# MSOR Connections

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

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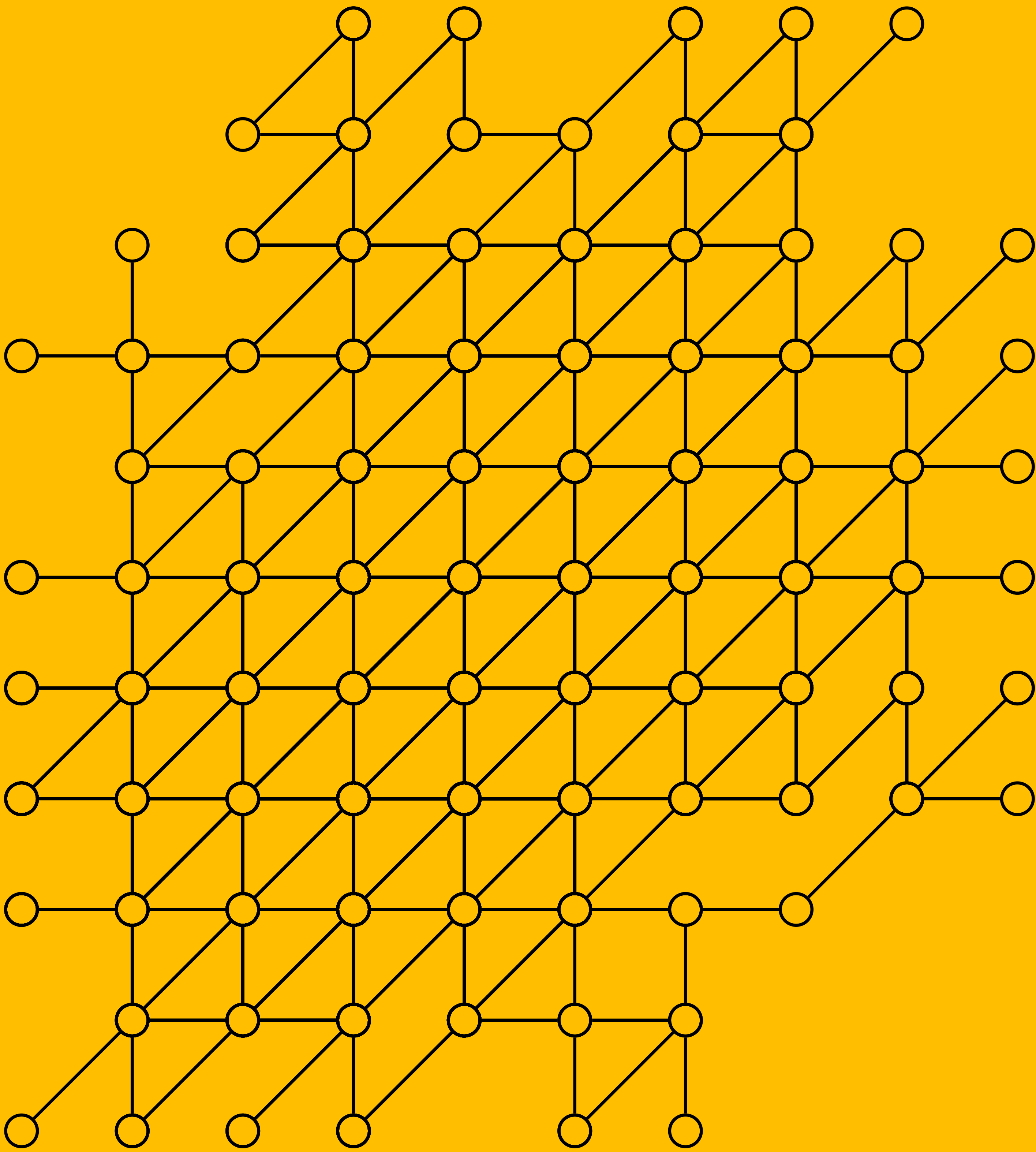

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# EDITORIAL

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This issue contains papers on a wide variety of topics. We open with a historical account of the development of the mathematics and statistics support community in the United Kingdom by Duncan Lawson, who himself has been (and continues to be) a large part of that history. We have papers by Calum Heraty et al and by Davide Penazzi and Charlotte Smith on aspects of mathematics support for students with particular needs. Two case studies by Clair Cornock, one co-authored with Alex Crombie, discuss innovations in mathematics teaching. Finaly papers by Daniel Jones et al and by Calum Heraty et al present reflections on online teaching.

We are delighted to report that the CETL/MSOR Conference for 2021 will go ahead in September at Coventry University, as a hybrid event accommodating in-person and virtual attendance. Please see the advert elsewhere in this issue for more information about this event.

*MSOR Connections* can only function if the community it serves continues to provide content, so we 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.

The current pandemic has resulted in drastic changes in the ways in which mathematics is taught and mathematics and statistics support is delivered all round the world. What we have learned about the methods and technologies introduced through necessity will certainly influence mathematics practitioners in higher education post Covid-19. As this issue shows, *MSOR Connections* is keen to publish articles reflecting on the issues faced during Covid-19 and the implications for the future, so we would particularly encourage readers to consider sharing their experiences by writing for *MSOR Connections* on such topics.

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*.

Finally, it is with regret that we report that Robert Wilson has decided that he is unable to continue as an editor of *MSOR Connections*. Rob has made huge contributions to the journal, most recently in editing the previous issue (Volume 18 Number 3), and the editorial team has benefited enormously from his advice, support and friendly encouragement. We look forward to continuing to work with Rob through his work for the **sigma** Network and the CETL-MSOR Conference, and in his other roles in mathematics education.


We are delighted to announce that the CETL-MSOR Conference in 2021 will be held at Coventry University on **Thursday 2nd and Friday 3rd September**. The theme of the conference is "*Celebrating our Past, Embracing our Future*" and will be the first CETL-MSOR conference to be a hybrid event, with in-person and virtual attendance and presentation possibilities (subject to Covid restrictions).

**Confirmed Keynote Speakers are:**

**Professor Tony Croft**, Emeritus Professor of Mathematics Education, Loughborough University

**Neil Sheldon**, Chair of the Teaching Statistics Trust and former Vice President of the Royal Statistical Society

**Professor Rolf Biehler**, Professor of Mathematics Education, Paderborn University, Germany

and giving our traditional closing plenary session, **Dr Joe Kyle**, Formerly of the Department of Mathematics, University of Birmingham.

More information regarding submissions, and details regarding registration for virtual and in person attendance will be provide in due course.

In the meantime, please visit our webpage for the conference for the latest information: http://sigma.coventry.ac.uk/cetlmsor2021

CASE STUDY / OPINION

# A history of the development of the mathematics and statistics support community in the United Kingdom. Part 1: From alpha to sigma

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## Abstract

In terms of the history of mathematics higher education, mathematics and statistics support (MSS) is a very recent development, existing as a formal feature for less than 50 years. However, in this short time, MSS has displayed its own characteristics. A particularly notable feature of MSS in the United Kingdom (and in other countries) has been the way in which practitioners have collaborated with each other, almost from the outset. This collaboration has led to the creation of a community (the **sigma** network) with a written constitution and formal membership. This two-part article traces the history of the development of the MSS community in the UK from its earliest incarnations to the present day. The first part of the article reviews the period from the early 1990s to 2005 during which time the key events were the rise and demise of the Mathematics Support Association and the creation of **sigma**, Centre of Excellence in University-wide Mathematics and Statistics Support.

**Keywords:** Mathematics and statistics support, community of practice, Centres of Excellence in Teaching and Learning.

## 1. Personal Introduction

This article springs from a keynote presentation that I gave at the *Continuing Excellence in Teaching and Learning in Mathematics, Statistics and Operational Research* (CETL-MSOR) conference in Dublin in September 2019. After the presentation, several delegates were kind enough to suggest that the material I had presented, particularly the "historical" information merited being written up and published. I set out to write an "objective history" of the mathematics and statistics support (MSS) community in the UK. However, I found that, as someone whose career coincides almost exactly with the time period under consideration and who has been actively involved in the MSS community for most of that time, it was very difficult to separate facts from personal experience from personal opinion. The result is perhaps a somewhat unusual article for this journal: a personal perspective on the subject rather than an objective record. However, I believe that this still has value and interest for the readers of *MSOR Connections* and, if you are reading this, then presumably the Editors shared this opinion.

## 2. Alpha – origins (pre-1993)

It is hard to date precisely when mathematics support (MS) began in the UK (Note that here I refer to mathematics support and not mathematics and statistics support; in the beginning statistics support was not considered separately). This imprecision stems from determining which practices count as MS and which do not. For example, one of the earliest formally organised MS provisions was the BP Mathematics Support Centre at Coventry Polytechnic, which began in 1991. However, prior to this at the same institution, there had been a service called "Maths workshop" where a few members of academic staff made themselves available during a few lunchtimes a week for students to come and ask them questions about mathematics. This activity was not part of the formal educational provision of the department, rather it was something the colleagues involved undertook "voluntarily" because they thought it would be beneficial for some students.

The BP Mathematics Support Centre at Coventry was established by Glyn James in 1991 following a successful bid to the BP [British Petroleum] Engineering Education Fund. In one way, this can be viewed as an outcome of collaboration and community, as Glyn James had met, through the SEFI (European Society for Engineering Education) Mathematics Working Group, Milton Fuller from the Mathematics Learning Centre at Central Queensland University (CQU). The two developed a long-standing co-operative working relationship with Milton Fuller spending some time as a visiting academic in the Mathematics Department in Coventry. Milton Fuller was a proponent of mathematics support (Fuller, 2002) and it seems likely that his experience influenced the proposal that Glyn James made to BP. According to Dzator and Dzator (2020), the Mathematics Learning Centre at CQU was established in 1984 and was the first such centre in Australia.

The motivation for establishing MS at Coventry Polytechnic and other institutions in the UK was the high failure rates on engineering degree courses. These high rates were often attributed to the mathematical component of the course. There was a feeling amongst academics that incoming students were not sufficiently well-prepared mathematically for study in higher education (see, for example, Hymas (1994) and Barnard & Saunders (1994)). In 1995, two influential reports *Tackling the Mathematics Problem* (LMS, IMA & RSS, 1995) and *The changing mathematical background of engineers* (Sutherland and Pozzi, 1995) were published by influential professional bodies and learned societies. These reports catalogued some of the difficulties being encountered by lecturers "at the chalk face" and introduced the phrase *The Mathematics Problem* as a recognised shorthand for the underpreparedness of many new undergraduates for the mathematical demands of their higher education study. A more complete discussion of the development of the Mathematics Problem can be found in Lawson, Grove and Croft (2019).

Although it took until 1995 for professional bodies and learned societies to issue their reports, academic colleagues had been introducing measures to address the Mathematics Problem for some time before then and MS, as exemplified by the BP Mathematics Support Centre, was one such measure.

## 3. Beta – the Mathematics Support Association (1993 – 1999)

It is perhaps a little unfair to categorise the Mathematics Support Association (MSA) as a beta-test version of later mathematics support networks since it functioned for six years as a formal community for those involved in MS. However, whilst it was valuable to its members, there is evidence that it did not achieve the widespread level of engagement across the HE sector that is necessary to sustain such a community of practice.

On 23 May 1993 the *1st National Conference in Mathematics Support in Further and Higher Education* took place at the University of Luton. This conference was organised by two colleagues from the University of Luton, Ian Beveridge and Rakesh Bhanot. One outcome of the conference was the establishment of the MSA which aspired to produce annually two issues of the Mathematics Support Newsletter. There was an annual subscription of £15 for institutions to be members of the Association and, in return, institutions received a hard copy of each issue of the newsletter and discount for all delegates attending future conferences.

A report by Lane (1994) in the first issue of the Newsletter describes the conference in some detail, including giving a delegate list. Lane describes his overall impression of the conference as *"dedicated enthusiasts, struggling to cope with a desperate situation which is getting worse each year. Usually with inadequate resources."* (Lane, 1994, p.14). There were 58 named attendees at the first conference, 27 were from higher education institutions, 29 from further education colleges and two others. The 27 from higher education included 14 from new universities (i.e. former polytechnics which had recently become universities in 1992 with the abolition of the so-called binary divide), eight from colleges of higher education (i.e. institutions not having full university title), two from the Open University and three from pre-92 universities. This lack of involvement in the Association from pre-92 universities, and particularly the Russell Group[1], seemed to continue throughout the lifetime of the association.

There was an article about mathematics support at Imperial College (Kent, Ramsden and Wood, 1996) in the double 4th and 5th issue, but otherwise involvement from the Russell Group was very limited. This limited involvement of Russell Group institutions and indeed pre-92 universities more generally may have been due to the inclusion of further education providers. These universities may not have wanted the needs of their students to have been seen to be similar to those of students in further education. Even with the universities that were part of the MSA, there was a tension between further education and higher education in terms of the nature of the provision. Bowers highlighted the different interpretations of what constituted a mathematics workshop, stating "some colleges use the 'total' workshop approach where the whole student experience in certain maths courses consists of more or less flexible attendance in a large open learning resources centre. At the other extreme, some institutions consider a workshop to be a handful of nominated hours per week when a lecturer is free to help students with problems" (Bowers, 1994, p.2). The latter part of this description is reminiscent of the aforementioned Maths Workshop at Coventry Polytechnic. Although not explicitly mentioned by Bowers, his extremes almost certainly represented, on the one hand, provision in further education and, on the other, provision in higher education. The MSA perhaps contained two sub-communities that grew apart rather than together: one where mathematics support was seen as the principal form of delivery (a replacement for traditional approaches to teaching, possibly because it was cheaper) and one where it was regarded as additional to standard teaching (because standard teaching was not delivering high enough pass rates).

Although each issue of the Newsletter contained a good range of articles with contributors from many different institutions, the initial intention of two issues per year was not often met. A total of eight editions (one being a double issue) were published over 6 years[2]. A second conference took place in Luton, once again organised by Ian Beveridge, in September 1995, although discussion of this in the Newsletter was limited to a quarter page anonymous report in the 1996 issue. A third conference took place in Loughborough in 1998, organised by Tony Croft, but no report of this conference was published in the newsletter. Furthermore, there is very little evidence in the Newsletters of collaboration between the conferences. In the 3rd issue, there is a proposal for a project to develop a Maths Support Handbook (Samuels, 1995), there is further discussion in the 4th/5th double issue and then notification in the 6th issue that the funding application for this project had been rejected. This appears to be the only attempt at a multi-partner collaboration in MS during this period.

Ian Beveridge was undoubtedly the central individual in the MSA. In addition to organising the first conference, he was Editor of all issues of the Newsletter, authored several articles in the Newsletter (including the first survey of the extent of mathematics support provision in further and higher education, (Beveridge and Bhanot, 1994)), acted as membership secretary and organised the second conference again at Luton, in 1995. Other individuals are named as Editorial Assistants of the Newsletter (including David Bowers who was also a regular contributor of articles), but most of

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[1] The Russell Group is an association of large research intensive universities which describe themselves as leading UK universities, see https://russellgroup.ac.uk/

[2] All issues of the Mathematics Support Newsletter can be accessed on the **sigma** Network website at http://www.sigma-network.ac.uk/maths-support-association-archive-1994-1999/

these took this role for only one issue. Only Tony Croft, who was Editorial Assistant for the final four issues, had any longevity in the role. Indeed the reliance of the Newsletter on one individual (and his family) can be seen most starkly in the credits for the double 4th and 5th issue which lists the following as responsible for its production: Editor: Ian Beveridge; Editorial Assistants: Bill Beveridge, Patricia Murdie; Newsletter designer: Martin Beveridge.

The MSA disappeared abruptly following the publication of the 9th issue of the Newsletter in Autumn 1999. The final issue gives no hint of the impending demise. Indeed, it proudly announces a new initiative: the development of a website for the MSA at www.luton.ac.uk/mathssupport. This newsletter does not look like it is from an association in decline. However, no further record of the Mathematics Support Association can be found and the reasons for its disappearance are a mystery. It is possible that, for some unknown reason, Ian Beveridge retired suddenly from higher education and there was no structure in place to find someone to take his place as the driving force of the MSA; however this is only speculation. Nonetheless, this unexplained closure of the MSA highlights the dangers of a community being over-reliant on a single individual.

## 4. Epsilon – the void (1999-2005)

In two-phase (solid-gas) flow, the letter epsilon is sometimes used to represent the void fraction (Grace, 2016); with the disappearance of the MSA, an organised MS community ceased to exist creating a void fraction of one. However, during this void period, there was considerable activity in MS and several activities and projects of this period paved the way for what would follow in terms of large-scale cross-sector and indeed, international, collaboration and community building in MS.

In 2000, the Engineering Council published the influential report *Measuring the Maths Problem* (Hawkes and Savage, 2000). The first two recommendations of this report were:

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

This validated the practice in many institutions of initial diagnostic testing, with follow-up provision of MS and was used in negotiations in several institutions to secure funding for MS.

At this time, improving learning and teaching in higher education was becoming an important priority for the Higher Education Funding Council for England (HEFCE) and the funding councils of the other nations of the UK. In 2000, the funding councils introduced the Learning and Teaching Support Network (LTSN). The LTSN's first strategic aim was

"To be the primary information and advice resource for all academic and related staff in HE on generic and subject specific learning and teaching practices." [1]

The LTSN consisted of 24 subject centres offering subject-specific expertise relating to learning and teaching and a generic centre providing information that crossed subject boundaries. The subject-focus of the subject centres, where typically most of the staff were current academic staff seconded on a fractional basis, gave them credibility with many academic colleagues across the sector. In the

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[1] https://web.archive.org/web/20040817074717/http://www.ltsn.ac.uk/index.asp?id=8

mathematical sciences, the subject centre was called the LTSN Maths, Stats and OR (MSOR) Network. This Network initiated *MSOR Connections*.

