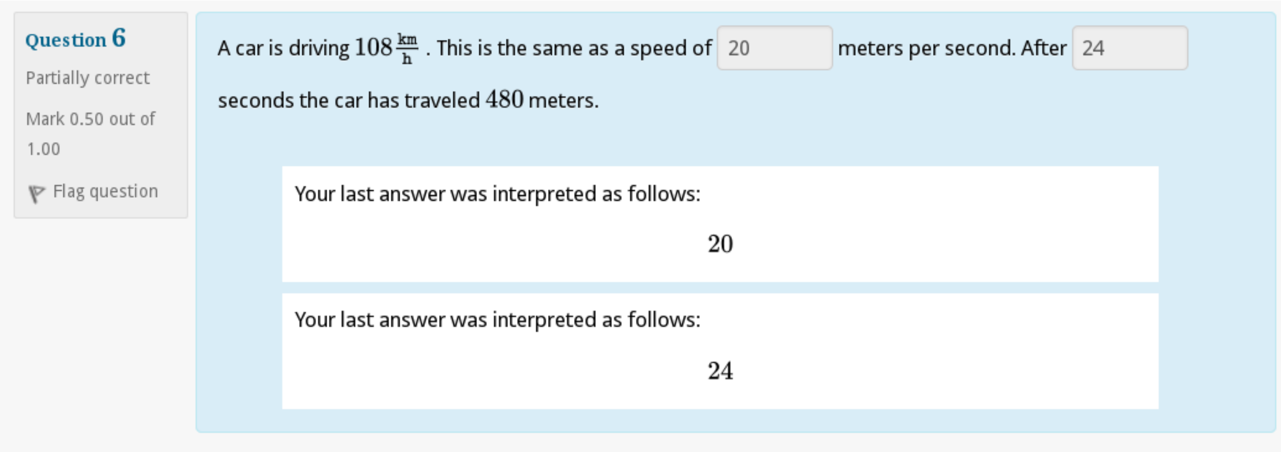

Figure 3a. The system checks if the second answer is consistent with the first (wrong) answer.

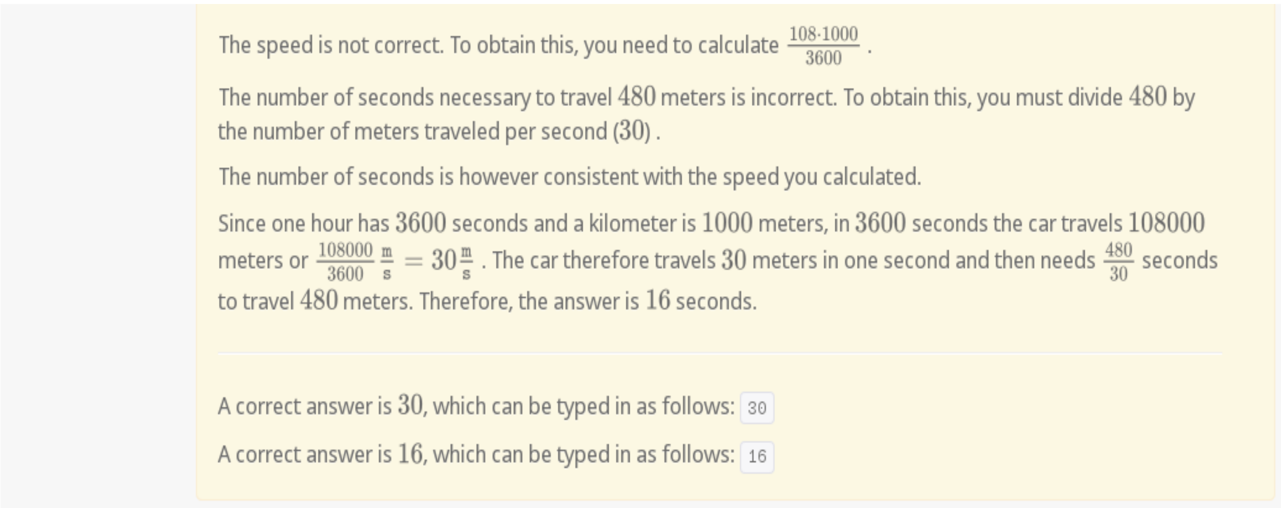

Figure 3b. Specific feedback for the consequential error.

