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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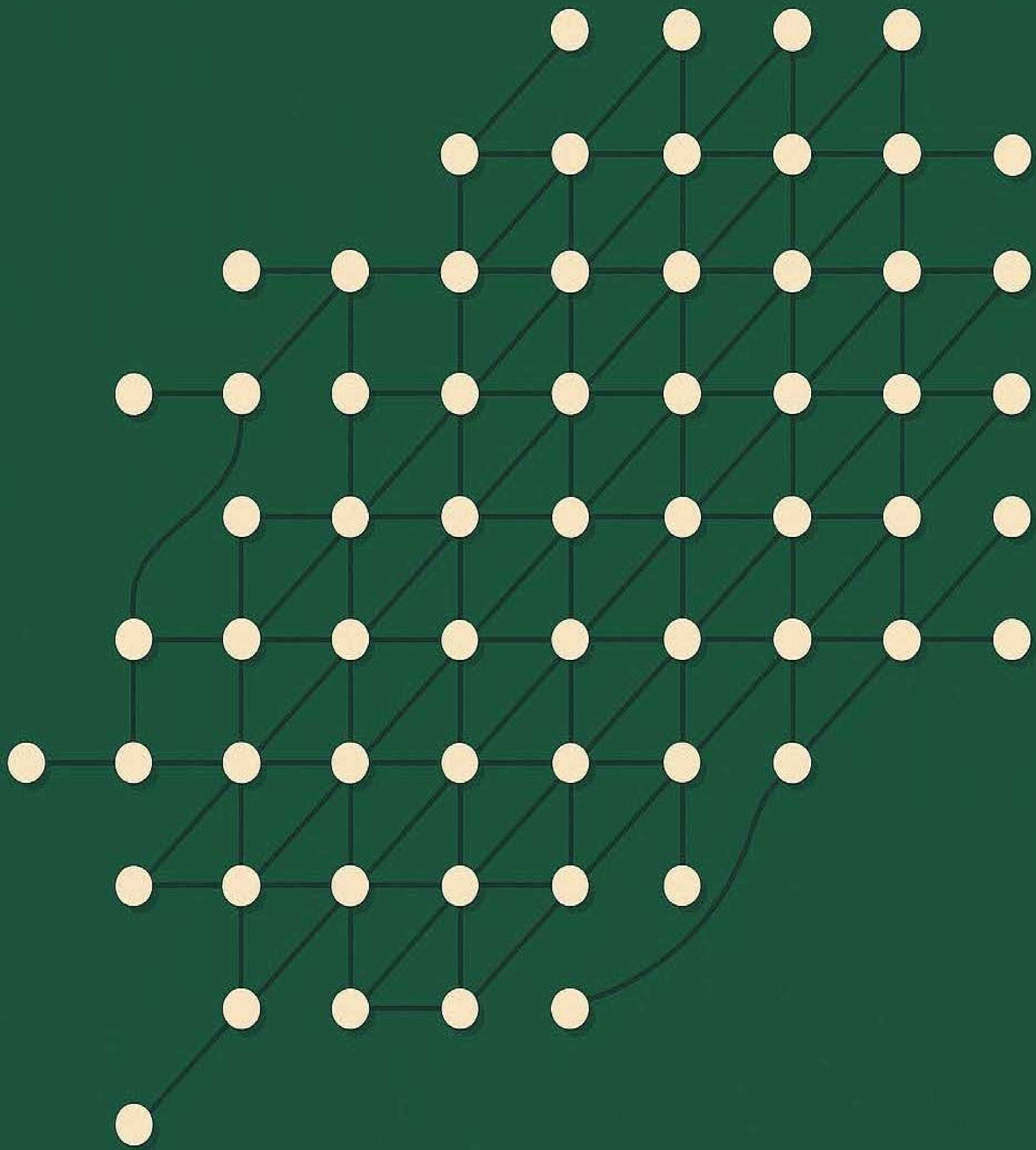

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Editorial

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Welcome to this issue of MSOR connections, the first of two issues featuring papers arising from presentations and workshops delivered at the CETL-MSOR Conference held at the University of Liverpool in September 2025. The conference brought together practitioners from the learning, teaching and support communities across Mathematics, Statistics and Operational Research, alongside those working in related disciplines such as Mathematics Education and Staff Development. The programme explored a wide range of topics including supporting students with statistics and data analysis, building student confidence with mathematics or statistics, transition of mathematics students into or out of higher education, initiatives to enhance student engagement or student community in mathematics and mathematics teaching and support in times of generative AI.