Although the MSOR Network had a brief that was very much wider than that of the now defunct MSA (i.e. supporting all aspects of teaching in mathematics, statistics and operational research, not just MS), it had something that the MSA never had: money. And MS practitioners had the opportunity to access this funding. One of the programmes that the MSOR Network operated was the mini-project scheme; in this scheme, an open call was issued for projects related to learning and teaching, with up to £5,000 per project available.

In 2001, Duncan Lawson (Coventry) and Tony Croft (Loughborough) secured funding from the MSOR Network for a mini-project entitled *Evaluating and enhancing the effectiveness of mathematics support centres.* The project set out to survey the extent of mathematics support across the sector, the first such survey since Beveridge and Bhanot (1994) and the first ever focused solely on higher education. Ninety-five institutions replied to the survey with 46 reporting that they had some form of mathematics support provision (Lawson, Halpin and Croft, 2001). The survey was followed up by visits to a selection of institutions where interviews with staff and students were carried out. Students were asked to identify the good and bad points of the mathematics support provision. One-to-one tutor support came top of the lists of both good and bad points. Eighty-eight percent of students identified it as a good point; with 71% identifying that there was not enough of it as a bad point (Lawson, Halpin and Croft, 2002). The final stage of this project was the publication of a practical handbook *Good practice in the provision of mathematics support centres* (Lawson, Croft and Halpin, 2003).

The LTSN was not the only source of funding available at this time. The Fund for the Development of Teaching and Learning (FDTL) was jointly funded by HEFCE and the Department for Employment and Learning (Northern Ireland) and had much larger budgets available. FDTL operated in phases following on from Quality Assurance Agency Subject Reviews. Mathematics was included in the subjects able to access funding in Phase 4. A consortium, led by Mike Savage (Leeds) including the Educational Broadcasting Services Trust and Tony Croft and Duncan Lawson, secured £500,000 funding from FDTL4 for a project *National Mathematics Support for the School/University Interface*. Subsequently a further £500,000 was given to this project by the Gatsby Foundation to extend the range of resources produced. This project developed the **math**tutor resources (www.mathtutor.ac.uk), originally a set of 7 DVD-ROMs covering key mathematics topics at the school/university interface. The resources were built around high quality videos providing teaching, supported by text-based documents and interactive exercises. As technology advanced during the lifetime of the project, the use of DVDs as a delivery vehicle was replaced by streaming over the internet. The **math**tutor resources were (and remain) freely available for use in MS in universities throughout the UK.

A smaller but nonetheless significant collaboration led by Tony Croft in association with Duncan Lawson and Mike Savage was the virtual UK Mathematics Learning Support Centre: **math**centre (www.mathcentre.ac.uk). A total of £80,000 was gathered for this project from a range of LTSN Subject Centres that had an interest in mathematics (in addition to the MSOR Network, funding was also provided by the Engineering, Physical Sciences and Material Sciences subject centres and the generic centre). The aim of this project was to gather into one place an extensive set of resources for MS. These resources would be freely accessible to anyone who wanted them. The project targeted both academic staff who provided MS, to save them having to develop their own resources, and students, particularly those in institutions that did not have a MS provision in their institution. This website remains a well-used repository of MS resources.

Although none of the above-mentioned projects had community building as one of their aims, these projects laid important foundations for the future. In particular:

1. They demonstrated the value of cross-university working (not least, in securing funding – consortia were preferred to single institution proposals, particularly for large amounts);
2. The principle of benefit to the community/sector not just the institutions of the project team was firmly established;
3. The difference that the availability of finance can make to "getting things done".

## 5. sigma – Centre for Excellence (2005)

The Centre for Excellence in Teaching and Learning (CETL) programme was HEFCE's largest ever investment in Teaching and Learning, the total funding in this programme was £315 million. Individual centres could bid for up to £2 million of capital funding and annual revenue funding of £0.5 million for five years (a total of £4.5 million). Bids could be from single institutions or from consortia with universities limited, according to their size, in the number of single institutions and consortia-leading bids they could submit. The programme had two primary aims: to reward excellent teaching practice, and to further invest in that practice to deliver substantial benefits to students, teachers and institutions.

The bidding process required applicants to establish the excellence of their existing provision and then to outline a plan of activity that would produce benefits for students, teachers and institutions. However, there was very little emphasis in the guidance on these benefits being beyond the institutions hosting the CETLs. In final evaluations of the CETLs, the lack of benefit beyond the host institutions is one of the major criticisms (SQW, 2011, Ramsden, 2012).

Loughborough and Coventry Universities submitted a consortia-bid for a Centre for Excellence in University-wide mathematics and statistics support. A number of points from this proposal are worth explicitly mentioning:

1. The proposal identified the different needs of statistics support as compared to mathematics support;
2. Despite the bidding guidance not stressing the need to explore benefit to the sector, this proposal had considerable focus on developing MSS in other institutions;
3. An early activity in the programme was the establishment of a mathematics support centre at Leeds University (where there was no centre) and through this to develop a blueprint for use in other institutions wishing to set up their own MSS provision;
4. A commitment to provide funding, to be allocated by competitive bidding, to establish MSS in two further institutions with no such provision;
5. Opportunities for MSS practitioners to have funded secondments to Loughborough or Coventry to work on a MSS project.

This proposal was successful and the collaborative CETL came into being in September 2005. It was soon apparent that most of the other CETLs had short, snappy names, usually clever acronyms, and that the title *Centre for Excellence in University-wide mathematics and statistics support* whilst descriptive of the Centre was something of a mouthful. At an early team meeting involving colleagues from both institutions, several hours of brainstorming focusing on meaningful acronyms had drawn a blank when the suggestion of **sigma** emerged. This was not an acronym, but a symbol that has meaning in both mathematics (upper case, summation) and statistics (lower case, standard deviation). In view of the difference in case between the usage in mathematics and statistics it was decided not to use the Greek letter but the word **sigma** itself as the name of the CETL, although Greek letters are used in its logo.

## 6. Conclusion

This paper has presented a personal recollection of events over the period from the early 1990s to 2005 in relation to the development of a MSS community. It covers periods where there was an organised, membership-based community (the MSA) and other times when there was no such organised community and collaboration was more ad hoc. A second paper will subsequently be prepared to continue the narrative from 2005, exploring the achievements of **sigma** as a CETL until 2010 and beyond with participation in the National HE STEM Programme and ultimately the development of the **sigma** network as a self-sustaining community of practice.

## 7. References


Barnard, T. and Saunders, P., 1994. Superior sums that don't add up to much. *The Guardian.* 28 December 1994.

Beveridge, I. and Bhanot, R., 1994. An examination of maths support in further and higher education. *Mathematics Support Newsletter*, 1, p.13. Available at http://www.sigma-network.ac.uk/wp-content/uploads/2018/11/MSA-Newsletter-1-Spring-1994.pdf [Accessed 4 June 2020].

Bowers, D., 1994. Maths workshops do exist. *Mathematics Support Newsletter*, 1, pp.2-3. Available at http://www.sigma-network.ac.uk/wp-content/uploads/2018/11/MSA-Newsletter-1-Spring-1994.pdf [Accessed 4 June 2020].

Dzator, M. and Dzator, J., 2020. The impact of Mathematics and Statistics Support at the Academic Learning Centre, Central Queensland University. *Teaching Mathematics and Its Applications*, 39(1), pp.13-28.

Fuller, M., 2002. The role of Mathematics Learning Centres in engineering education. *European Journal of Engineering Education*, 27(3), pp.241-247.

Grace, J., 2016. Fluidised bed catalytic reactors. In: Z. Onsan and A. Avci, eds. *Multiphase Catalytic Reactors*. New Jersey: Wiley. pp.80-96.

Hawkes, T. and Savage, M., 2000. *Measuring the mathematics problem*. London: The Engineering Council.

Hymas, C., 1994. Engineers unable to bridge the maths gap. *The Sunday Times*. 20 November 1994.

Kent, P., Ramsden, P. and Wood, J., 1996. Maths support at Imperial College. *Mathematics Support Newsletter*, 4&5, pp.10-11. Available at http://www.sigma-network.ac.uk/wp-content/uploads/2018/11/MSA-Newsletter-45-Summer-1996.pdf [Accessed 4 June 2020].

Lane, J., 1994. Conference Proceedings. *Mathematics Support Newsletter,* 1, pp.14-16. Available at http://www.sigma-network.ac.uk/wp-content/uploads/2018/11/MSA-Newsletter-1-Spring-1994.pdf [Accessed 4 June 2020].

Lawson, D., Croft, T. and Halpin, M., 2003. *Good practice in the provision of mathematics support centres*. 2nd edition. Birmingham: LTSN MSOR Network.

Lawson, D., Grove, M. and Croft, T., 2019. The evolution of mathematics support: A literature review. *International Journal of Mathematical Education in Science and Technology*. DOI: 10.1080/0020739X.2019.1662120.

Lawson, D., Halpin, M. and Croft, T. 2001. After the diagnostic test – what next? Evaluating the effectiveness of mathematics support centres. Part 1. *MSOR Connections*, 1(3), pp.19-23.

Lawson, D., Halpin, M. and Croft, T. 2002. After the diagnostic test – what next? Evaluating the effectiveness of mathematics support centres. Part 2. *MSOR Connections*, 2(1), pp.23-26.

LMS, IMA and RSS, 1995. *Tackling the Mathematics Problem.* A joint report of the London Mathematical Society, the Institute of Mathematics and Its Applications and the Royal Statistical Society. London: LMS.

Ramsden, P., 2012. A poor policy, poorly managed leaves little to show for £315m. *Times Higher Education*. 15 March 2012.

Samuels, P., 1995. Maths Support Handbook, *Mathematics Support Newsletter,* 3, p.22. Available at http://www.sigma-network.ac.uk/wp-content/uploads/2018/11/MSA-Newsletter-3-Summer-1995.pdf [Accessed 4 June 2020].

SQW, 2011. *Summative evaluation of the CETL programme*. Report for HEFCE. Available at: https://dera.ioe.ac.uk/13215/1/rd11_11.pdf [Accessed 4 June 2020].

Sutherland, R. and Pozzi, S., 1995. *The changing mathematical backgrounds of undergraduate engineers*. London: The Engineering Council.

## CASE STUDY

# A trial of resources to support students with Dyslexia

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## Abstract

In this paper we report on a pilot of resources to support students with dyslexia conducted at a university in Ireland. We give brief background to the development of these resources and describe the steps taken to pilot them in a mathematics support centre. We outline the feedback received from tutors and students, and close with observations on how the pilot outcomes may influence the future implementation of these and other similar resources.

**Keywords:** Accessibility, dyslexia, resources, mathematics support.

## 1. Introduction and Background

There are increasing numbers of students with disabilities in Higher Education (HE) in Ireland and the UK (AHEAD, 2018; Equality Challenge Unit, 2017) and there is a need to provide appropriate support for these students. In Ireland, the subject area of mathematics and statistics has the third highest proportion of students with a disability (AHEAD, 2018). AHEAD recommend that it is imperative for HE Institutions to create inclusive environments, providing '*cross-campus initiatives to respond to the ever-diversifying needs of the student populace*' (AHEAD, 2018, p. 64). Maynooth University has a high proportion of students who are registered with Maynooth Access Programme (MAP), and students supported include those with disabilities. Each academic department has a MAP Academic Advisor who acts as a point of contact for MAP students with regards to their specific learning needs in the subjects they are taking. The second author has held this role for the Department of Mathematics and Statistics (the Department) for many years. While he often found that MAP students benefitted from standard advice, e.g. how to study mathematics, how to use existing resources etc., he felt that he did not have the training or skills necessary to help mathematics students effectively with their specific learning needs. When sigma (Network for Excellence in Mathematics and Statistics Support) established the Accessibility Special Interest Group (SIG) in 2016, he immediately joined. Details of the SIG are available online (http://www.sigma-network.ac.uk/sigs/accessibility-sig/).

The SIG conducted a survey in Ireland and the UK on staff awareness of the accessibility barriers that students encounter in HE (Cliffe et al., 2019). The SIG also started a project to develop a series of resources specifically for those who co-ordinate and tutor in mathematics support. The initial development of these resources, in the form of advice sheets for mathematics support tutors and co-ordinators, was mainly facilitated through meetings of experts in the UK, in the summers of 2018 and 2019. The completion of most resource working drafts was paused until the end of 2020 due to the implementation of certain aspects of accessibility legislation in the UK. A SIG review established that the resources for dyslexia were suitable to be piloted and the second author offered to carry this out at his home institution, Maynooth University. It was left to the authors to conduct the pilot as they saw appropriate, subject to local factors.

The remainder of this report provides details of how we ran the pilot and the circumstances that may have influenced it. We summarise the feedback collated from tutors and students and we close with a brief outline of our plans for 2020-21.

## 2. Methodology

The resources for each accessibility issue come in pairs, one for support tutors (Appendix A) and another for mathematics support managers/co-ordinators/administrators (Appendix B). The manager sheet opens by briefly describing dyslexia. It then details equipment and software that should be available to tutors for helping students. It provides information on suitable physical and virtual learning environments and suggests that both tutor training and coordination with other institutional student services is important to maximise the supports in place for students. The tutor sheet also opens with a brief description of dyslexia and the impact it can have on students. It then lists strengths that students with dyslexia may have. The main part of the sheet lists the impacts that dyslexia can have on the study of mathematics and possible strategies that a tutor might use to address them. Both sheets also have links or references to further information on dyslexia.

In June 2019 we conducted an internal review of the documents in terms of their clarity for practical implementation, and observations are listed in Section 3.1. If a student is registered with the Disability Office, then their module lecturers can view information relevant to the student's learning needs on an internal Maynooth University system. Department tutors, who run the small group tutorials or work in the Mathematics Support Centre (MSC), do not have access to this information and are made aware only if the student requests it or tells the tutor directly themselves. However, students may not be aware that tutors do not have access to this information. The second author met with MAP Disability Office staff to make them aware of the trial and we agreed that students would need to inform support tutors that they would like to use the resources. To create student awareness of the resources, we decided to:

1. Contact MAP students regularly via email and announcements at MAP student events.
2. Ask department tutors to make short announcements in tutorials.
3. Provide an information sheet about the trial to all students who visit the MSC for the first time and put posters on the MSC noticeboards.
4. Verbally remind students in the MSC about the availability of these resources when assisting them.

As students may be reluctant to tell a tutor about their learning needs, when possibly surrounded by their peers, in a public and busy environment (the MSC), we also made students aware that they could e-mail the MSC directly to discuss how best to use the resources in a manner that was comfortable for them. Furthermore, to ensure that the use of these resources in the MSC did not stand out or draw the attention of other users, we decided to introduce packs for the MSC tutors which they would carry with them at all times. These packs contained items that featured in the resource sheets, for example coloured paper, squared paper, post-its, highlighters etc. The tutor packs also contained paper which we use when assisting students. So, when helping any student in the MSC, it would be normal for the tutor to open their pack and take out materials.

In order to assess the use of the resources and include the student voice, a feedback sheet (Appendix C) was developed. It was designed for use every time a student requested the resources, and filled in by the tutor and the student simultaneously. It sought to obtain summary information on how dyslexia impacted on the student, which strategies the tutor utilised during their interaction and how students rated these. This feedback sheet was also included in the tutor pack. In an effort to make the feedback process more efficient and minimise disruption to the student learning experience in the MSC, most of the feedback form had 'Yes/No' questions with one Likert-type response, and we added the option of a brief follow up outside the MSC via interview.

The MSC is based in a large room in the library, with seating for around 120 students and operates a drop-in service. During 2019-20, there were typically between 20 and 25 weekly hours of drop-in available before closure due to COVID-19. Drop-in is available to all Maynooth University undergraduates and hours are usually very busy, with weekly attendance of approximately 900 individual visits. In September 2019, as part of MSC training, tutors were informed about the trial, the tutor packs and how to assist students who requested these resources. Tutor participation was optional, but all agreed to partake. The second and third author made sure that resources mentioned in the manager sheet were available for tutors in the MSC. Ethical approval was received for this study and the trial commenced in October 2020 when drop-in sessions commenced.

During the trial, there were a total of six requests from five individual students to use the resources. Feedback was completed on each occasion (Section 3.2), and all five students agreed to be interviewed. The university closure disrupted the planned schedule for interviews, and ultimately we were only able to interview one student (Section 3.3). No students sought to use the resources during the online support sessions provided after the shutdown.

## 3. Feedback

### *3.1 Initial Tutor and Manager Feedback*

The observations gathered were positive, and any issues raised were minor, relating to the clarity of understanding of some points. For example, for the strength 'Taking a holistic approach' on the tutor sheet, a tutor stated that '*I don't know what this means or would look like in a maths context*'. In relation to the impact 'Reading a mix of text and non-text, finding it difficult to move from text to notation.' and the associated strategy 'Use diagrams where possible', a tutor commented, '*If reading a mixture of text and non-text is a problem I am unsure as to how diagrams help with this rather than make it worse, maybe some elaboration or further explanation is needed.*'. Finally, in relation to the impact 'Copying errors' a tutor added that

> '*I've come across students who said they were dyslexic and they had taken down notes incorrectly during lectures, (they wrote down words that had similar letters but were completely different meanings). So their own notes made no sense to them. When a student is showing you their notes, it might be good to check if their notes are correct and encourage them to cross-check their notes with another student?*'.