On the subpage “Persönliche Übersicht” (“Personal Overview”), participants can see their test results broken down to the specific areas. For each area, the percentage of achieved points is displayed as well as a visual feedback in form of zero to four golden stars. If participants choose to repeat the test, for each area the best result of all attempts is shown. On this page, there are also listed the corresponding chapters of the two online mathematics bridging courses OMB+ and viaMINT. With a click on the logo of one of these courses, participants can (after accepting with another click) create an account on the chosen learning platform. The results of the test are then sent to the chosen platform, and the recommended chapters are highlighted on the learning platform. Participants can work either on one of the platforms, or on both at the same time.

For the future, it is planned to implement the other direction of information transport – if a participant chooses one platform and passes the final exam of the recommended chapter, the learning progress will be shown as well at the MINTFIT test page in the Personal Overview.

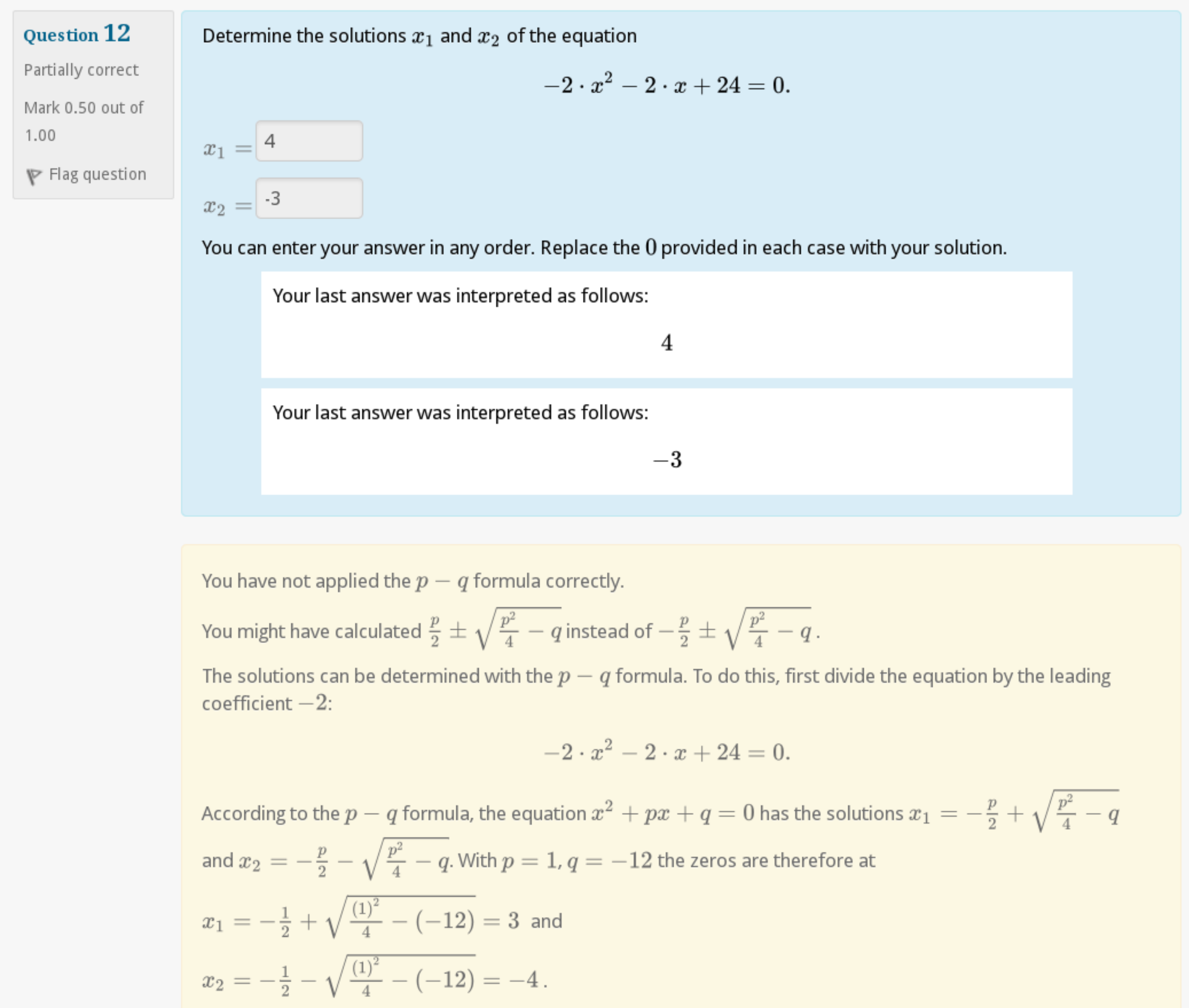

Figure 4. Specific feedback for a wrong result. Here, the system checks for common errors in applying the p-q formula.

7. The Learning Platforms OMB+ and viaMINT

The Online Mathematik Brückenkurs Plus OMB+ (Online Mathematics Bridging Course Plus OMB+) is a joint project of 14 German universities and the company integral learning GmbH. The development was managed by the OMB+ consortium under the auspices of TU9. Its predecessor was the OMB, a cooperation between several German universities and the KTH Royal Institute of Technology in Stockholm. For legal purposes it was completely reengineered and extended in the years 2013/2014 by the OMB+ consortium and is online accessible since November 2014. Authors of the HafenCity University Hamburg, the Hamburg University of Technology and the Universität Hamburg were involved in the development. The OMB+ offers its participants the opportunity to repeat and complement high school mathematics. It addresses those interested in STEM degree programmes and covers the subject matters defined in the cosh catalogue. The approach is text oriented, but there are many questions, interactive elements and also videos. A lot of examples with standard solutions which can be uncovered step by step are presented as well as a huge amount of training questions. Meanwhile, 40 German universities, the Deutsche Physikalische Gesellschaft DPG (German Physical Society), the NRW StudiFinder (an online tool for self-assessment and information about study programmes) and the platform Studiport (an online platform supporting freshmen with their start of university studies) use and recommend the OMB+. The OMB+, originally only in German, is available in English since March 2016. Further chapters covering e.g. stochastics, complex numbers and formal logic as well as more supplementing educational videos are currently in production. See www.ombplus.de.