In relation to the manager sheet, clarity was sought on the meaning of 'rapid naming' in the initial quote. It was also observed that post-its '*…are not mentioned on the corresponding sheet for tutors. … Perhaps some guidance on what these would be used for would be good*. Coloured paper is also not mentioned on the tutor sheet. Under equipment, more information was sought on what types of colour for 'coloured paper' and in the section 'Online Learning Environment', elaboration on the meaning of 'accessible word document' was sought.

### *3.2 Student and Tutor Implementation Feedback*

We describe the six interactions in random order. Participant I was in first year. 'Copying Errors' e.g. switching digits or signs was the impact and strategy G 'Squared Paper' was used. Participant II was a postgraduate taking some undergraduate modules. 'Read the question text' and 'Reading, remembering and recalling information' were identified as impacts. Strategies C 'Use of colour for different aspects of a problem', D 'Use bullet points to break up text' and J 'Write down what you [the tutor] say as the student will be likely to not recall this' were the strategies used. Participant III was a second year and 'reading the question text' was the impact identified. The tutor used strategy B 'Highlight key points in the material' but noted that they also made use of F 'Use diagrams where possible', G and J.

Participant IV was in first year. For the impact 'Taking notes at speed', J was used, for impact 'Reading the question text, having to read several times to gain meaning', C and D were used, and for impact 'getting lost in the middle of the problem', F was used. All four participants rated the effectiveness of the strategies used as 'very good'. Participant IV used the resources on a second occasion. This time a specific impact was not listed but the tutor '*used coloured paper (yellow). Text is easier to read for the student on yellow paper*'. While this was not a strategy listed, the MSC was supplied with a range of different coloured paper as this featured on the manager sheet. The effectiveness was rated 'good'. Participant V had impacts 'getting lost in the middle of the problem' (F used), and 'reading remembering and recalling' (B and J were used). Strategy F's effectiveness was rated as 'very good' and strategies B and J were rated as 'neutral'.

All five students indicated that they were willing to be contacted for a follow up on the trial, and that they were aware of and registered with MAP.

### *3.3 The Student Interview*

Only Participant III was available for interview, which was conducted via Microsoft Teams by the first author and lasted for approximately 10 minutes. We present a brief summary.

Participant III responded positively to their experience of using the resources in the MSC. The student commented that the MSC was well-equipped to meet students' needs, '*I think for the dyslexia and that, they had the right tools for helping people*'. The specific resources that benefitted the student included the use of coloured paper to help focus on the question, '*I think the coloured paper just makes the words pop out a bit more and makes it more understandable*' and writing down the steps on how to approach the question. The student reported that they further applied the latter approach outside the MSC when attempting questions. The student endorsed the in-person implementation of the resources by the MSC and suggested it could be made available online. They added that dyslexia most impairs their reading and interpretation of questions and putting down on paper what they want to do. The student reported that they had not received any specific resource support for dyslexia in secondary school or in Maynooth University, and that they would like to see the resources provided by the MSC implemented by other academic departments within Maynooth University. The student's final comments referred to the MSC's general supports and effectiveness, '*I wasn't really that good at the maths but I found* [attending] *the support centre really boosted my grade*'. The student indicated they would be willing to continue using the resources for dyslexia upon returning to the MSC.

## 4. Conclusion and Future Work

The 2019-20 academic year was, in hindsight, perhaps not the best time to pilot a new resource. Covid-19 and other local Maynooth University decisions had a major impact on MSC opening hours and tutor numbers, and this certainly influenced student engagement and feedback (interviews). Also, as the students filled out the feedback forms with the tutors who helped them in the MSC, it is possible this influenced their responses. A larger study would be required to give further details on the resources which worked particularly well, and identify any which are less effective. Nevertheless, we are glad to have had this opportunity and hope that this preliminary report is of benefit to those in the wider mathematics support community hoping to use these and similar resources.

We have given the feedback to the SIG leads, and have recommended that when the finalised resources are placed on the sigma website, they be accompanied by a FAQ sheet which addresses many of the queries raised in Section 3.1. As such, we believe that as further resources are released, it is important that they are piloted.

We intend to continue using the dyslexia resources and will incorporate some changes. We will circulate the sheet to MSC tutors in advance of tutor training to enable queries to be discussed and addressed during training. We have not yet decided if we will continue to use the evaluation sheet, as it did interrupt the fluidity of the mathematics support that the tutor was providing to the student.

The biggest local challenge we face is trying to ensure that more students with dyslexia seek to use this resource, and this is something that we will try to progress via discussions with MAP staff.

In terms of the other accessibility resources, those for Dyscalculia and Dyspraxia are ready (August 2020) but both require the Maths Anxiety resource which is not yet finalised. The SIG aims to complete this resource, and others e.g. autism, hearing impairment, visual impairment etc. as soon as possible. Maynooth University is happy to pilot these resources as they become available and would encourage other institutions to also get involved.

## 5. Acknowledgements

The trial of these resources is part of the ICT and STEM Enhancement Project at Maynooth University funded by the HEA. Ciarán Mac an Bhaird is the lead on the Mathematics strand of this project, and James O'Malley and Rachel O'Neill's positions are fully funded by the HEA.

## 6. References

AHEAD Educational Press. 2018 *Numbers of Students with Disabilities Studying in Higher Education in Ireland 2016/17*. Available at: https://www.ahead.ie/data-statistics?id=76 [Accessed 4 August 2020].

Cliffe, E., Mac an Bhaird, C., Ní Fhloinn, E. & Trott, C., 2019. Mathematics instructors' awareness of accessibility barriers for disabled students. *Teaching Mathematics and its Applications: An International Journal of the IMA*, https://doi.org/10.1093/teamat/hrz012

Equality Challenge Unit. 2017 *Equality in higher education: students statistical report 2017*. Available at: https://www.ecu.ac.uk/publications/equality-in-higher-education-statistical-report-2017/ [Accessed 4 August 2020].

## Appendix A:

### For tutors: Dyslexia (draft summer 2019)

### Introduction

Dyslexia is lifelong. It can impact on reading, spelling, working memory and organisation. Dyslexia encompasses a spectrum of difficulties that can affect learners in different ways. Some learners will have strong mathematical skills but struggle with accessing and communicating information. Others may struggle with arithmetical procedures and foundational understanding.

The dyslexic student may have some of the following **strengths**:

- Visual thinking
- Taking a holistic approach (looking at the larger mathematical context)
- Thinking outside the box
- Problem solving
- Good at mathematics
- Preference for conceptual fluency over procedural fluency

### Possible Impacts on Mathematics (suggested strategies in brackets)

- Reading the question text, having to read several times to gain meaning (A, B, C, D)
- Reading a mix of text and non-text, finding it difficult to move from text to notation (A, B, C, D, F)
- Reading, remembering and recalling new technical words (B, E, J)
- Taking notes at speed while a tutor is talking (E, J)
- Difficulty documenting a full solution (H)
- Aligning digits (G)
- Copying errors, e.g. switching digits or signs (G, I, J)
- Remembering and recalling notation, maths facts and procedures (B, E)
- Getting lost in the middle of a problem (C, F, H)

### Strategies to Help

A. Allow time for the student to read
B. Highlight key points in the material
C. Use of colour for different aspects of a problem, e.g. different variables
D. Use bullet points to break up the text
E. Make a list or glossary of technical words, symbols or notation
F. Use diagrams where possible
G. Use squared paper
H. Encourage the student to write down all their working in an orderly way
I. Encourage the student to check for mistakes
J. Write down what you say as the student will be likely to not recall this

### Further information

Further assistance on time management, organisational and other study skills can be accessed from your Disability Department or relevant Student Support.

Further information from Trott C. (2012) Mathematics, dyslexia, and accessibility. In Good Practice on Inclusive Curricula in the Mathematical Sciences, Ed. Cliffe E and Rowlett P. January 2012. pp 26-30, http://www.mathcentre.ac.uk/resources/uploaded/inclusivecurricula.pdf

## Appendix B:

# For Managers: Dyslexia (draft summer 2019)

## Further introduction

"Dyslexia is likely to be present at birth and to be lifelong in its effects. It is characterised by difficulties with phonological processing, rapid naming, working memory, processing speed and the automatic development of skills that may not match up to an individual's other cognitive abilities. It tends to be resistant to conventional teaching methods, but its effects can be mitigated by appropriately specific intervention…" (BDA, 2007)

A dyslexic student thinks in different ways, often more visually and can have good insight. They are frequently good mathematicians. However, there will be some issues with reading, writing or memory.

## Recommended provision

### Equipment and software

It is recommended that you have the following equipment available for helping students with dyslexia:

- Highlighters
- Coloured paper
- Squared paper
- Post-its
- 2-line calculators (which display input and output)

There are a wide range of softwares which students may use for assistance. The website (http://stemenable.referata.com/wiki/Welcome_to_STEM_Enable), currently under construction, will maintain an up-to-date description of softwares and their functionalities. If a student is using a specific software, and you need further guidance, we recommend that you liaise with relevant support staff, e.g. in the Disability Office.

### Physical learning environment

A quiet space to work is helpful.

### Online learning environment

Provide documents in a format which can be transformed to meet the reader's needs and which can be read aloud and colour annotated, including the equations. Accessible Word documents and accessible web pages are best. Guidelines will be available from sigma (http://www.sigma-network.ac.uk/) soon. Provide materials in a choice of formats, e.g. the same concept explained in video, via interactive example and in text.

### Additional/alternative provision

Think about providing 1:1 support.

## Tutor training

We recommend that you include a discussion on these Manager and Tutor leaflets in tutor training at your institution. Over the coming years, accessibility training will become an important feature of maths support tutor training at local and national levels. For further information on tutor training, contact your maths support network.

## Working with other university services

It is important to know the Disability Department in your institution who can supply further details about dyslexia.

- You should have information leaflets about the Disability Department available for students in your centre and vice versa.
- The Disability Department may also be able to recommend that other students use your maths support centre.
- If you think a student in your centre has dyslexia, you should encourage and support the student to make contact with the relevant Disability Department in your institution.

## Recommended reading

Trott C. (2012) Mathematics, dyslexia, and accessibility. In Good Practice on Inclusive Curricula in the Mathematical Sciences, Ed. Cliffe E and Rowlett P. January 2012. P. 26-30 http://www.mathcentre.ac.uk/resources/uploaded/inclusivecurricula.pdf

Some basics are covered in the 2003 Good Practice in the Provision of Mathematics Support Centres (http://www.mathcentre.ac.uk/resources/guides/goodpractice2E.pdf) p22-27

Hunter-Carsch M and Herrington M (2001) Dyslexia and Effective Learning. Whurr, London

Henderson A (2012) Dyslexia, Dyscalculia and Mathematics. Routledge, Oxon.

Du Pre L, Gilroy D. and Miles T.R. (2008) Dyslexia at College. Routledge, Oxon.

## Appendix C:

**Date:** **Tutor Name:**

### MSC Dyslexia Resource Feedback Sheet

This is the first part of an international project to develop a range of resources available for students. In order to refine and improve the resources, student feedback is essential. **However, feedback is optional.** The feedback below can be provided anonymously if the student prefers. **All information provided will be strictly confidential and held securely.**

| | |
|---|---|
| **Student No.** (optional) | |

**(Student number would allow us to identify the frequency of use of the resources. Individual students will not be identified in any reporting of this information.)**

| | | | | | |
|---|---|---|---|---|---|
| **Please list the "impacts on mathematics" you identified (from the sheet) and specify which strategies were used for each impact.** | | | | | |
| **How would you rate the effectiveness of the resources?** | Very Poor | Poor | Neutral | Good | Very Good |

**(These are to be completed by the student and tutor together)**

| | | |
|---|---|---|
| **Are you willing to be contacted in future for a brief follow up on this trial?** | Yes | No |

**The MAP office (Maynooth University access programme) offers a wide range of supports which are freely available to students with learning difficulties.**

| | | |
|---|---|---|
| **Is the student aware of MAP?** | Yes | No |
| **Is the student registered with MAP?** | Yes | No |
| **If not, is the student interested in meeting with MAP?** | Yes | No |

**MAP Academic Advisor for the Department of Mathematics and Statistics, Dr. Ciarán Mac an Bhaird, normally emails MAP on the student's behalf to arrange an introduction (the student will be cc'd in the email).**

RESEARCH ARTICLE

# Conquering the 'Fear Fortress' – Returning to a mathematics exam as a Community Practitioner Nurse Prescriber

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## Abstract

Building confidence is essential for qualified nurses undertaking numeracy assessments. This qualitative research study explores self-reported levels of confidence in nurses at various stages of the life-course, including when undertaking a numeracy test as part of the Community Practitioner Nurse Prescribing (CPNP) qualification. An hour-long, semi-structured focus group was conducted by the authors, and the resulting data was thematically analysed. The authors explored the experience of CPNP students returning to a learning and exam environment, and how this experience impacted on their confidence. Overall, a high level of confidence in the use of numeracy in clinical practice, but strong test anxiety, was identified in all participants. Participants reported an increase in confidence levels following the successful achievement of the numeracy test, with some going on to display advanced numeracy skills in clinical practice. Teaching staff have a responsibility to support returning learners to build confidence throughout this process and the authors conclude with some suggestions of how to support teaching and learning in this setting.

**Keywords:** Non-Medical Prescribing, Mathematics Anxiety, Test Anxiety, Confidence, Community Nurses.

## 1. Introduction

Community Practitioner Nurse Prescribing (CPNP) is a qualification undertaken by qualified nurses working in community settings. Successful completion of the course allows the qualification holder to prescribe items from a limited formulary for patients in the community (Nursing and Midwifery Council, 2018). Prescribing practice for non-medical health professionals has been proven to be safe, efficient and cost-effective, relieving pressure from GP services and providing specialist knowledge to patient consultations (i5Health, 2015). Assessment of the necessary competencies for successful award of the CPNP qualification is robust and is governed by the professional body, the Nursing and Midwifery Council (NMC). Safe prescribing relies on effective drug calculations as well as skills such as converting units, measurement, and dose, age and weight calculations. Where the NMC allows autonomy in some areas of assessment, it is understandably steadfast in its insistence that all students undertaking the qualification pass a numeracy assessment with 100% (Nursing and Midwifery Council, 2018).

The numeracy assessment at the authors' Higher Education Institution (HEI) consists of five questions. This perhaps does not sound challenging, and indeed students embarking on the course have significant experience of using numeracy in their workplaces. However, previous studies by the authors have identified high levels of anxiety surrounding the CPNP numeracy test (Smith and Penazzi, 2020). Further exploration suggests that this anxiety relates to the test itself, rather than the numeracy content.

CPNP students are familiar with the numeracy needed in the exam, and, depending on their profession they might be actively using numeracy every day. However, many CPNP students have experienced mathematical anxiety in the past. Thus, the authors want to explore whether the 100% pass rate test for the CPNP exam could induce mathematics anxiety in practitioners who had already been able to overcome past negative mathematics experiences and functionally complete numerical tasks in their job. The literature suggests that calculation errors are not a major cause of prescribing errors (Wright, 2010), which tend to be caused by distraction (e.g. inappropriate use of decimal points), communication issues (e.g. illegible drugs names) and pharmacological knowledge (e.g. the nurse dispense a similar-sounding drug to the prescribed one) (Williams, 2007). Nonetheless these errors occur in the decision-making process, and there is a proven link between mathematical anxiety and reduced ability to make advantageous choices and good decisions (Morsanyi, Busdraghi and Primi, 2014). Renewed maths anxiety in CPNP students thus has the potential to increase medication errors. We thus investigate the following research questions:

- Q1) Why is test anxiety rather than maths anxiety prominent for this demographic?
- Q2) Does successfully passing the test with 100% rate increase or decrease mathematics anxiety when performing drug calculations in the workplace?

The exploration and conclusion of these two questions led to further consideration:

How do we take into account students' clinical experience when preparing students for the CPNP exam?

## 2. Methodology

Ethical approval was obtained from the HEI. Students from two CPNP cohorts were invited to participate in a focus group. A single focus group of five participants lasting one hour was conducted, facilitated by the authors. In order to maintain integrity of academic standards, the focus group was conducted after the CPNP course had been completed and participants had received their results.

Prior to the focus group, participants were provided with a task to complete. They were asked to complete a graph to represent their confidence levels across the lifespan. Key events in the students' lives were highlighted on the graph: Primary school, High school, adulthood and the CPNP course. This would form the basis to start the focus group discussion and approach the questions.

To explore participants' responses in more detail, the authors asked questions from an ethically approved selection of semi-structured questions and prompts:

- Would you like to say anything about your timeline? (possible prompts: Why is there a peak/trough at this point in the timeline?)
- Where would you place yourself on the timeline in terms of your confidence in numeracy now?
- How did you feel when you learned the exam had a 100% pass rate?
- How did you feel as you entered the exam?
- How do you feel now you have done the exam?
- How do you think you will use numeracy in practice?

The focus group was conducted in a semi-structured way, and space was allowed for the participants to discuss their experiences outside of the remit of the above questions. The first 30 minutes of the focus group was dedicated to discussion around participants' wider lifespan experience of numeracy. The remaining 30 minutes focussed on participants' experiences as CPNP students and the present time.

The focus group was recorded, transcribed and thematically analysed by each researcher individually using Auerbach and Silversteins' (2003) coding model. This model was selected due to its clear, stepped model and its emphasis on data-checking and triangulation – with two researchers coding the data, this model supported discussion of emergent themes and allowed for new data to be introduced at each stage. The authors then reconvened and compared the coding obtained and identified common themes.

## 3. Q1. Why is test anxiety more prominent than maths anxiety for this demographic?

There is evidence to suggest that maths anxiety is more prominent in the demographic who participated in our research (Tariq, Qualter, Roberts, Appleby and Barnes, 2012; McMullan, Jones and Lea, 2012; Chen, Wang, Kirk, Pethel and Kiefner, 2014). CPNP students tend to be female and aged between 25-55, and this was represented in our focus group. The authors' assumptions in previous research have therefore been that maths anxiety is likely to feature in this demographic. This assumption was supported to an extent by the participants in the focus group.

*"It was horrid. It was a horrible, horrible time and I wish that things would have been different because then I could have done my training earlier..."* (Participant D)

*"...as soon as they mention maths, I could have cried and I could have left right then because it was my worst nightmare"*

However, throughout their timelines and in the data gathered from the focus groups participants tended to express high levels of confidence in their numeracy ability. This was particularly true when discussed in the context of clinical practice, where participants felt confident and competent in undertaking the necessary calculations and computations to do their jobs effectively.

"*I've always had maths skills… I like to do maths when I'm stressed out. I find it relaxing*" (Participant B)

"*I've never been confident with maths… but on the drug calculations, I'm fine!*" (Participant E)

Furthermore, one participant expressed a level of expertise in their clinical numeracy practice.

"*…all my colleagues used to ring me for all the drip rates and setting up IVs [Intra-Venous drips]*" (Participant A)

The concept of 'nursing maths' was mentioned by several participants during the focus group – the idea that there is a specific 'type' of maths that nurses use, which is different to 'regular' maths. Participants expressed confidence in their ability to use 'nursing maths'.

"*…they have that little formula I can follow. I think that takes me back to primary school… I had that little formula [then]*". (Participant E)

"*I didn't actually make the link between nursing and maths*" (Participant B)

Numeracy exams and tests were not directly referred to in the timeline exercise, or in the focus group questions, yet as participants described their histories, each of them referred to tests or exams across their learning life course. In each case, it seems that the test rather than the numeracy content was the source of anxiety. A question asking what caused confidence in maths to drop or grow elicited the following responses:

"*…the sort of exams as well affects your confidence. The stress of having an exam and wondering how you are going to do when you thought you were OK at (maths)*". (Participant A)

"*I've always enjoyed maths… I didn't pass my GCSE*" (Participant B)

"*We had to do the test to get onto the course. It was 'Oh my God, really? And you gotta get a certain percentage right'. That was horrendous. The length of time I had it open on the screen [where the online exam was displayed] before I clicked 'go', it took a good half hour to build up the courage to click 'go'. It was not good*" (Participant D)

What appeared to emerge from the focus group discussion was that the CPNP numeracy test was the focus of anxiety. Even when participants felt confident with their responses in the CPNP numeracy test, the exam format caused them to question themselves:

"*I actually had to check the answers of the maths questions just to make sure I got them right*" (Participant E)

"*I think I felt a bit nervous… I kept going over and over [the answers] and thinking, 'they're definitely right', and I knew they were right as soon as I had done them. But then I was thinking, 'What if they're not?'*" (Participant B)

The 100% pass requirement was also mentioned as a barrier to confidence when enrolling in the course.

"*I think it's hard work when you've got to get 100%. I think the stress of an exam and having to get 100%... I'd rather do 100 questions and get 95% than do 5 and get 100%. This is just the anxiety of the exam. It's so easy to make mistakes*". (Participant A)

The 100% pass mark is indeed questionable in terms of appropriate assessment. Race (2014) Coben, Hodgen, Hutton and Ogston-Tucks (2008) refer to such practice as 'high-stakes testing'. However, the need for clinical precision in CPNP practice demands exact results – patient safety is the focus of this qualification, and this overrides student comfort.

Many students undertaking this qualification have extensive experience of using numeracy within their roles. However, the participants' responses suggest that for them, formal testing in these skills is a distant, and sometimes upsetting, memory which is difficult to reconcile with their practice experience.

## 4. Q2. Does successfully passing the test with 100% rate increase or decrease mathematics anxiety when performing drug calculations in the workplace?

Participants expressed both increased confidence and relief after passing the exam.

"*So elated it was unreal, 'cause I don't normally get 100% on anything. So, the fact that I've passed them without having to put myself through it again the second time, well, you saw the reaction when you told us that we'd passed. It was… it was a good day.*" (Participant D)

"*I felt relieved and confident in my skills*". (Participant B)

Participants expressed confidence in their numeracy abilities after the test. Themes which emerged were increased confidence in calculations skills and in their ability to apply these skills to learning new procedures.

"*Before I used to work… work it out and then I second guessed myself for the rest of the day. Maybe going 'round and 'round in the head, saying, "well yeah, I have. I've worked it out right on it. That's right", but you still end up second guessing yourself. Well, now I don't really do that.*" (Participant D)

"*I'm my own worst enemy as well. So, I always second guess myself and think 'no, you've not done it right', but now I've proved myself by completing that exam and get them all right, 'no, actually, I can!'*" (Participant E)

"*I've recently done a 'syringe driver'. We were mixing drugs together and one was a little bit more of a complex calculation. I thought 'no I can do this, I'm not going to get stressed' and it gave me the courage*". (Participant E)

Here participants show the ability to manage or stop the onset of anxiety, and to make effective decisions. The positive effect of the success at the test also seems to have raised participant self-esteem and self-care.

"*[I have] start[ed] to talk to myself a little bit better. I would never say some of the things I said to myself to a friend. But now I started talking to myself as if I'm a friend*" (Participant E)

"*it is helpful to think, "Oh yeah, this is good. I know this that I can do that" and not just look back. […] I've had this rough start and then I feel like I've shut it up now and I'm proud of myself and I want to kind of help others.*" (Participant C)

Perhaps most importantly in terms of numeracy confidence, positivity was expressed in relation to numeracy learning in colleagues and mentees.

"*I've got an associate nurse [and] I'm her mentor for the rest of her training, […] she told me she was worried about maths and I said 'well, that makes two of us'. So [I printed the tutorial questions given in class and told her] that we will go through them and I will show it out how she can achieve the right answers, now. Before I couldn't have done that, […] I would have said: 'go find out yourself'*" (Participant D)

"[*With colleagues] I'd share my experiences. […] I think sharing those stories of how difficult things are and how you come out the other side is really important. And I'd probably notice if somebody was trying to avoid it, 'cause I know what the avoidance skills are*" (Participant C)

Participants were united in reporting that successfully passing the numeracy test was effective in managing or overcoming their maths anxiety.

## 5. Discussion

The exploration and conclusion of these two questions encourages consideration of the following enquiry: how do we take into account students' clinical experience when preparing students for the CPNP exam?

The authors' teaching focussed on using the students' experience in practice as a base to acknowledge their existing abilities and build on their numeracy confidence. Classroom discussions brought up stories of practitioners having to solve similar problems in real life, making evident the link between being a CPNP and answering a mathematical question. The less-familiar exam setting which involved interpreting a written question unrelated to a specific patient prompted discussions on how to read mathematical questions, methods to ensure a correct answer was obtained and strategies to overcome anxiety. In the classroom students were encouraged to present to their peers how they reached their answer, in order to reinforce that there are multiple ways of obtaining a solution. Students reported that this was reassuring, and exposure to other methods gave them a way of checking solutions. Most students were comfortable with the mathematical content (percentages, conversions, calculations etc); these were discussed in detail only if students needed some clarification. Workshops structured in this way are also more similar to the learning methods adopted in clinical practice, where learning through peer observation, demonstration and discussion is commonplace.

The study alerted the authors to the tension between the anxiety participants experienced prior to undertaking the test, and the increase in numeracy confidence they expressed on successful achievement. On considering classroom interventions to help students resolve this tension, the authors caution against setting a "practice" numeracy test as a stand-alone intervention, to artificially make students overcome mathematical anxiety. Students know that they can "*wing it and get it through*", as (Participant C) describes, not gaining the needed confidence for entering the nurse degree despite having obtained the needed GCSE C in Maths entry grade "*But still would say my skills are pretty pants, like, even though I resat my GCSE and got a C, I don't think that shows my knowledge.*" Any "practice" test or other formative activity needs to be embedded into a more holistic program which bridges the gap between clinical practice and assessment, in order that the latter can be seen by the students as a powerful addition to their "professional toolkit" that can be used to more confidently perform their duties and when mentoring junior colleagues.

## 6. Conclusion

Confidence levels in numeracy appear to be directly impacted on by test situations, throughout the learning lifespan. Even where participants express confidence and competence in their numeracy ability, test situations appear to create an obstacle which – albeit temporarily – quashes this confidence. However, on conquering the obstacle and passing the test, anxiety vanishes, and confidence is restored, and even increased. We thus conclude by comparing the experience of CPNP students in the numeracy test to the analogy of 'Fear Fortress':

"*A hypothetical castle in a forest near Saragossa, Fear Fortress represents that terrible obstacle which fear conjures up, but which vanishes into thin air as it is approached by a stout heart and clear conscience*". (Room and Brewer, 2002)

The authors realised that teaching and learning strategies which focused more on the development of confidence and strategies to overcome the "fear fortress" were more effective to our participants than strategies which focus entirely on explanation of mathematical concepts.

Ultimately, the following suggestions were identified for teaching and learning practice:

- Adopting a "clinical focus" to examples used in the classroom;
- Acknowledging students' existing knowledge and skills as the basis for building confidence;
- Keeping in mind a "growth mindset" ethos – that is to say, looking beyond the passing of the exam and recognising that some students have the capacity to develop advanced numeracy skills;

In practice, CPNPs use numerical skills in a wide range of situations, many of which are not reflected in the assessment – for example, wound measurement, IV calculations, syringe driver calculations. Supporting CPNP students to build their confidence in numeracy is essential for patient safety, empowers practitioners to apply their skills to new learning experiences, and encourages networks of practitioner-led learning in clinical practice.

## 7. References


Auerbach, C. and Silverstein, L.B., 2003. *Qualitative data: An introduction to coding and analysis,* Vol. 21. NYU press.

Chen, Y., Wang, J., Kirk, R., Pethtel, O. and Kiefner, A., 2014. Age Differences in Adaptive Decision Making: The Role of Numeracy. *Educational Gerontology,* 40(11); pp.825-833. https://doi.org/10.1080/03601277.2014.900263

Coben, D., Hodgen, J., Hutton, M. and Ogston-Tuck, S., 2008. High stakes: Assessing numeracy for nursing. *Adult Learning*, 19(3-4), pp.38-41. https://doi.org/10.1177/104515950801900308

i5 Health, 2015. Non-medical prescribing - an economic evaluation. *Health Education North West.* http://www.i5health.com/NMP/NMPEconomicEvaluation.pdf [Accessed October 2020]

McMullan, M., Jones, R. and Lea, S., 2012. Math anxiety, self-efficacy, and ability in British undergraduate nursing students. *Research in nursing & health*, 35(2), pp.178-186 https://doi.org/10.1002/nur.21460

Morsanyi, K., Busdraghi, C. and Primi, C., 2014. Mathematical anxiety is linked to reduced cognitive reflection: a potential road from discomfort in the mathematics classroom to susceptibility to biases. *Behavioral and Brain Functions*, 10(1), pp.1-13 https://doi.org/10.1186/1744-9081-10-31

Nursing and Midwifery Council, 2018. *Standards for Prescribing Programmes.* London, Nursing and Midwifery Council, Available at: https://www.nmc.org.uk/globalassets/_sitedocuments/education-standards/programme-standards-prescribing.pdf [Accessed September 2020]

Race, P., 2014. *Making learning happen: A guide for post-compulsory education*. Sage.

Room, A. and Brewer, E.C., 2002. *Brewer's dictionary of modern phrase & fable*. Sterling Publishing Company, Inc..

Smith, C. and Penazzi, D., 2020. Triggering language and maths anxiety in non-medical prescribing students. Journal of Prescribing Practice, 2(5), pp.226-232 https://doi.org/10.12968/jprp.2020.2.5.226

Tariq, V., Qualter, P., Roberts, S., Appleby, Y., and Barnes, L., 2012. Mathematical literacy in undergraduates: role of gender, emotional intelligence and emotional self-efficacy. *International Journal of Mathematical Education in Science and Technology* 44(8), pp.1143-1159 https://doi.org/10.1080/0020739X.2013.770087

Williams, D.J.P., 2007. Medication errors. *Journal-Royal College of Physicians of Edinburgh*, *37*(4), p.343.

Wright, K., 2010. Do calculation errors by nurses cause medication errors in clinical practice? A literature review. *Nurse education today*, 30(1), pp.85-97 https://doi.org/10.1016/j.nedt.2009.06.009

## CASE STUDY

# Student-Generated Examples and Group Work in Mathematics

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## Abstract

An assignment from Higher Education is presented within this paper as a case study of students generating their own examples whilst working in groups. The student perspective was gained through a questionnaire at the end of the assignment with each cohort over a three year period, which was completed by 123 students in total. The students provided insight on creating their own examples, as well as the group work aspect of the assignment. In particular, students indicated what they believe to be the most beneficial assessment approaches. Elements of learning, understanding and motivation are explored, and the student perspective is compared with the literature.

**Keywords:** Student-generated examples, problem posing, collaborative learning, student perspective, assessment for learning.

## 1. Introduction

Lecturers are usually the ones providing examples (exemplars of a topic that are then worked through), which can result in students taking a passive role in the learning process (Silver, 1994). Getting students to develop examples themselves, known as student-generated examples, is *'a particularly powerful tool in teaching'* (Watson and Mason, 2002b, p.237). It involves problem posing, which has a positive impact, particularly on understanding (Chang, Wu, Weng and Sung, 2012), and its practice is *'central'* to thinking processes required within Mathematics (Silver, 1994, p.22).

Generally working with examples can be very effective in the learning process (Anderson, Reder and Simon, 1996), but too much rote learning does not allow students to develop understanding (Lithner, 2012). In the case when students create different examples to the ones they already have, then *'knowledge transformation beyond generalizing a format is likely to take place'* (Watson and Mason, 2002b, p.246). An example generation task partly requires students to get to grips with the information they have been given (Watson and Mason, 2002a). However, the task requires far more than blindly following examples they have seen before because, as presented by Fried (2006, p.209), students *'probe and crystallize their mathematical knowledge more deeply'* when generating examples. Students make discoveries through a deeper engagement, as well as the relationships between examples and techniques (Bills et al., 2006). Anthony and Walshaw (2007) also highlight that being able to make links themselves, helps the students see connections between different ideas.

Tichá and Hošpesová (2009) say an advantage of students posing problems is that it allows the students to judge their level of understanding and the reasons behind any mistakes. There is evidence in the literature that students who create examples are better at understanding new ideas (e.g. as presented by Dahlberg and Housman, 1997). Student-generated examples also give the marker a good indication of how much the students have learnt (Watson and Mason, 2002a). This is because problem posing can be a good test of students' understanding (Silver, 1994) and assessors can distinguish between different levels (Tichá and Hošpesová, 2009).

The focus of this paper is an assignment for the formal languages and automata part of a final year Abstract Algebra optional module, and its evaluation that was carried out over a three year period (2015/16, 2016/17 and 2017/18). The assignment was designed based on the principles of assessment for learning, which aims to encourage learning (Wiliam, 2011) and is not purely to determine what students have learnt (Stiggins, 2007). The intention was to encourage students to take a deep learning approach, in which they concentrate on relationships (Smith and Wood, 2000). To encourage this type of approach, the students create their own examples of languages in the assessment. They create some recognisable languages and at least one that is not (more information on this topic can be found in Lawson, 2004). Nine methods are provided and students have to apply each at least once to show their languages are either recognisable or not recognisable, using each method a maximum of two times. They are encouraged to try lots of examples without presenting them all. They are warned that their examples may change as they develop the assignment because, as presented by Silver (1994), they may ask more questions after one particular problem is solved.

The assignment is done within groups, which is partially due to the usual benefits of group work, as explored by Laal and Ghodsi (2012). Students are more likely to do well through collaboration in assessment for learning (Hargreaves, 2007) and cognitive autonomy support encourages students to take responsibility for their learning (Stefanou et al., 2004). Some research has been undertaken surrounding student-generated examples and group work. For example, Ahn and Class (2011) present a case study of Teacher Education undergraduate students, in which they created exam questions in groups. Gaining both the teacher and student perspectives, Ahn and Class concluded that group work improves engagement, encourages deeper thinking and changes how students do their work.

The module presented in this paper is assessed via coursework (50%) and an examination (50%). There are three assignments, which are equally weighted. In 2015/16 and 2016/17, the group assignment was the second assignment, but in 2017/18 the group assignment was the final one. Other than the order of the assignments, there was very little difference in how the module was taught during the three year period. The students choose support groups of three to five people at the start of the academic year and sit in their groups throughout the taught classes. There are plenty of opportunities for students to work together on class exercises due to the workshop nature of the sessions, including during the 12 weeks before the group assignment is handed out. More information on the teaching methods, the support groups and the degree can be found in Cornock (2015).

Like all assignments for the module, marking is based on factors such as the demonstration of understanding and relevant skills, the selection of approaches, communication, the correctness of the work and explanations, the elegance and clarity of solutions, and whether sufficient detail is provided. In addition to these, the selection of examples to demonstrate the techniques, the links made between them and the sophistication of the examples are also assessed within the group assignment. The students have to fill in a contribution sheet at the end of the assignment to indicate whether members of the group provided an equal contribution, and marks are adjusted if appropriate.

Given the advantages of student-generated examples and group work, this paper will consider the student perspective in this area following an experience of example creation and whether students recognise the advantages as presented in the literature.