viaMINT is an online learning platform for bridging courses developed and nearly completed by Hamburg University of Applied Sciences (HAW) and funded by the Bundesministerium für Bildung und Forschung BMBF (Federal Ministry of Education and Research). In viaMINT first-year students can find different bridging courses on one common learning platform. The mathematics bridging course has been available for several semesters. The physics course is still being developed. viaMINT has a video oriented approach with supplemental exercises. It includes numerous examples, animations and interactive applets that serve as visualizations. Supplement material such as the formula sheet are included to support the sustained learning. Students using viaMINT work in a personalised learning environment, the “Persönlicher Online-Schreibtisch” (Personal Online Desk). The Personal Online Desk supports organised study by visually indicating the study recommendations on the basis of an entrance test as well as the corresponding learning progress. Fitting the specific needs of each individual student, viaMINT offers different learning opportunities e.g. a “Detailed Learning Track” and a “Short Learning Track”. As further supplement, custom-fit courses with on-site attendance are held at the Hamburg University of Applied Sciences. viaMINT is available in German. An English translation is in progress. A distinction for different degree programmes is scheduled. A more detailed description of viaMINT is available in Landenfeld et al. (2014) and Landenfeld et al. (2016). See viamint.haw-hamburg.de.

8. Additional Use of the MINTFIT Math Test

At the HafenCity University the MINTFIT Math Test and the bridging courses OMB+ and viaMINT are recommended for a parallel use in the first year courses in engineering mathematics. The classroom online test (just to pass) is mandatory but could be repeated as often as necessary. As is typical for practiced e-assessments, 80% must be achieved. The actual lecture can so be focused on university mathematics. First results show a strong correlation between the passing of the test and success in the final examination. Additionally, in Hamburg there are special rules for persons without a German “Abitur”, but three years of vocational experience. They can apply for an examination to be accepted as a student for a particular programme. Following the idea that the most important obstacle for a successful STEM study programme is mathematics and that the minimum competencies are defined in the cosh catalogue, we use a variant of the MINTFIT Math Test as the major part of the examination. The candidates can prepare themselves using the mintfit.hamburg portal and get an immediate result.