## 2. Methods

Marton and Säljö (2005) critique various methods for researching the student experience and present how self reports from students gives the required insight into their perspective. This study took a similar approach as students were asked for information about their experience and views.

The group assignment in this study was evaluated over a three year period through an anonymous questionnaire. This was completed by 34, 47 and 42 students in 2015/16, 2016/17 and 2017/18 respectively (89.5%, 92.2% and 80.8% of the students in the classes) on the completion of the assignment. The questions were:

- On the scale of 0 to 10 (with 0 being the least confident), how confident do you feel in tackling questions on the following topics on your own having done the recent assignment? *[List of 9 topics]*

- Which would have been more beneficial to you on this assignment? (Two separate questions)
  *Options: developing own examples; working with given examples*
  *Options: working within a group; working on your own*

- Did you feel that you were learning whilst doing this assignment?
  *Options: Yes, a lot; yes, a bit; no, not at all*

- If you answered yes [to the previous question], how were you learning?

- What motivated you to put effort into this assignment?

Throughout the questionnaire, the students were asked for reasons for their responses.

Taking the same approach as Marton and Säljö (2005) with regards to textual data, appropriate student comments were separated out into themes based on similarities. Quotes from students were used to indicate the type of comments that were being made within each theme.

## 3. Results

When asked what motivated them to put effort into the assignment, 75.4% of students who answered the question (95.9% of students provided a response to the question) said it was getting a good mark. There were a number of other responses including wanting to do well for other people in their group (18.6%) and seeing others work hard (5.1%). One student said they wanted to improve and a few (3.4%) said they wanted to increase their understanding. It is clear from the questionnaire results that the students' definition of *'beneficial'* varied and their interpretations can be seen through their responses to the open questions.

### 3.1 Students working with examples

When asked whether developing their own examples or working with given ones would be more beneficial for the assignment, there was a bigger proportion who selected given examples (Table 1):

| | Overall |
|---|---|
| **Developing own examples** | 38.2% |
| **Working with given examples** | 57.7% |
| **Both responses selected** | 4.1% |

Table 1: A breakdown of student opinions of what would be more beneficial regarding examples

#### 3.1.1 Students creating their own examples

Out of the 38.2% of students who thought that developing examples was more beneficial, 40.4% said it was because they developed a better understanding, particularly surrounding why examples worked. Student comments included that *'it's better for me…to understand why and how something is working'* and the *'element of understanding how different languages work would have been missed had there been given examples'*. Some of the students pointed out what they were able to spot why examples did not work (8.5%), with one student pointing out that this was more beneficial than seeing examples that were successful.

Students recognised that they needed a greater understanding of the topics in order to create examples. One student thought that *'there's no shortcut method'* as *'you have to know the topics well'* and another said that the assignment *'tests your understanding in further depth'*. One student provided a particularly interesting response. They expressed a preference for given examples, but then went on to say *'I definitely agree that it's more beneficial to develop own examples because it helps improves understanding of topics.*

A response made by several students was that they had to *'think'* or *'think more'* (25.5%). Comments included they had *'more freedom to think about our ideas'* and working with their own examples *'creates more independent thinking instead of the repetitive process of being told what to work on'.* In particular, they had to think about the methods and *'realise links between techniques'*. Comments included that *'it made me think more than just following steps and applying it to a given example'* and they were not just *'following steps from the book'*, they *'learned more than the basic 'how to do'',* and it made them *'look at languages in a different way'*.

Some students reported that they tried more examples (12.8%), which meant they worked with lots of languages (both ones that worked and ones that did not). One student pointed out *'with given examples, I would have only focussed on how to answer specific questions'.* A number of students thought that creating their own examples challenged them more and led to richer discussions.

#### 3.1.2 Students working with given examples

Amongst the 57.7% of students who thought that working with given examples would have been more beneficial, 22.5% of them said that creating examples took a long time and 18.4% said they found it difficult. A couple of students said they could not create any and did not fully understand the material. One comment was that it was *'difficult to learn examples and rules never mind find languages as well'* and there were other comments about how working with given examples is better if they do not fully understand them (5.6%). There were remarks about how given examples help them to understand the material (16.9%) as it provides them with a *'basis to start from'* and *'it may be a good idea to have a mixture of the two'*.

There were concerns about marking, with 14.1% of the students commenting that they found it difficult to know whether they had done enough work and if their languages were complex enough, with one student saying it is *'hard to know what's needed for top marks'* and another saying that *'leaving it so open winded it's going to be harder to get a better grade'.* A number of students (7.0%) did not like the *'broader'* mark scheme when creating their own languages and one did not like the assessment of creativity. A couple of students said they like the security of seeing whether they are on the *'right track'*.

There were several other reasons why students preferred working with given examples. When generating examples, they did not like how there were no model solutions afterwards, there was more room for error and they were not able to just repeat the processes presented in class. Despite many students expressing that working with given examples would have been more beneficial, there was some still acknowledgement amongst the students that creating their own examples helped them.

## *3.2 Students working in a group and individually*

When asked whether working on their own or working in a group would have been more beneficial to them during the assignment, Table 2 shows more students said working in a group.

| | **Overall** |
|---|---|
| **Working in a group** | 68.8% |
| **Working on own** | 31.1% |

Table 2: A breakdown of student opinions of what would be more beneficial regarding group / individual work.

### *3.2.1 Students working in a group*

There were a larger number of students who felt they benefitted more from the assignment being a group assignment than doing an individual one (68.8%). A common response was that they shared ideas and created examples together (27.4%). One comment was that *'bouncing ideas off each other is an effective method of doing work'.* Unlike many other assignments, they thought the assignment was *'quite creative'*. Some of the students acknowledged that they lack creativity, but that the group work element helped with this. Another student pointed out that it helped with decision making as *'without discussing it, it would be much harder to argue (with yourself) which language is best'.*

The students highlighted that they could help, support and learn from each other (23.8%). In particular, some students said it helped with the topics in which they were weaker (7.1%) as they could gain help and advice from each other, and could work through examples together. They liked that *'you get more insight from a different perspective'.* Some of the students thought the group work element helped as the techniques were difficult, and 13.1% of the students said it was easier to check and spot errors. One student said they could *'discover any misconceptions so can avoid it in the future'.* A number of students felt that the group work helped with understanding (15.5%) and an advantage was that people have different strengths (13.1%).

### 3.2.2 Students working on their own

A large reason why the students thought that working on their own would have been more beneficial was that they did not do examples for every topic, so they have gaps in their knowledge and understanding (36.8%). There were some reports of topics being strategically delegated due to the strengths of individuals. Despite lots of indications of students supporting each other in the group work, a couple of other concerns were that *'people who were comfortable with a process would complete it quickly and leave those without confidence unchanged in their abilities'* and *'sometimes group members can finish an example when you get stuck, so although they're explaining what they're doing you're not necessarily trying it yourself'.* Looking at the confidence scores that the students provided for the nine topics at the end of the assignment, about half (50.2%) of the students provided at least one score above five and one score below five. One student in particular scored ten for four topics and one for the other five. There were other reasons for the preference of individual working, which were mainly general concerns about group work.

Looking at the two factors together in Table 3, very few students (7.4%) said working with their own examples on their own would have been more useful. The biggest proportion (35.2%) said that it would have been more beneficial to work on given examples in a group.

| | Own examples | Given examples | Both |
|---|---|---|---|
| **Working on own** | 7.4% | 22.1% | 1.6% |
| **Working in a group** | 31.1% | 35.2% | 2.5% |

Table 3: A breakdown of student opinions of what would be more beneficial regarding examples as well as group/individual work.

### 3.3 Learning during the assignment

When asked whether they felt that they had learnt whilst doing the assignment, Table 4 shows that the majority said they did:

| | Overall |
|---|---|
| **A lot** | 52.0% |
| **A bit** | 46.3% |
| **Not at all** | 1.6% |

Table 4: Opinions on whether the students felt they were learning during the assignment.

There were a variety of answers when asked how they had learnt, with some students mentioning the creation of examples (14.9%) or group work (33.8%). Ways in which they were learning included that they re-capped material (30.6%), they went over parts they did not understand (14.0%) and they used the techniques (19.0%).

There were still a number of students who said they had learnt a lot despite not seeing the creation of their own examples in a group as the most beneficial way of doing the assignment. This was 36.6% of the students who said that working with given examples would have been the most beneficial, 39.5% of the students who said working on their own, and 25.9% of the students who said working on given examples on their own.

## 4. Discussion and conclusions

Following its completion, more students thought that doing the assignment with given examples would have been more beneficial than creating their own. The reasons were mainly negative views of creating examples, such as the amount of time it required and the difficulty. Despite this, findings from the student perspective seemed to match up with results from the literature on student-generated examples and problem posing, which included help with understanding (Chang et al., 2012), finding links between topics (Bills et al., 2006) and becoming comfortable with the given material (Watson and Mason, 2002a). Some students acknowledged that they were not just going through steps provided in class, which is the 'routine' approach presented by Smith et al. (1996) in which similar questions can be answered by repeating the steps in previously seen examples. Students recognised that the task of creating their own examples meant that they had to do more, which included that they had to think more about what they were doing.

The task of creating examples stretches stronger students, as indicated by comments made throughout the questionnaire. Results also suggested that students with a weaker understanding find the task of creating examples particularly difficult due to the level of understanding required. These students may benefit by building more understanding from given examples. It is hoped that the group work element and the opportunity to practice lots of questions before the assignment helps with this. However, this is an area which needs further consideration.

There were a lot of students who thought that it would have been more beneficial to have worked in a group than individually for the assignment. The main reasons were that they were able to share ideas and provide each other with support. The students who thought that working on their own would have been more advantageous mainly said it was because of general group work issues or that they did not cover all the topics in the assignment. The tactical delegation of topics within groups, based on the strengths of individuals, meant that some students were not able to look at topics they were least confident about. The confidence scores suggest that a large number of students did not cover every topic during the assignment. The strategic approach of splitting tasks may have resulted in the short term gain of a better assignment mark for the group, but also had the disadvantage of individual students not receiving the full benefit of the task. The questionnaire results suggest that many of the students thought that the task would have been too difficult as an individual assignment and the support of the group was needed. The group work aspect was typically perceived as more useful than creating their own examples.

Despite what the students saw as most advantageous, a large proportion of students said they learnt a bit or a lot during the assignment, which suggests that most students benefitted from creating their own examples in a group. It is noted that student views on learning can be inaccurate (Deslauriers et al., 2019), so there are limitations on what can be drawn from the student responses on this topic. However, the student comments indicated that deep learning had taken place. For example, some students said they could see links between the topics, saw how and why certain languages worked, and learnt from misconceptions.

When looking at the results together, working on given examples in a group was seen as the best way of doing the assignment. The students thought that creating examples was difficult and working in a group provided them with support. The main motivator for doing well in the assignment was to receive good marks, whereas building an understanding was only mentioned by a few students when asked about motivation, which provides a reason for the responses regarding assessment design and the way the assignment was approached.

## 5. References


Ahn, R. and Class, M., 2011. Student-centred pedagogy: co-construction of knowledge through student-generated midterm exams. *International Journal of Teaching and Learning in Higher Education,* 23(2), pp. 269-281. Available via https://files.eric.ed.gov/fulltext/EJ946152.pdf (last accessed 10 June 2020)

Anderson, J. R., Reder, L. R. and Simon, H. A., 1996. Situation learning and education. *Educational Researcher,* 25(4), pp. 5-11 DOI: 10.3102/0013189X025004005

Anthony, G. and Walshaw, M., 2007. Effective pedagogy in mathematics. Educational Practices Series-19. International Academy of Education & International Bureau of Education. Available via http://www.ibe.unesco.org/fileadmin/user_upload/Publications/Educational_Practices/EdPractices_19.pdf (last accessed 10 June 2020)

Bills, L., Dreyfus, T., Mason, J., Tsamir, P., Watson, A. and Zaslavsky, O., 2006. Exemplification in Mathematics Education. In J. Novotná, H Moraová, M Krátká & N Stehlíková, eds. *Proceedings of the 30th International Group of the Psychology of Mathematics Education* (*Vol. 1,* pp. 1-125). Prague, Czech Republic: Charles University in Prague, Vol 1, pp. 1-125 Available via: http://mcs.open.ac.uk/jhm3/PME30RF/PME30RFPaper.pdf (last accessed 10 June 2020)

Chang, K.-E, Wu., L.-J., Weng, S.-E. and Sung, Y.-T., 2012 Embedding game-based problem-solving phase into problem-posing system for mathematics learning. *Computers and Education,* 58(2), pp.775-786 DOI: 10.1016/j.compedu.2011.10.002

Cornock, C., 2015. Teaching group theory using Rubik's cubes. *International Journal of Mathematical Education in Science and Technology*, 46(7), 957-967 DOI: 10.1080/0020739X.2015.1070442

Dahlberg, R.P. and Housman, D.L., 1997. Facilitating learning events through example generation. *Educational Studies in Mathematics,*33(3), pp. 283-299 DOI: 10.1023/A:1002999415887

Deslauriers, L., McCarty, L.S., Miller, K., Callaghan, K. and Kestin, G., 2019. Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom, *PNAS* 116(39) pp. 19251-19257 DOI: 10.1073/pnas.1821936116

Fried, M. N., 2006. Mathematics as a constructive activity: learners generating examples. *ZDM,* 38(2), pp. 209-211 DOI: 10.1007/BF02655890

Hargreaves, E., 2007. The validity of collaborative assessment for learning. *Assessment in Education: Principles, Policy and Practice,* 14(2), pp. 185-199 DOI: 10.1080/09695940701478594

Laal, M. and Ghodsi, S.M., 2012. Benefits of collaborative learning. *Procedia - Social and Behavioral Sciences* 31, pp. 486-490 DOI:10.1016/j.sbspro.2011.12.091

Lawson, M.V., 2004. *Finite Automata.* Chapman & Hall / CRC

Lithner, J., 2012. Learning Mathematics by Creative or Imitative Reasoning. In S. Cho, eds. Selected Regular Lectures from the 12th International Congress on Mathematical Education. Springer, Cham pp. 487-506 DOI: 10.1007/978-3-319-17187-6_28

Marton, F. and Säljö, R., 2005. 'Approaches to Learning'. In: Marton, F., Hounsell, D. and Entwistle, N., eds. The Experience of Learning: Implications for teaching and studying in higher education. 3rd (Internet) edition. Edinburgh: University of Edinburgh, Centre for Teaching, Learning and Assessment. pp. 106-125. Available via: http://www.docs.hss.ed.ac.uk/iad/Learning_teaching/Academic_teaching/Resources/Experience_of_learning/EoLChapter3.pdf (last accessed 10 June 2020)

Silver, E.A., 1994. On mathematical problem posing. *For the Learning of Mathematics,* 14(1), pp. 19-28 Available via: https://www.researchgate.net/profile/Edward_Silver2/publication/284047623_On_mathematical_problem_posing/links/575988b308ae9a9c954f06f1/On-mathematical-problem-posing.pdf (last accessed 10 June 2020)

Smith, G. and Wood, L., 2000. Assessment of learning in university mathematics. *International Journal of Mathematical Education in Science and Technology*, 31(1), pp. 125-132 DOI: 10.1080/002073900287444

Smith, G., Wood, L., Coupland, M., Stephenson, B., Crawford, K. and Ball, G.. 1996. Constructing mathematical examinations to assess a range of knowledge and skills. *International Journal of Mathematical Education in Science and Technology*, 27(1), pp. 65-77 DOI: 10.1080/0020739960270109

Stefanou, C.R., Perencevich, K.C., DiCintio, M. and Turner, J.C., 2004. Supporting Autonomy in the Classroom: Ways Teachers Encourage Student Decision Making and Ownership. *Educational Psychologist,* 39(2), pp. 97-110 DOI: 10.1207/s15326985ep3902_2

Stiggins, R., 2007. Assessment for learning: an essential foundation of productive instruction. In D.B. Reeves, eds. *Ahead of the Curve: The Power of Assessment to Transform Teaching and Learning.* Bloomington IN: Solution Tree Press, pp.59-76.

Tichá, M and Hošpesová, A., 2009. Problem posing and development of pedagogical content knowledge in pre-service teacher training. *Proceedings of CERME (Vol. 6,* pp. 1941-1950). Lyon, France. Available via: https://pdfs.semanticscholar.org/3320/5b6705c524c17c18ef505d28457c6d735568.pdf?_ga=2.224026259.923145160.1591807633-498329837.1591807633 (last accessed 10 June 2020)

Watson, A. and Mason, J., 2002a. Extending example spaces as a learning/teaching strategy in mathematics. In A. Cockburn and E. Nardi, eds. *Proceedings of the 26th Conference of the International Group of the Psychology of Mathematics Education*. Norwich, UK: University of East Anglia, Vol 4, pp. 377-385 Available via: http://mrbartonmaths.com/resourcesnew/8.%20Research/Inquries/Extending%20Example%20Spaces%20-%20Watson%20and%20Mason.pdf (last accessed 10 June 2020)

Watson, A. and Mason, J., 2002b. Student-generated examples in the learning of mathematics. *Canadian Journal of Math, Science and Technology Education,* 2(2), pp. 237-249 DOI: 10.1080/14926150209556516

Wiliam, D., 2011. What is assessment for learning? *Studies in Educational Evaluation,* 37(1), pp. 3-14 DOI: 10.1016/j.stueduc.2011.03.001

CASE STUDY

# Introduction of a video assignment: advantages and disadvantages from the students' perspective

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## Abstract

We present a case study on the introduction of video assignments into Level 4 (year 1) and 6 (year 3) modules within a BSc Mathematics degree. The students were required to provide verbal explanations within a video about some written steps in their argument. We present the details of the assignments and assessment criteria. The introduction of the video assignments was evaluated through focus groups. We present a number of advantages and disadvantages from the students' perspective when they compared the methods of providing answers through videos, presentations and written work. In particular, we present information on confidence levels, the ability to spot mistakes, skills development and the usefulness for job applications. We provide some practical suggestions for anyone thinking about introducing their own video assignment.

**Keywords:** Video assessment, skills development, job applications, confidence, student perspective.

## 1. Introduction

The module 'Number and Structure' sits within Level 4 of a BSc Mathematics course. The course has an applied focus and there is a large emphasis on the development of employability skills throughout. The module 'Number and Structure' is one of the purer modules, but still has a reasonable amount of connections with the real-world and includes some skills development (Corner and Cornock, 2018). The assessment consists of several coursework tasks (50%) and an end of year examination (50%).

In 2016/17, when approximately 85 students were taking the module, a video assignment was introduced. The video assignment was one of many pieces of coursework assessment within the module, and was worth around 8% of the coursework mark in 2016/17. An appropriate question was selected, which was to either prove or disprove the following statements:

1) If an integer $a$ is not divisible by 3 and an integer $b$ is not divisible by 3, then the product $ab$ is not divisible by 3.

2) If an integer $a$ is not divisible by 4 and an integer $b$ is not divisible by 4, then the product $ab$ is not divisible by 4.

3) $3^{2n} + 11$ is divisible by 4 for all positive integers $n$.

The students had to present their answers via a video, which needed to be less than five minutes long. The students had to provide some written work, but had to give their explanations verbally. In preparation for the assignment, the students took part in a workshop where they were briefed on the assignment, the technology and submission details, and also tried out the recommended technology (screencast-o-matic).

The subsequent Level 4 cohort in 2017/18 also did a video assignment, which contained different questions. They also had the option of presenting their next assignment via a video. Also, in 2017/18 some Level 6 students had the choice to present some of their answers via a video in a similar type of module, but did not have to do a compulsory video assignment.

Mark schemes were provided for the video assignments, which were marked using grades rather than marks. There were communication criteria surrounding descriptions, the focus on meaning behind results, why results can be used, whether statements follow in a logical order and are connected, if explanations provide details of how the work progresses from one step to the next, having sensible and appropriate presentation, having easy to follow arguments, and a balance between mathematical content and explanations. There were also criteria on the demonstration of knowledge, understanding and skills, the correctness of answers, and the overall approach. Within the mark scheme for the video assignments, the explanations were referred to as "verbal explanations" and there was the criteria that "verbal explanations add more insight than the written/typed work" to discourage the students from just reading out a written assignment.

## 2. Evaluation

Student views were gathered through focus groups, which took place with ethical approval. Comments made within them were recorded, but details about individuals (e.g. gender) were not collected. All the students taking the modules under consideration were invited to take part and all the volunteers were accommodated within the focus groups.

### *2.1 Focus groups in 2016/17*

Focus groups were carried out following the Level 4 video assignment in 2016/17. There were two focus groups, which contained a total of 14 students. They were asked questions about how they found the assignment, similarities and differences between the methods and their preparation, and whether they had developed skills. They were also asked questions about the practicalities and what they would do if they had the option of a video in the future. The last part of the focus group involved them looking at cards that were provided. These included 'talking out loud', 'confidence', 'video interviews', 'use of technology', 'presentation skills', 'length of descriptions' and 'verbal explanations'.

### *2.2 Focus groups in 2017/18 following choices*

There were focus groups that took place in 2017/18 when students had the option of submitting work through a video. The students were separated into the four groups depending on their level of study (Level 4 or Level 6), and whether they had opted to present answers via a video. They were asked about the reasons for their choices and experiences.

## 3. Advantages and disadvantages

There were a number of advantages and disadvantages that were highlighted by the students.

### *3.1 Understanding*

The video assignment was shown to have an impact on the required levels of understanding and thought, as well as the development and the ability to demonstrate understanding. Further details and analysis is presented in Cornock and Crombie (submitted).

### 3.2 Confidence

The video assignment in 2016/17 effected the confidence of some of the Level 4 students. As well as confidence with presenting, the video assignment affected their confidence with the material. One student pointed out that they "*feel a lot more confident for those topics where [they] had to explain if they did come up because [they have] actually had to talk about it and explain [their] answers whereas actual written assignments you just do the question and hand it in and don't really think about what you've done*". One of the Level 6 students who chose to do their assignment on paper in 2017/18 said that if you are confident doing the video, then it *"reassures"* the marker, but if they do not sound confident *"they might come across as if they don't"*.

### 3.3 Spotting mistakes

When asked in the focus groups in 2016/17 what could be done through a video assignment that could not be done through other assignment, one student said that it was *"easier to spot mistakes"* when listening to the recording because "*if it's written it's harder to see where you've gone wrong".* On the other hand, not all students agreed with this. Amongst the students who opted to do a written assignment in 2017/8, a Level 4 student said *"it's easier to check on paper"* and a Level 6 student said that *"with writing you can check what you've actually done"*. A Level 4 student mentioned that *"it's easier to fix on paper"* and a Level 6 student said they can *"proof read it and change it instantly"*. A Level 6 student who opted to do a video also highlighted that *"there is a problem as well when you are checking through your work 'cause no one likes to listen afterwards".*

### 3.4 Comparison of video assignments and presentations

During the focus groups in 2016/17, the students made comparisons between the video assignments and presentations. One students said it *"might be easier to do it face to face rather than a video"* as they *"use [their] hands quite a lot to explain things and it would have been a lot easier to just talk to someone about it."* Another comment was that "*it would be easier to know if the staff knew what you were going on about if they were in front of you as well.*" However, there was general agreement that a presentation would not be better. One student described the video assignment as a *"confidence booster"* as what *"scares [them] is having an audience"* and *"you haven't got anyone physically watching you while you're doing [the video] so [they] didn't feel like scared doing it."* It was felt that there is *"less pressure*" with doing the video assignment as "*you can do it in your own time sort of take it one step at a time rather than being put in front of somebody*". It was also mentioned that in presentations, you do not necessarily get to say everything you want to say. A Level 6 student in a 2017/18 focus group who did the assignment on paper said that they could do a presentation through a video as they can re-do the recording and as with a presentation they are *"totally relying on remembering everything on the spot"*.

Comparisons of the video assignment and presentations in 2016/17 and 2017/18 showed that some students preferred presentations because of body language. Whereas others preferred taking their time, not having to remember everything, having the flexibility to edit and having the privacy of the video assignment. Further work looking into a choice between a presentation and video assignment would be an interesting study.

### 3.5 Skills development

The students in the focus groups in 2016/17 were asked whether they developed any new skills or improved existing ones through the video assignment. The responses included video editing and developing or improving communication. When asked about the impact on presentation skills, the responses were about talking clearly and concisely, thinking about what was being said more and bearing the listener in mind. It was noted by a Level 6 student in a 2017/18 focus group that *"you* *improve quite a lot doing videos"*, stating that they had taken 10 attempts at the first question and one attempt at the second. A Level 6 student who did a video said that they think that *"doing a video might actually help you to write things"*.

### *3.6 Videos in job applications and interviews*

In addition to the awareness of how the video assignment helped them on the course, the students talked about the use of videos in job applications and interviews in the focus groups in 2016/17. One student said that they *"feel like video interviews would be more personal than in the assignment where [they] were explaining the maths"*. When asked directly about video interviews and the relevance of the video assignment, one response was that it would depend on what it was. They gave the example of a Skype interview being more like a presentation, but if they had to present an answer to a question in a video, then the video assignment *"would definitely help because it's just obviously a different question that would be relevant to what you're applying for."*

There was not common agreement that a video assignment helps in preparation for any video interviews. Some students thought that doing the video assignment helped them to prepare for future applications that involve video as it did not matter what they were talking about. However, others did not think it would help due to the questions being less mathematical in job applications.

### *3.7 Technical side of the assignment*

The students in the 2016/17 focus groups recognised that they had developed technological skills whilst doing the assignment, but found the use of technology the difficult part of the assignment. When they were asked how they found the assignment, the responses included that they struggled with the time limit. However, when asked whether there were benefits of having a short time, one student said that *"you're more precise when you're explaining things"* and are *"not waffling as much"*. Another student mentioned that with a shorter time, they *"feel like you miss stuff out"* and there was general agreement with this. There were several comments that suggested the time limit contributed to the video taking a lot of time to create as the students did many attempts to get their video under five minutes. There was concern about how much work was involved. One student estimated that "*it was approximately 30% of [their] time [spent] on the maths and 70% on the video".* A Level 6 student pointed out in 2017/18 that a video assignment is *"bad in a way for feedback"* as they could not remember what they said in the video they produced.

There were concerns about what they were being tested on in 2016/17, despite a detailed mark scheme and reassurance that they were not being tested on the video making skills. Comments included that they "*felt like that assignment was judging [them] more on how well [they] can make a film than on [their] maths skills".*

There were also further comments in the 2016/17 focus groups about other technical problems, which included editing and uploading. However, most of the problems mentioned seemed to be linked with this being the first time they had done a video assignment. One student said that "*getting used to doing that style of assignment at the same time as doing it was the challenging aspect*". There was general agreement that it would be easier next time.

As expected, the technical side of the assignment took up the most time. Providing a time limit of five minutes caused most of the issues with how long the assignment took to do, but there was some recognition that it meant they were more concise. There were other problems which included getting used to the software, editing and uploading. Despite these problems, there was a sense amongst the Level 4 students in 2016/17 that it would be better if they did another video assignment, however there was little uptake when they had the option to do a second video assignment in 2017/18. This will be explored further in a separate paper.

## 4. Practical considerations

When introducing a video assignment into a module, the following are recommended:

1) Start with a small cohort or some student researchers as a trial to make sure the assignment brief cannot be misinterpreted;
2) Be very clear in the mark scheme about what is required – in particular, make sure the students are discouraged from just reading out what they would have done for a usual written assignment;
3) Specify what is not being assessed (e.g. editing skills) and what the requirements are (e.g. that they do not have to physically appear in the video, but their verbal explanations must be clear);
4) Set clear requirements – for example, you may want to specify the type of videos that will be accepted (e.g. mp4);
5) Make students aware of anything that may lead to accidental academic misconduct (e.g. reading out answers in a public place);
6) Have a training session to go through the assignment requirements, show the students how to use the technology and give them the chance to try;
7) Think about the point of submission and whether it will accept large files;
8) Consider how you will provide feedback to students – getting students to provide a print out of the written part of their work gives you something to annotate as you are watching their video;
9) Set a time limit for the video;
10) Give it a go yourself – this will bring up potential problems (e.g. if you are setting too much work to do within the time limit).

## 5. Conclusions

There are a number of advantages that can be gained from students doing a video assignment, particularly around the area of skills development and preparation for future job applications. There were also plenty of concerns about the technical aspects of the assignment, such as the time it takes to produce a video. There is a lot of room for difficulties within a video assignment, but a lot of these problems can be minimised by careful consideration when it is being set.

## 6. References


Corner, A.S. and Cornock, C., 2018. Applications and props: the impact on engagement and understanding, *MSOR Connections* 17(1) DOI: https://doi.org/10.21100/msor.v17i1.908

Cornock, C. and Crombie, A. (submitted) Development and assessment of mathematical understanding through video assignments

Screencast-o-matic. Available via https://screencast-o-matic.com/ [last accessed 5 July 2020]

CASE STUDY

# Reflections on remote teaching

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## Abstract

The COVID-19 pandemic has forced us to reconsider the way we teach our students. The inability of UK-based lecturers to deliver via traditional lecture-based courses in China (due to ongoing travel restrictions) has been an obstacle to overcome but also an opportunity to investigate innovative remote-teaching methods. Here we review a case study based on teaching three different year groups at the Jinan University - University of Birmingham Joint Institute during the early part of 2020. We reflect on how technology was used, draw conclusions and discuss potential opportunities for the future of remote-teaching.

**Keywords:** Remote-teaching; technology; flipped learning; Zoom; distance-learning

## 1. Introduction

The ongoing COVID-19 pandemic highlights that in extreme circumstances we must rely on remote-teaching if the disruption to the education of our students is to be minimised. Notably, opportunities to develop methods present themselves when lecture-based teaching methods are unavailable. In this paper we focus on various methods of remote-teaching available and present a case study of distance-learning which took place at the Jinan University (JNU) - University of Birmingham (UoB) Joint Institute (J-BJI).

## 2. Background

At the J-BJI based in Guangzhao, China, flying faculty lecturing staff (herein referred to as lecturers) are UK-based lecturing staff who fly out to China to teach 20-credit core mathematics modules within a standard BSc UK degree programme in Applied Mathematics.

Increasing movement restrictions within China in January 2020 ultimately led to the decision that staff could not travel to Guangzhou to deliver teaching in person for the foreseeable future. To deliver live sessions, Zoom software (Zoom, 2020) was procured during the week before delivery began, having tested: Skype for business; Big Blue Button; Skype; and WebeX. Lecturers were not sure how well Zoom would work. The main concern was that students would need to access Zoom from their homes and we could not guarantee the speed of their internet connections. An additional concern was the inevitable change in nature of verbal interactions between staff and students, previously being face-to-face. In practice, however, students seemed to adapt quickly and Zoom proved to be an effective tool to facilitate staff-student interaction. For our teaching we would use: the virtual learning environment Blackboard, Panopto, Möbius and Zoom.

Semesters consist of four consecutive four-week teaching blocks, during each of which, typically, 10 credits is delivered by UoB staff to each year group (in addition to credits delivered by JNU staff). The start of the semester was delayed by two weeks, which meant the initial four-week teaching block was condensed into three weeks. Condensing teaching blocks to three weeks has occurred in the past and student feedback (via student representatives and module evaluation questionnaires) has indicated that this is more stressful than four-week blocks. Discussions amongst the wider lecturing team were held regarding how lecturers might adapt their course materials. Motivation to provide additional support to the students led to the provision of extra Q&A sessions each week. Moreover, to avoid overburdening lecturers and students, formative assignment submissions were cancelled.

The case study discussed here corresponds to lecturers A, B and C at the J-BJI teaching year-groups 1, 2 and 3 respectively during 2019/20 academic year, semester 2, teaching block 1. This case study should be considered in context with arrangements within HEI delivering programmes based within the UK.

## 3. Teaching delivery

Traditional lecture-based teaching was substituted with pre-recorded videos and the students had some flexibility in how these were viewed. Students had control over how they distributed their break time, the significant deadline being that viewing of a day's video(s) was to be completed by the beginning of the post-video live 'Q&A session'. For year-groups 1 and 2, Panopto was used to create pre-recorded video content. Alternatively, for year-group 3, pre-recorded videos were a combination of Panopto recordings of lectures delivered at the UoB in 2018/19 and new videos made specifically for the J-BJI. Some students noted that UoB recordings (of traditional lectures) were slower (in terms of pace of delivery of material) and easier to follow. The new videos occasionally omitted pieces of information in the theory, prompting students to pause their videos and fill in the blanks before referring to the full notes for clarification. The time difference between the lecturers (based in the UK) and the students (based in China) meant that potential delivery times of Q&A sessions were limited. It was necessary for these to be held in the UK AM / China PM (see Table 1).

| Session (time in China) | Monday | Tuesday | Wednesday | Thursday | Friday |
|---|---|---|---|---|---|
| 9 (17:35-18:20) | VS | VS | S (all) | VS | S (MAM/ICS) |
| 10 (18:30-19:15) | VS | VS | S (all) | VS | S (Econ/Stats) |
| 11 (19:25-20:10) | VS | VS | | VS | |
| 12 (20:20-21:05) | Q&A | Q&A | | Q&A | |

Table 1 - Generic timetable (subtle differences were present for different year-groups). VS: allocated video viewing session. Q&A: Question and answer session (optional attendance). S: Seminar (mandatory attendance). JNU-taught modules were delivered between 08:30 - 17:25 (time in China) in sessions 1-8. Note the 8 hour time difference with (UoB)-based lecturers.

The pre-recorded videos were organised by topic, sidestepping the usual constraints of lecture session times and providing more coherently organised course content (making revision easier). The allocated video viewing sessions on a given day provided students with structure but students had flexibility to modify the times at which they watched videos, provided they finished the content by the end of the final viewing session. The teaching block contained a total of twenty-seven 45-minute viewing sessions, in contrast to the typical twenty-four lecture sessions under normal teaching circumstances. Recordings were made using either Panopto, Zoom or some combination of the two.

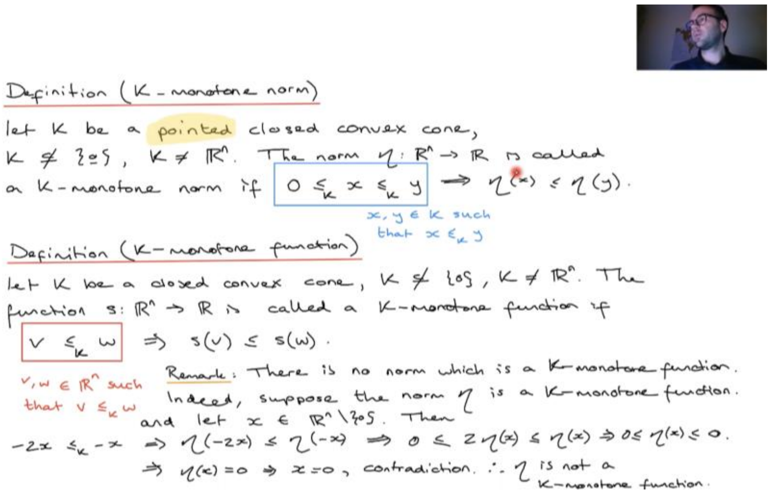


Figure 1 - Two streams viewed during a video recorded on zoom

Two video feeds were used in the recordings - one showing the lecturer and the other showing the on-screen content. Note that Zoom (see Figure 1) outputs an MP4 recording and so students see precisely as is seen in Figure 1, whereas Panopto (Panopto, 2020) outputs a webcast with distinct video feeds so that students have the choice to view both or one as they see fit.