Additionally, the HCU maintains many cooperations with schools and encourages the use of their mathematical eAssessment system Maple T.A.® (Maplesoft™) that offers more possibilities than Moodle for formative assessment in the classroom. For that purpose, we translated the MINTFIT questions to that system which offers the teachers the possibility to easily combine the questions to own assessments fitting to their current need.

Since 2016, a copy of the MINTFIT Math Test has been used with the freshmen at the Hamburg University of Technology. They can earn bonus points which can be used to slightly improve their result in the Linear Algebra written examination at the end of the first term.

9. Reception and Evaluation of the MINTFIT Math Test

It is too early to have a final evaluation of the whole project with math test and learning platforms. In general, it would be very difficult to measure if our activities have an impact on the drop-out rates in STEM degree programmes. However, there are some strong hints that they are helpful for students and that it is recognized by them. A representative subset of participants completed a survey after finishing the math test. A huge majority classified our test with a median of 1 as helpful for freshmen on a scale from 1 (best) to 5 (least).

In one mathematics course at the HafenCity University Hamburg, the math test is mandatory. There is a strong positive relation between the results in the math test and the final mathematics exam grades.

On workshops on the subject, we got the feedback from mathematics teachers at high schools in Hamburg that the math test is highly estimated because their students get an impression of what is demanded at the institutions of higher education.

10. A Look into the Present Activities and the Near Future

In the summers of 2016 and 2017, we offered an on-site attendance bridging course "Math Camp" for all those interested in a STEM degree programme at one of the universities in Hamburg. It was separated in two parts, one covering the matters of Basic Skills I, the other part covering Basic Skills II. Each part was offered at two levels. After taking the MINTFIT Math Test, participants got a recommendation which course to attend and at which level. After these courses, the "Free Practice" started, which is a course over half a year, starting weeks before courses of the first semester begin and ending when courses at the universities end. In these courses, students or even high school students got the opportunity to work with tutors on their basic skills using exercises from the OMB+ and viaMINT. Taking the experiences from the first two runs, the course is now offered in summer 2018 to prepare for the winter term 2018.

The MINTFIT Math Test will be continuously complemented with new questions. A similar concept of online test and online course for physics is in the making, the physics test is already available in German and is currently being translated into English. Also, a test specifically composed for the needs of students at the Universität Hamburg (UHH) of a business, economics or social sciences degree programme has been published in 2018.

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OPINION

Accessible equations

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This opinion piece is modified from a blog post at The Big Conversation, University of Birmingham (https://blog.bham.ac.uk/bigconversation/2018/03/19/accessible-equations-by-dave-smith-school-of-mathematics/).

There is a divide in the academic world between those for whom equations and mathematical expressions are their primary tools, and everyone else! Mathematicians, statisticians, operational researchers, computer scientists, physicists and many computational biologists (for the purposes of this opinion piece I will refer to all of us as *mathematicians* for brevity) typically find that widely-used tools such as Microsoft Word and PowerPoint are unsatisfying for the preparation of mathematics. Their main drawbacks are the combination of a clunky point-and-click interface with, to the experienced eye, substandard aesthetics. The most popular alternative system is the typesetting language LaTeX which was mainly developed in the 1970s and 80s. LaTeX enables the production of professional-quality printed documents with equations that most mathematicians consider rather beautiful; it is no surprise therefore that the vast majority of us produce all of our lecture notes and other course materials (handouts, exercises, slides and even examinations) in LaTeX. Typically the implementation that is used is pdfLaTeX, which converts LaTeX 'source code' into a PDF file that can be viewed electronically or printed. LaTeX has undoubtedly revolutionised mathematical publishing, and has also influenced the development of HTML (hypertext markup language), the basis for the web.

One of the great appeals of pdfLaTeX is that it gives us complete control over visual layout. However, therein lies a weakness – not everyone consumes lecture material visually, and not all who do see in the same way. The most powerful example of this diversity is the use of screenreaders by blind and visually-impaired students. Equations appearing in PDF files produced by LaTeX are completely unintelligible to a screenreader. A workaround for this difficulty, used with success in my own institution, involves providing the LaTeX source files so that the code itself can be interpreted – 'backslashes, curly brackets and all' – by a screenreader. This is certainly workable, but wouldn't it be preferable if the core set of notes were suitable to be adapted by students to their varying needs? Other examples of how materials may need to be 'consumed' differently include the use of large print by students with visual impairments, or the use of sans-serif fonts and coloured backgrounds by students with dyslexia. Special materials can be printed out on request, but wouldn't it be better if students could simply enlarge text, or experiment with changing the font or background to see what works best for them? The issue of how we consume reading material is most acutely relevant to those with visual impairment, however across all of the academic community we now view content across a range of devices, from monitors to laptops to tablets and phones, all of which require text to be able to resize and reflow according to the dimensions of the screen. We wouldn't expect online newspapers to come in the form of a downloadable PDF; it seems reasonable that students should have similar expectations of course materials.

HTML-based materials by contrast provide an excellent and up-to-date way to deliver device-friendly, resizable and reformattable content, along with the other advantages of web-based materials, particularly hyperlinking. Virtual Learning Environments such as *Canvas* (used at the University of Birmingham) and equivalent systems can provide a user-friendly platform for colleagues unfamiliar with HTML code to prepare webpages – but what about mathematics? The simplest solution I am aware of involves integrating the old and the new: LaTeX expressions – which can be included by enclosing within the symbols `\(` and `\)` – within an HTML web page. LaTeX expressions can then be interpreted into mathematics through the online service MathJax[*], a JavaScript engine developed by the American Mathematical Society and Society for Industrial and Applied Mathematics. MathJax can be included in a webpage by adding a code snippet to the start of the HTML file; in Canvas this is done automatically so one does not even need to write a line of HTML. The result is mathematical expressions that look beautiful but more importantly are then available as MathML for the use of screenreaders. MathJax *accessibility extensions* further enable improved visual and aural rendering by detecting mathematical structure, allowing features such as collapsing and exploring of subexpressions. Having prepared materials in this way one no longer needs to anticipate all of the possible needs of current or future students – the power is with the student to manipulate the content appropriate to their needs. An example Canvas-LaTeX page is available to view[†]. For the lecturer, converting a set of LaTeX notes to 'Canvas-LaTeX' or 'HTML-LaTeX' is essentially a task of cutting-and-pasting and then modifying commands such as section headings and figures – something that can be accomplished in a few hours for a 40 lecture course.

I initially posted the comments above to the Big Conversation blog at the University of Birmingham and Twitter, resulting in several replies. One commenter with dyspraxia said that they found that printed notes were much easier to organise and interact with, and asked whether HTML notes would replace pdfLaTeX. HTML notes can also be printed, and indeed I typically print and distribute my online notes, with a few gaps added intentionally, to help with student engagement during lectures. However, it is certainly clear that many would like the option of outputting a pdfLaTeX document too. Along these lines, another commenter highlighted the Python-based documentation package Sphinx, which can output both LaTeX and HTML from a format called restructuredText. It was also pointed out that LaTeX itself should be regarded as an *input system* rather than an output format as such. The package tex4ht can convert .dvi files produced by LaTeX into HTML, although the mathematics output is poor; a much better solution developed by Andrew Stacey[‡] introduces a new {internet} document class for LaTeX from which a range of formats can be generated. For those who find LaTeX both powerful and comfortable to use – probably most of the mathematical community – this approach may be very appealing. Further options – highlighted by an anonymous reviewer of the present article – are Pandoc[§], which can convert between many formats, including from LaTeX to HTML with MathJax and MathML, the Python package plasTex[**] and its associated TeX-to-Braille converter BrlTex[††] (for more on BrlTex, see Whapples, 2007; Rowlett et al., 2010). My current preference is using MathJax `\(...\)` expressions within HTML due to the fact that no compilation or special software is required. There will no doubt be a range of approaches and mathematicians will find the one which best fits their style, workflow, and comfort level with IT.