It was a common opinion among the flying faculty lecturing team that students may find it difficult to adapt (considering the requirement to view up to 135 minutes of material over a 155 minute period) and so it was common practice to make the cumulative length of the videos, on viewing days, less than 135 minutes. Practically, there were potential issues: lecturers creating/uploading pre-recorded content in a short space of time (in practice, content was uploaded sufficiently early); students streaming content (content was not downloaded and so stable connections for the students was a concern); and disruption to live sessions (for lecturers and students).

## 4. Additional support

Following each viewing session was a ‘Q&A session’, included in an attempt to mimic the opportunity for students to ask questions after and/or during lectures. Lecturer A encouraged his students to use the hand raising feature in Zoom and ask questions using a microphone. If students had trouble with this, they sent images of questions via the chat function. Lecturers B and C both requested their students to ask questions via the chat function. Additionally, questions sent via email to the lecturers prior to the session were often discussed. Crucially, Q&A sessions were available to students to discuss their findings and inquire further when progress was difficult. Lecturers A and B used Zoom to deliver Q&A sessions and seminars. OneNote was used to capture hand-written content arising from these sessions with all the aforementioned available via Blackboard. For lecturer C, Q&A sessions often served to fill in the missing details via group discussion and students responded positively to this introduction to a flipped learning approach (Lo, Hew, and Chen, 2017). Q&A sessions were not recorded, instead summary pdfs were produced with screenshots from the session.

'Seminars' on Wednesdays and Fridays were delivered via Zoom and allowed students to ask more general questions about their course, not necessarily restricted to one particular topic. Seminars were delivered via a mixture of lecturer-led and Q&A style sessions since discussions sometimes led to the delivery of additional programme specific content. Across all year-groups, the seminars featured some combination of: demonstrating solutions to typical examples; answering questions from the session; and addressing relevant questions received via email in advance of the session (lecturers A and B note that they received fewer student email queries throughout the teaching period than in previous years before the adoption of Q&A sessions). Attendance at seminars was mandatory and monitored using Zoom's attendance monitoring features. Seminars were recorded by administrative support staff (also present in seminars) and made available via Blackboard. We stress here the added value to the student experience of administrative support, which was available to students in real time, in particular at the beginning of the teaching block when students were unfamiliar with accessing, and engaging in, sessions.

Private office hours (1-1 sessions) were conducted each week. Students were invited to join a live video Zoom session where they could speak privately with the lecturer. It is the opinion of the authors that 1-1 sessions were not widely used with only a small number of distinct students using them (relative to the number of students using face-to-face office hours in previous years). On reflection, it appears that Q&A sessions are effective in addressing student concerns. However, it could also indicate that students are less inclined to speak 1-1 with a lecturer with whom they have had little to no contact with in person. Alternatively, this could be a result of language issues. It seems plausible, from past experience, that when several students have questions, the strongest communicator of the group would be elected to represent the group. This hypothesis fits with the experience of lecturer C who notes that although few students attended his 1-1 sessions, the students who attended typically had many questions.

## 5. Assessment

In previous years at the J-BJI, Möbius (DigitalEd, 2020) was used for computer-aided assessment, initially via closed-book class tests and, subsequently, via open-book assessments open for several days. Class tests were invigilated and lasted for 45 minutes. However, due to the remote delivery of teaching, Möbius assessments in this case study were open-book, not invigilated and accessible for several days. Open-book assessments were designed so that students should take roughly two hours in total (excluding revision/preparation time) to complete each assessment. This time limit (as opposed to a limit on the number of questions) was meant to keep assessments, to an extent, uniform amongst courses. Students were given one attempt at each assessment but were able to access each one on multiple occasions before submission. This decision was taken since student timetables were packed, leaving little time for preparation, in addition to the possibility of short-term and unpredictable loss of access to Möbius. Elements of randomisation were implemented in previous class tests and the present open-book assessments, whereby different students typically saw different instances of questions. The scope of randomisation was typically broader for year-groups 1 and 2 where a larger bank of questions existed from previous years. We reflect that in open-book assessments with longer deadlines (when compared to closed-book class tests), one can ask questions which are more complex and/or require a deeper conceptual understanding to answer. For example, inverting a 4x4 matrix is essentially as conceptually difficult as inverting a 3x3 matrix but is more complex and, therefore, only appropriate when sufficient time is available. Perhaps more informatively, one can ask questions to assess deeper conceptual understanding (as outlined in Sangwin (2013)) in assessments open over large time periods when students have access to their notes and can be challenged to develop their understanding beyond the given course material.

Formative assessment was omitted since the group submission structure was deemed to be insufficiently supported in our remote-learning setting due to limitations (more difficult for students to collaborate effectively with each other) combined with the added strain of compulsory submissions. Practice questions were given out for students to use as they saw fit. Solutions were given out sooner than usual so that students could receive timely support during Friday seminars. Consequently, lecturers had concerns regarding individual feedback on deeper concepts. This relates to concerns about timely feedback and discussions on deeper concepts. Specifically, lecturers would not be able to see an individual student's attempts at proof and mathematical writing. There are concerns that some students became isolated, since group submissions were the only collaborative tool we employed prior to their removal.

## 6. Discussion

In the context of remote-learning, students having access to full typeset lecture notes allows them to engage with course material independently of the availability of other resources. This applies more-so when the VLE and related video resources can be sporadically unavailable (here, mostly due to evening/weekend maintenance).

Pre-recording allows us to create videos that can: be used in future years to supplement live lectures; provide resilience in the future if a lecturer is unable to teach at short notice; and enable us to experiment with flipped learning techniques. Practically, the risk that students could experience difficulty in accessing live lectures is mitigated by the inclusion of pre-recorded videos. With this in mind, recordings would typically be made available to students by the Friday of the week prior to the designated viewing session, so that they might exercise some autonomy in structuring their own learning. Note that in future, videos will be made available further in advance and the present deadline was mostly a function of the short-notice nature of preparations. Lecturer C will continue with the flipped learning approach in an attempt to move towards a research-motivated learning environment as the ultimate objective (Brew, 2006). For instance, lecturer C is planning for level H students in future years to be introduced to connections between Game Theory and Tropical Linear Algebra and, consequently, some contact time will be used to examine existing research problems distinct from the given course material. Through extra open-ended tasks, students will be able to explore special cases of unsolved problems and discuss their findings in small groups. Through this, research material will become a component of course content (Russell Group, 2020). Regarding remote delivery style, Bassili (2008) suggests body language is important in communications and so it is advisable that lecturers are visible in recordings. By using Panopto and Zoom, it is easy to accommodate this by displaying multiple feeds.

It is worth advising students on how videos should be viewed. We also note that students for whom English is a second language may experience difficulties in English-medium interaction (EMI) and so it is crucial to take pre-emptive measures to mitigate associated negative effects (Hu, Li, and Lei, 2014). There are two main issues to consider here: delivering content efficiently; and not speaking too quickly. For year-group 3, recordings were delivered at a sensible pace (pace of speaking) but students still felt that they were fast. What is clear is that international students learning through EMI may experience difficulties in keeping pace despite the best intentions of the lecturer. It is suggested by Jiang, Zhang, and May (2019) that complementary English language sessions can help to mitigate these effects by focusing on module-specific vernacular as advised by module leads.

Connection difficulties for lecturer C meant that one Q&A session had to be cancelled at short notice. This seems to be an inherent risk with remote-teaching and is a reminder that pre-recorded content has a significant part to play in the future of online teaching. Conversely, immediate feedback is the main positive in live sessions and thus finding a balance between live / pre-recorded content is crucial.

Panopto (hosted in China for better access speeds for students) had been used in the previous two years (with no major issues) to supplement course materials. During the semester it was used for all lecture content delivery (and accessed far more frequently than previously). The higher load caused unexpected problems for students and staff, which ultimately led to an upgrade mid-semester and lecturers resorting to using UoB Panopto as a back-up (with student access speed issues an inevitable consequence). These events should serve as a reminder to load-test IT infrastructure before deployment (ideally not during teaching blocks).

We reflect that Möbius, when used in conjunction with longer submission periods, posed fewer risks than the corresponding short submission periods in class tests of previous years. This is due to the longer time frames mitigating against short-term loss of access to the internet for the students. In the past, students were forced in these circumstances either to re-start a test (giving them an unfair advantage over their peers) or delay the start of a test. However, in addition, unnecessary stress was placed on students (accidental submission / temporary lack of access / confusion regarding deadlines) which, in our opinion, likely impacted negatively on the student experience. It is not necessarily inappropriate to run short time limit assessments, but conditions need to be favourable to run them in a way in which one has confidence in their effectiveness.

It was decided prior to the teaching block that not all Q&A sessions would be recorded due to privacy concerns. In practice, however, students often asked questions via the private chat function (not captured in recordings) and the questions were re-stated and answered publicly. It seems that recording Q&A sessions (provided students are notified) in future would be beneficial to students whilst preserving their anonymity. It was noted by lecturer C that students would typically not want to ask questions verbally or appear on video during 1-1 sessions. This is in comparison to our face-to-face teaching at the J-BJI in previous teaching blocks, when students appeared less reluctant to speak to lecturers outside of class. It is not clear what the dominating factors are here, some considerations are: the learning culture of Chinese students; language confidence; or asking questions online versus in person (Grimshaw, 2007). This is a problem since if students are completing a dual-degree, they should have opportunities to practise their English speaking/listening and gain in language confidence. It seems that there is a conflict between encouraging students' language development and what is most convenient to deliver mathematics sessions. There does not seem to be a conclusive answer yet as how to best strike this balance.

Q&A sessions were generally very active, with a high number of students attending (relative to the number of students who would typically remain behind for questions after a traditional lecture). Based on the level of engagement, the amount of lecturer-led support seems appropriate. Although lecturers may have viewed Q&A sessions as feedback mechanisms introduced to address the remote delivery setup, to a lot of students they were the most regular and timely feedback mechanism. We have ultimately taken the view that Q&A sessions should remain in both remote and non-remote setups.

Practically, it is often necessary in Zoom sessions with large numbers of students to mute audio and block video feeds. It can, therefore, be hard to gauge if a student has understood a given answer to a question, since visual cues often give an impression of comprehension. It is also common for students based at JNU to use WeChat (2020) over email as a mode of communication with staff in relation to their studies. For practical purposes at JNU, WeChat achieves parts of the functionality of email, Skype (Microsoft, 2020a) and Microsoft Teams (Microsoft, 2020b). However, while JNU classify WeChat as being embedded in the VLE, the UoB classify it as a social media application and hence there is a conflict with UoB policy to avoid the use of social media for official teaching purposes.

This can lead to delays in students having their questions answered. To this end, administrative support staff often mediate questions directed at lecturers via WeChat. Cultural differences like this appear to exist in joint-institute setups but can be readily addressed.

Lecturer A reflects that due to the additional allocated viewing time, he elected to cover all content (including that usually left to the reader) and some students reacted negatively to this, suggesting it was ‘too much’. Lecturer C felt a similar temptation to have a ‘complete’ video series which made producing too much content for the students a real (and unintended) possibility. It should be made clear to students which content is essential and which is optional - perhaps by storing optional content in a separate folder.

## 7. Reflections and conclusions

Content created during this case study will be used in future years, even if restrictions are lifted and face-to-face teaching is allowed to resume as usual. Lecturers A and B propose using the recorded material for content that is preliminary to the course or for non-examinable / technical content. This approach will allow students to engage more deeply in the material if they so wish. Lecturer C proposes to use the videos as the core medium through which the module content is delivered, in an effort to further progress a flipped learning (Brew, 2006) approach. Traditional lectures will become Q&A type sessions during which the most technical content can be discussed and students may compare their own ideas, allowing the allocated lecture sessions to discuss the relative merits and limitations of different approaches (though there are concerns with how well students communicate with each other when working together) (Grimshaw, 2007).

It has also been observed in all year-groups that the Q&A / seminar sessions are preferable to the more traditional ‘examples classes’ where the lecturer would demonstrate solutions or the students may work quietly and only occasionally ask for help privately from the lecturer / teaching assistant. An obvious benefit of this approach is the lack of repetition - questions may be asked privately but answered publicly. In relation, in the traditional setting students do not seem to like to be seen asking questions - Zoom appears to offer a way around this problem. Although not used in the present case study, discussion boards within Blackboard were adopted by other lecturers and seem to be an effective way of encouraging student interaction.

Overall, the experience has been mixed. Certainly, there are positives to take away, for example the Q&A sessions. These have been experimented with in previous years as a contingency plan in case of clashes and missed sessions but it is clear now that these should be a key component of our teaching setup. In future, these will replace a significant proportion of office hours. Also, our computer-aided assessment (CAA) allowed lecturers to cover a greater breadth of material by taking assessment outside of contact hours. Whilst CAA does have limitations in assessing higher level conceptual understanding, the lecturers noticed that this limitation is probably not as great as they initially expected (it is certainly possible to ask deep and difficult CAA questions). There are also, of course, drawbacks to remote-teaching. Face-to-face interaction is lacking and, as such, it is more difficult to get an impression if a student understands what one is talking about. It also seems to hinder students who are less confident to communicate verbally. It is not necessary to omit formative assignment in remote-teaching but its omission in the present case studies made it difficult to ascertain the competency of students’ written proofs and other deeper concepts. It also limited the team-work / collaboration aspect of learning (although this was not helped by the physical distance of the students from one another).

## 8. Acknowledgements

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## 9. References

Bassili, J.M., 2008. Motivation and cognitive strategies in the choice to attend lectures or watch them online. Journal of Distance Education, 22, pp. 129-148.

Brew, A., 2006. Research and Teaching - Beyond the divide. New York: Palgrave Macmillan. Available at https://doi.org/10.1080/03075070701794866 [Accessed 19 November 2020].

DigitalEd, 2020. Möbius. https://www.digitaled.com/platform [Accessed 19 November 2020].

Grimshaw, T., 2007. Problematizing the construct of 'the Chinese learner': Insights from ethnographic research. Educational Studies, 33(3), pp. 299-311. Available at https://doi.org/10.1080/03055690701425643 [Accessed 19 November 2020].

Hu, G., Li, L. and Lei, J., 2014. English-medium Instruction at a Chinese University: Rhetoric and Reality. Language policy, 13, pp. 21-40. Available at https://doi.org/10.1007/s10993-013-9298-3[ Accessed 19 November 2020].

Jiang, L., Zhang, L.J. and May, S., 2019. Implementing English-medium Instruction (EMI) in China: teachers' practices and perceptions and students' learning, motivation and needs. International Journal of Bilingual Education and bilingualism, 22(2), pp. 107-119. Available at https://doi.org/10.1080/13670050.2016.1231166 [Accessed 19 November 2020].

Lo, C.K., Hew, H.F. and Chen, G., 2017. Towards a set of design principles for mathematics flipped classrooms: a synthesis of research in mathematics educations. Education Research Review, 22, pp. 50-73. Available at https://doi.org/10.1016/j.edurev.2017.08.002 [Accessed 19 November 2020].

Microsoft, 2020a. Skype. https://www.skype.com/en/ [Accessed 19 November 2020].

Microsoft, 2020b. Microsoft Teams: More ways to be a team. https://www.microsoft.com/en-gb/microsoft-365/microsoft-teams/group-chat-software [Accessed 19 November 2020].

Panopto, 2020. The Leading Video Platform For Education. https://www.panopto.com/panopto-for-education/ [Accessed 19 November 2020].

Russell Group, 2020. Benefits of the research-intensive learning environment at Russell Group universities. Available at https://www.russellgroup.ac.uk/media/5515/research-intensive-learning-briefing-may-2017-revised.pdf [Accessed 19 November 2020].

Sangwin, C., 2013. Computer Aided Assessment of Mathematics. Oxford Scholarship Online. Available at https://doi.org/10.1093/acprof:oso/9780199660353.001.0001.

WeChat, 2020. Connecting a billion people with calls, cchat and more. https://www.wechat.com/en/ [Accessed 19 November 2020].

Zoom, 2020. Simplified video conferencing and messaging across any device. https://zoom.us/meetings/ [Accessed 19 November 2020].

CASE STUDY/OPINION

# Technological Explorations in the Move to Online Mathematics Support

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## Abstract

Due to Covid-19, mathematics support at Maynooth University transitioned from in-person to online over a very short period in March 2020. This paper provides a brief description of the technologies used by six tutors to facilitate this move. We outline why the tutors picked these technologies and how they used them. We also consider the issues tutors wanted to resolve and reflect on the outcomes of their experiences.

**Keywords:** Online mathematics support, technology, resources.

## 1. Introduction

On Thursday 12th of March 2020, due to Covid-19, the Irish Government announced the closure of Higher Education Institutions for face-to-face teaching. Due to a mid-term break the following week, this gave Maynooth University (MU) six working days before teaching restarted, exclusively in an online environment. As all staff and students at MU had access to Microsoft (MS) Teams, the Department of Mathematics and Statistics (Department) decided to support modules by getting Department and Mathematics Support Centre (MSC) tutors to respond to student queries via drop-in sessions on MS Teams. Students could log on and ask tutors questions in real time.

Due to Covid-19 guidelines, tutors were required to work from home. With the short transition time to online teaching, tutors received some guidance but, in the main, the responsibility was theirs to provide the best support they could to students with the resources they had available. Prior to this, none of the tutors had used MS Teams, or most of the technologies outlined below.

Coincidentally, six MSC tutors were involved in ongoing tutor training. Lawson et al. (2019) identifies training as crucial for tutors of mathematics learning support (MLS) and approximately half of Higher

Education Institutions (HEIs) in Ireland and the UK with MLS provide such training. Grove et al. (2019) give a detailed description of the development of MLS tutor training in Ireland and the UK. Five of these tutors had several years of face-to-face tutoring experience and were on short-term contracts. The remaining tutor, Tara, was a postgraduate student in her first year of tutoring. One aspect of the tutor training involved the use of technology for the development of digital supports. When in-person MLS ceased, the six tutors were encouraged to use their experience of moving to online MLS as part of their digital training and to write a brief report.

In this paper, we use the individual tutor reports as a basis from which to outline the specific technologies they used, how they supported students, and finally, to reflect on the outcomes of their experience. While these were short-term interventions, developed quickly, in difficult circumstances, we hope that sharing an overview of their experiences will assist the MLS community with making informed decisions about the nature of online support they may provide.

## 2. Examples

### 2.1 Wacom Tablet

**Why this technology/support?**
Prior to the onset of Covid-19, the Department already had some 'One by Wacom' creative pen tablets (https://www.wacom.com/en-us/products/pen-tablets/one-by-wacom) available to staff. The tutor (James) had previously used the tablet to record screencasts and wanted to use it, in conjunction with a virtual whiteboard, so students could see him working through problems in real time.

**Technical details.**
The tablet (see Figure 1) comprises of a pen and a writing surface that connect to PCs or laptops via USB. The pen can be used to control the mouse by moving it over the drawing surface. This allows for accurate writing of text and mathematical notation on a computer screen. If the user installs the generic Microsoft graphics tablet driver, then the mapping from the writing surface to the computer screen is not a bijective one. This makes writing on the screen much more difficult, but the issue is easily resolved by installing the product specific driver from the Wacom website.

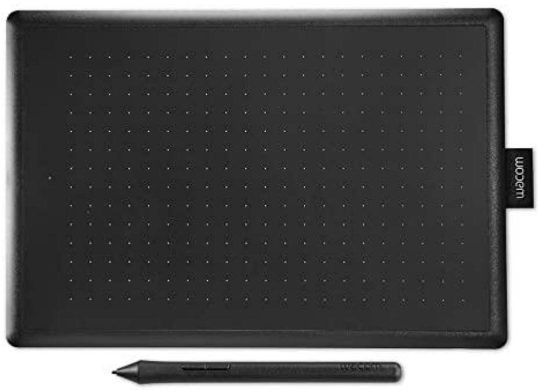


Figure 1: Wacom tablet and pen

**How the resource(s) were used to support students.**
James used the Wacom tablet along with the screen sharing feature of MS Teams during his online hours, approximately 19 each week. When students logged on, they would ask a question or provide pictures of work they had done. James would open the free MS Whiteboard app, share his screen with students and use the Wacom tablet and pen to facilitate clear and accurate writing (see Figure 2). The tablet was also used, along with screen casting software (Explain Everything), to produce 8 short videos to address recurring student problems during drop-in sessions.

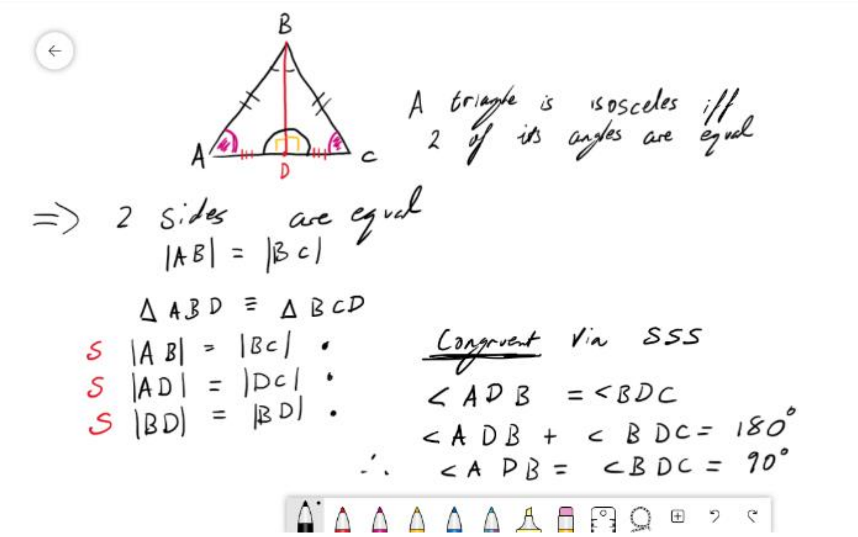


Figure 2. Example of an explanation on MS Whiteboard written via the Wacom tablet.

**Outcomes.**
James found the tablet to be intuitive and responsive. It felt like using a real pen and, after prolonged use, the user can utilise the pen without looking at the writing surface. There was no negative feedback from students in terms of the legibility of the text written using the tablet.

### *2.2 OneNote*

**Why this technology/support?**
OneNote software is provided to both MU students and staff as part of MS Office 365. Calum used this software because of its functionality as a virtual whiteboard and Rachel used it to overcome the issue of not having a tablet, such as described in Section 2.1, to write mathematical text for students.

**Technical details (Calum).**
OneNote provides a blank canvas with utilities that trump the conventional pen and paper. It provides unlimited space both horizontally and vertically, expanding as you input material. You can easily zoom in and out, either to focus on smaller details or to quickly locate previous work. A customisable toolbar provided pens and highlighters in any choice of size and colour. It has a variety of shapes that can be used to create text boxes and add directional arrows. All these resources are clearly visible, with no clutter or excess.

**How the resource(s) were used to support students (Calum).**
Calum used OneNote during 13 sessions each week, and after each session the notebook could be converted to pdf and shared with attendees. Calum found the multiple tabs or pages feature, as described by Rachel (below), very useful for supporting students. OneNote also contains a variety of features that support mathematics directly. Selecting equations using the Lasso tool, in conjunction with the Mathematics tool, opened a side panel which allows the performance of numerous tasks. This includes automatically solving simultaneous equations or differentiating, with detailed steps of the process. A convenient feature was the ability to convert equations to 2D graphs and paste them anywhere in the workbook. This made OneNote ideal for preparing notes and presenting examples.

**Outcomes (Calum).**
Overall, OneNote proved to be an extremely versatile virtual whiteboard. However, some features were problematic in the circumstances. Without a tablet and stylus, writing with a mouse was difficult and quite slow, especially with legibility being so important. The Mathematics tool had limited ability to predict which mathematics symbols your ink represents. Although you can change incorrect symbols individually, a significant amount of time is lost when trying to correct more complex equations. This reduces its practicality in a live session.

**Technical details (Rachel).**
Rachel had a laptop, touchscreen stylus and a Samsung Galaxy tablet. She wanted to screen-share while writing on a digital whiteboard, but writing clearly with a mouse is difficult. She preferred writing on the tablet with the stylus, however, the tablet would not screen-share. Since OneNote can be used in a browser or as an app the same OneNote document (Notebook) could be opened simultaneously on both devices. This was ideal in the circumstances, as Notebooks can be edited collaboratively in real time and can be used as a digital whiteboard. Thus, edits made on the tablet could be seen updating on the laptop and vice versa. This allowed Rachel to use her laptop to screen-share while writing on the tablet.

**How the resource(s) were used to support students (Rachel).**
Being able to screen-share with students while writing, allowed the tutor to provide assistance which resembled in-person support. Notebooks have sections and tabs to organise content, and they support text, drawing, uploading of images, and the embedding of videos and documents like PDFs. A Notebook was created for each of the four modules supported, collating various resources such as practice sheets, lecture notes and statistical tables. Rachel found it particularly useful that drawing tools could write over uploaded pictures and documents. Rachel used OneNote during 15 sessions each week.

**Outcomes (Rachel).**
Writing on one device and screen-sharing on another was cumbersome and is not recommended. A graphics tablet (such as One by Wacom) would easily remedy this situation. However, students, using just their mobile phones, could use OneNote and a cheap stylus to create their own Notebook with the content that they wanted support with. Then, during any sort of audio call, the student could share this Notebook with the tutor who could annotate it in real time.

### *2.3 Group work via MS Teams*

**Why this technology/support?**
The purpose was to try and replicate, in an online space, the group work environment that students would normally experience in the MSC.

**Technical details.**
Similar to ‘breakout rooms’, MS Teams uses ‘channels’. In any Team, you can create up to 30 channels, containing up to 250 members in total. In these channels users can easily screen-share, upload and share files, collaborate on the whiteboard and make video/voice calls with each other. However, unlike breakout rooms which are temporary, these channels are private and permanent, and only available to members of the channel.

**How the resource(s) were used to support students.**
Pádhraic used channels to provide support to 27 students taking a pre-degree mathematics course. Before each session, students were allocated into six separate channels (Group A, Group B, etc.), each channel contained 4-5 students. During the session, students would work on questions together by setting up a meeting in their channel. The group could message if they needed help, and Pádhraic would then join their meeting. He would also periodically jump around each channel to check on student progress.

**Outcomes.**
Some students reported that it could be intimidating to ask a question in class, and that the small group size of their channels created a more inviting atmosphere for engagement. Pádhraic found multiple groups difficult to support at the same time. Also, if a common issue arose across multiple groups, the only way to discuss it with the entire class would be to arrange a separate meeting for all the students.

## *2.4 Videos*

**Why this technology/support?**
Two tutors identified recurring issues during their drop-in sessions and decided to develop short videos with a view to having reusable resources available for all their students. Aisling used a free screen recorder, *Free Cam,* downloaded from www.freescreenrecording.com which recorded calculations on Microsoft Paint using a Wacom tablet. Tara did not have a tablet and used MS PowerPoint to create her videos.

**Technical details (Aisling).**
Free Cam records both your screen and audio. Unlike other free screen recorders investigated, e.g. Icecream Screen Recorder or Debut Video Capture Software, it had unlimited recording time and recordings could be edited. The screen recorder can be any size required and positioned anywhere on the screen. The recordings can be paused and restarted repeatedly using keyboard shortcuts. When editing, segments of the video or audio from sections of the video and volume can be adjusted. However, it is not possible to add anything (audio or video clip) after recording is finished.

**How the resource(s) were used to support students (Aisling).**
Aisling identified common issues of notation and poor exposition during her first-year drop-in sessions and grading. In the Department, students can be deducted marks in their coursework and final exams for exposition. As the issues were module specific, Aisling decided to create three bespoke videos, each under 15 minutes in duration, using Free Cam. One featured the correct use of ‘equal to’ and ‘implies’, and the other two on correct notation when answering integration and probability questions. These were placed on the first-year mathematics workshop Moodle pages.

**Outcomes (Aisling).**

Aisling identified the benefits of being able to make a video with examples and detailed explanations to help students if they were having issues or struggling with a topic in mathematics. She identified the videos as reusable learning objects which could be available for any students struggling with the same topic.

**Technical details (Tara).**

For MS Powerpoint, mathematical notation was created on each slide (Insert Symbol➔Equation➔Ink Equation). The 'Record Slide Show' option was used to record audio inserted over each slide individually. The 'Appear' option allowed expressions to be revealed using the click of a mouse, and a pointer to hover over any part of the slide required. The file must be saved as a .pps (PowerPoint show) in order for it to automatically open as a show, however, for full functionality, the file must be opened in PowerPoint rather than PowerPoint online. To resolve this issue, a video can be created using PowerPoint (File➔Export ➔Export to Video).

**How the resource(s) were used to support students (Tara).**

Tara discovered, towards the end of the second semester module, that first-year students were struggling to identify which method to use when presented with an integral. Due to the specific structure of the module, she could not find suitable materials online. She decided to create a video with a flowchart on identifying appropriate integration methods depending on the problem, and one video of worked examples to reinforce the use of the flowchart. Tara also used MS Forms to develop a quiz for students which allowed them to answer integral questions and receive an indication of those they got wrong along with correct answers. All materials were placed on the first-year mathematics workshop Moodle pages.

**Outcomes (Tara).**

Tara found using PowerPoint to create videos a mixed experience. She had no tablet, and inserting mathematical notation was cumbersome but easier than writing with a mouse. She could prepare the slides in advance of recording the audio, and edit the audio slide by slide to fix any errors, rather than redoing the whole video. Unfortunately, she could not access the 'Insert Form' option to embed the quiz in PowerPoint. This would have allowed her to give clues to students if they had answered questions incorrectly. She felt that having the quiz separately on MS forms made it less interactive.

## 3. Reflections and Future Work

To reflect on the tutors' experiences and consider the implications for future online MLS at MU, the authors held a meeting in June 2020. This online meeting was also attended by Cormac Breen (Technological University, Dublin) and Michael Grove (University of Birmingham). They had received the six case studies in advance and their role was to give an external perspective to the discussion.

The sudden change from face-to-face teaching and the technology available to the tutors was identified as the largest influence on the level and type of online MLS provided. While student engagement with these and other MLS services were low, the tutors observed that once students engaged, they tended to return. This type of engagement with online MLS was commonplace in HE during this period (Hodds, 2020). However, the six trials impacted on Department practices. The trial of the Wacom tablet was positively received, and the Department ordered tablets for all tutors and many lecturers to use for teaching and support during the 2020-21 academic year. The functionality of OneNote proved very popular and most tutors are now using it as their virtual whiteboard of choice. High student engagement with channels in MS Teams, when compared with online drop-in sessions led the MSC to offer study group support through channels for all undergraduates in 2020-21.

In terms of making resources for students, the development of practice and assignment quizzes on Moodle has been given priority by the Department for 2020-21. However, the MSC still creates screencasts for first-year workshops (while in-person MLS is not possible) but based on the tutors' experiences above, sections 2.1 and 2.4, the software 'Explain Everything', which is not free, is being used. Explain Everything has additional editing features, such as the ability to edit pen strokes if the voiceover is correct. This saves valuable time when recording these lessons. Our general approach to videos needs to be assessed carefully, and is being reviewed on and ongoing basis to consider accessibility factors and avoiding the replication of existing suitable resources.

The tutors highlighted that the two-way interaction between student and tutor, which is prevalent in an in-person MSC, needs to be replicated online. They commented on the danger of static teaching, with little or no input from students. Multiple paths to addressing this issue were suggested. Tutors found that microphones rather than text chat options seemed to get more students involved during live sessions, and that students should be encouraged to prompt the tutor's next steps.. The tutors also commented that they could not see what students were writing and that an interactive screen that both tutor and student could write on simultaneously would be desirable. For students that do not have access to a tablet, a cheap soft tipped stylus to write on their phone, as suggested by Rachel, may also work. The tutors also suggested asking students to send PDFs of their attempts which tutors could annotate or address in real-time. Regular use of online quizzes might also help students recognise that they need assistance. One tutor recommended https://itempool.com/ and the YouTube channel of 3Blue1Brown as a good place to start investigating interactive online teaching practices and banks of questions.

Tutors reflected on the challenge of determining student body language and facial expressions in an online setting. During in-person support, tutors can pick up on non-verbal cues regardless of what students might say. The tutors also realised how much they relied on their own gestures, facial expressions etc. when explaining in-person, and that they had to bear that in mind when explaining via audio, writing on screen or recording a video.

The tutors recognised the potential benefits of online support. For example, during in-person support, help is often 1-1 and a tutor may have to repeat a similar explanation several times to different students. Online drop-in tended to have more than one student attending, so one explanation could suffice and even promote discussion amongst students. The tutors also saw the merits of sharing existing videos, where possible, or developing short tailored videos to resolve recurring issues that students were encountering.

From the perspective of the MSC Director, the second author, these six case studies combined two very important features of MLS: ongoing tutor training (Lawson et al., 2019); and the exploration of online MLS, which a 2018 survey (Mac an Bhaird et al., 2020) suggested was not being used to its full potential. While these explorations of technologies and developments of online MLS supports were carried out over a very short period of time, they did have a significant influence on practices in the Department at MU. The case study reports will be available in full from the Teaching and Learning Mathematics Online website [http://talmo.uk/index.html] We hope that sharing this overview of the tutors' initial experiences will be of benefit to the wider MLS community.

## 4. Acknowledgements

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## 5. References

Grove, M. J., Mac an Bhaird, C., & O'Sullivan, C., 2019. Professional development opportunities for tutors of mathematics learning support. *MSOR Connections,14(3), pp.* 4–15. https://journals.gre.ac.uk/index.php/msor/article/view/1021 [Accessed 13 November 2020].

Hodds, M., 2020. A report into the changes in Mathematics and Statistics support practices due to Covid-19. sigma Coventry: Coventry University. Available via http://www.sigma-network.ac.uk/wp-content/uploads/2020/07/Report-into-the-changes-in-Maths-and-Stats-Support-practice-during-Covid-19.pdf [Accessed 13 November 2020].

Lawson, D., Grove, M. & Croft, T., 2019. The evolution of mathematics support: a literature review. *International Journal of Mathematical Education in Science and Technology,* https://doi.org/10.1080/0020739X.2019.1662120 [Accessed 13 November 2020].

Mac an Bhaird, C., Mulligan, P., & O'Malley, J., 2020. Mathematics Support Centres' Online Presence: Provision in Ireland and the UK in 2018. *Teaching Mathematics and its Applications,* https://doi.org/10.1093/teamat/hraa010 [Accessed 13 November 2020].