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[*] https://www.mathjax.org/

[†] https://canvas.bham.ac.uk/courses/30102/pages/introduction

[‡] https://github.com/loopspace/latex-to-internet

[§] https://pandoc.org/

[**] http://tiarno.github.io/plastex/

[††] http://brltex.sourceforge.net/

In summary there is a great opportunity to bring our teaching materials into the 21st Century, retaining many of the advantages of 'traditional' pdfLaTeX along with much greater accessibility. This change requires a shift in how we view course materials – precise control over visual appearance to suit the lecturer's aesthetic sensibilities is of low priority to blind, visually-impaired or dyslexic students. Our primary job as educators is to provide *content* (text and equations) the format of which students are then empowered to adapt best to suit their needs.

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Review a legacy resource: a new feature in MSOR Connections to aid discovery of hidden gems

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1. Call for contributions

Over recent decades, our community has operated numerous projects and produced countless resources. Certainly some of these were of their time and are now of limited value, but many still offer huge potential for those engaged with teaching, learning, assessment and support in higher education mathematics, statistics and OR. However, projects that are no longer running may not be in a position to advertise their resources, so how will people discover them?

The issue of how these resources might be discovered has come to mind again recently as I engage with a **sigma** Network project around storage and use of legacy resources (operating under the working title ‘Mathcentre 2.0’). I write to propose a new feature in *MSOR Connections* that would offer short reviews of legacy resources. These could be resources for use with students or teaching practice guides. The aim is to shine a light on little-used, perhaps-forgotten but good-quality resources produced under now-defunct projects.

Do you have a favourite resource that fits the label ‘legacy resource’? Please consider writing a review of it, to help others discover and use this. We will gladly accept contributions on these lines for MSOR Connections through the usual route (see the journal website[*] for details).

The remainder of this article offers a little history of the sort of projects and initiatives in the UK that I am thinking about. The intention is for this to be indicative, and *not* to be a restrictive list of projects and initiatives that are in the scope of what I am suggesting you might review.

2. A little history

The Maths, Stats and OR (MSOR) Network was formed in 2000, a kind of merger of the Computers in Teaching Initiative (CTI) Centres for Mathematics (at Birmingham) and Statistics (at Glasgow) and the Mathwise project, along with some higher education activity from the Royal Statistical Society Centre for Statistical Education (Blake, 2012). Initially part of the Learning and Teaching Support Network (LTSN), the MSOR Network later became part of the Higher Education Academy (HEA) before the HEA closed its 24 subject centres in 2012. As I write this, there is an archive of the MSOR Network website at the time of its closure available[†]. This includes:

- an archive of 38 funded mini-projects which delivered their outputs between 2001 and 2011;
- articles from *MSOR Connections* volumes 1-12, published between 2001-12, as well as so-called ‘volume 0’, a newsletter called *Maths, Stats & OR* published in 2000;
- proceedings from CETL-MSOR Conferences 2006-11;

[*] https://journals.gre.ac.uk/index.php/msor/

[†] http://www.icse.xyz/mathstore/

- 59 articles in the maths-caa-series, which focused on developments in mathematics computer-aided assessment, published between 2001-6;

- leaflets, booklets and books published by various initiatives.

Some content from the MSOR Network is also available via the Higher Education Academy website. This contains another archive of *MSOR Connections*, this one including volume 13. Though I don't believe there is an index, so you can only really find resources there if you know what you are looking for. It may be worth noting that when I did an audit comparing my print copies of *MSOR Connections* to these two archives in 2015, I found that neither is a complete archive, they don't match each other and neither is a subset of the other, which I cannot explain.

In response to "the mathematics problem" (that incoming undergraduates might be "under-prepared for the mathematical demands of university courses") in the 1990s, universities began setting up mathematics support provision (Croft and Lawson, 2017; p. 196). In 2002, the universities of Loughborough, Coventry and Leeds gained funding to establish **math**centre[*] (Croft and Lawson), joined by **stats**tutor[†] in 2010 (Owen et al., 2010). In 2005, Loughborough and Coventry were funded to establish '**sigma** – Centre for Excellence in University-wide Mathematics and Statistics support', later developed under the National HE STEM Programme and direct HEFCE funding into the **sigma** Network for Excellent in Mathematics and Statistics Support, now a volunteer-led professional association (Croft and Lawson). There are equivalent organisations to **sigma** in the Irish Mathematics Learning Support Network (IMLSN), formed in 2009, and the Scottish Mathematics Support Network (SMSN), formed in 2008 (Ahmed, 2018).

The other mathematics and statistics Centre for Excellence in Teaching and Learning (CETL) projects alongside **sigma** were the Postgraduate Statistics Centre at Lancaster and the Centre for Open Learning of Mathematics, Science, Computing and Technology (COLMSCT) at the Open University (Lawson, 2012).

The Undergraduate Mathematics Teaching Conference (formerly University Teaching Conference) started in 1975 (Emery, 2000) and ran in 2007 (Challis, 2007), I believe for the last time. This included a collection of working groups each year which produced numerous papers on different themes relevant to undergraduate teaching published in its proceedings.

As well as the **sigma** Network, the National HE STEM Programme (2010-12), following on from More Maths Grads (2007-9), funded various projects, including through the Institute of Mathematics and its Applications and the MSOR Network. I coordinated the work under the MSOR Network, which we called the Mathematical Sciences HE Curriculum Innovation Project (Rowlett, 2012). An archive of HE STEM activity and outputs has been established at the University of Birmingham[‡].

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[*] http://www.mathcentre.ac.uk

[†] http://www.statstutor.ac.uk

[‡] https://www.birmingham.ac.uk/university/colleges/eps/STEM/National-HE-STEM-Programme/national-he-stem-programme.aspx

There are surely other initiatives and projects I have overlooked here but which may be considered valuable contributions by our community, but hopefully I have given a glimpse of the range of activity that might be investigated by those looking for hidden gems.

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RESOURCE REVIEW

Review a legacy resource: Industrial Problem Solving for Higher Education

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In 2011-12, the Mathematical Sciences HE Curriculum Innovation Project (which I coordinated), part of the National HE STEM Programme, funded a project 'Industrial Problem Solving for Higher Education' (IPSHE), described in an article by Benjamin, et al. (2012). This built on the approach taken by the Department of Engineering Mathematics at University of Bristol – a "long-standing teaching methodology that emphasises experience with real research problems in every year of undergraduate education to develop transferrable skills in addition to technical ones" (p. 23). The key output from this project was a wiki hosted by Bristol containing information on the teaching methodology and a collection of problems suitable for different undergraduate levels. The aim was to "lower the bar for other institutions to adopt a similar teaching methodology" (p. 23). This wiki is still available via https://wikis.bris.ac.uk/display/ipshe/Home.

Projects are grouped into 'introductory', 'intermediate' and 'advanced', "intended to correspond loosely to the first, second and third years of UK mathematics undergraduate study" (p. 24). There are 15 introductory, 23 intermediate and 20 advanced project briefs. Project briefs contain background information and materials sufficient to explain the project, along with indication of required prerequisites, hints and suggestions for how the project could be extended.

Some sample project briefs, chosen somewhat arbitrarily but with an eye on demonstrating the range of topics available:

- Car parking – "How can you arrange to park for 100 cars in a farmer's field so that as little grassland is driven over as possible?" (introductory);

- Home Decorating – "You are called in by a decorating shop who want to publish a table to show their customers how many rolls of wallpaper they will need to paper their room" (introductory);

- Automatic disease diagnosis – "Students are asked to perform the role of a consultant assisting the department of health, using data to automatically diagnose diabetes on the basis of a number of measured attributes" (intermediate);

- Bolton Satellite Systems – "Students are asked to analyse a control system to stabilise the orbit of a satellite" (intermediate);

- Customer Solutions – "Students are asked to perform the role of a consultant investigating the possibility of an automatic customer direction system for supermarket self-service checkouts" (intermediate);

- London Tube – "Can you identify potential inefficiencies and vulnerabilities in the London Underground network, from the data provided?" (intermediate);

- Search strategies – "In this problem students are asked to explore the efficiency of stochastic search strategies for an autonomous explorer vehicle" (intermediate);

- Automatic Music Classification – “Students are asked to work with raw audio signals and to develop techniques for distinguishing types/genres of music using machine learning” (advanced);

- Disease Spread on a Network – “Students are asked to consider the relationship between social networks and the spread of contagious diseases” (advanced);

- Perception-based Decision Making – “Students are asked to consider the way in which humans make judgements based on previous experience” (advanced).

I believe this archive of material can provide useful inspiration to anyone looking for topics for student activities in a project-based mathematical modelling module.

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