The first two papers in this issue focus on involving students as partners, a theme that was also the subject of the conference's first keynote presentation. We are delighted that the keynote speaker, Louise Walker has contributed a paper co-authored with two students Sophie Marshal and Sarah-Sonia Balan. Drawing on the keynote presentation, the paper explores two Students as Partners projects undertaken and reflects on the experience of those involved. In the second paper, Thomas Coleman examines two approaches used at the University of St Andrews to facilitate the co-creation of mathematics and statistics support resources. Comparing and contrasting these methods, he presents examples of the resources produced and discusses the perspectives of both students and supervisor.

The second group of papers focuses on Generative AI and addresses two key themes. The papers by Ben Derrek and Peter James, and by Carol Calvert and Emma Steele both examine how students can use Generative AI to support their studies. Derrek and James focus specifically on a business research module, exploring how students can use Generative AI to assist them with specific tasks, such as survey design and the interpretation of research findings. Calvert and Steele consider how educators can support students in making ethical and informed decisions on how and when to use Generative AI. The other two papers examine Generative AI, from an academic perspective. By examining AI literacy, pedagogical integration, perceived trust and acceptance Maryam Alarfaj explores whether academics in Saudi Arabia have accepted Generative AI. Ria Symonds discusses how Generative Ai can streamline the assessment cycle, including the designing discipline specific assessment, the creation of detailed rubrics and the enhancement of feedback.

The final group of papers explores mathematics support and the development of mathematics education within higher education. Shazia Ahmed, Jenny August, Emma Coutts, John McDermott and Morgiane Richard provide insight into the changing landscape of mathematics and statistics support in Scotland, documenting developments since the last report in 2016 and recommendations for the future. Clare Wallace, Dan Evans, Sam Fearn, Stephen Harrap, Jamie Mason, Maciej Matuszewski, and Daniele Turchetti outline their collaborative approach to conducting scholarship and pedagogic research at Durhan University discussing its benefits and challenges. In the final paper of the issue Jason Yip. Ciarán Mac an Bhaird and Peter Rowlett report on a workshop delivered at the conference exploring the how the use of historical narratives foster inclusivity, enhance student engagement and support a stronger sense of belonging particularly for under-represented groups.

It was a pleasure to attend the CETL-MSOR Conference 2025 and engage with the vibrant mathematics and statistics education community. The articles in this issue reflect many of the themes and conversations that emerged during the conference. My thanks go to all the authors who contributed papers and to the reviewers whose careful and constructive feedback made this issue possible. Their collective efforts are greatly appreciated.

MSOR Connections can only function if the community it serves continues to provide content, so we strongly encourage you to consider writing research articles or case studies about your practice, accounts of your research into teaching, learning, assessment and support, and your opinions on issues you face in your work. Another important way readers can help with the functioning of the journal is by volunteering as peer reviewers. When you register with the journal website, there is an option to tick to register as a reviewer. It is very helpful if you provide appropriate information 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.

RESEARCH ARTICLE

1+1 is greater than 1: Developing Scholarship with Students as Partners

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Abstract

This article is based on a keynote presentation delivered by the corresponding author at CETL-MSOR in September 2025 at the University of Liverpool. The article is co-authored with two student partners. It explores the pedagogy of students as partners and how this can be used to develop scholarship of teaching and learning in mathematics. Examples are provided of projects involving the authors on assessment and feedback literacy and the development of scholarly informed activities for abstract algebra teaching.

Keywords: Scholarship, students as partners, feedback.

1. Background

The 'student voice' has become an important part of quality assurance in higher education. The National Student Survey introduced a new set of questions under Student Voice in 2017; the Teaching Excellence Framework included an independent student submission in 2023 and the UK Quality Code for Higher Education includes 'Engaging with students as partners' as one of its core principles (QAA 2024).

There are several ways that the student voice can be recognised and utilised, for example student surveys and via student representatives (Peart, Rumbold and Fukar 2023). Student surveys offer an opportunity to capture feedback from all students but, in practice, response rates can be low due to survey fatigue and other factors (Adams and Umbach 2012). It is important to close the feedback loop by ensuring that students see how their feedback has been acted on. However, a 'you said, we did' approach can appear transactional, reinforcing the idea that students are 'consumers' of their education.

Student representatives are widely used in higher education but due to competing demands on their time, they may not always be able to fully represent their cohort and provide timely feedback to their peers. If student representatives are expected to do this as an unpaid voluntary role, this may exclude this opportunity for students who need to undertake paid work alongside their academic studies.

2. Students as Partners

Students as Partners (SaP) is a pedagogical approach where students and academic or support staff work collaboratively to improve teaching, learning and the student experience (Healey, Flint and Harrington 2014). There is an ongoing dialogue between staff and student partners and an emphasis on learning from each other so that all parties benefit from the experience. SaP projects will often take place over a several weeks or months and the student partner may receive payment for the work which means they are viewed more as a colleague, breaking down the academic-student hierarchy. Student partnerships may focus on co-creating teaching and learning resources, co-developing the curriculum and university policies or co-researching in the scholarship of teaching and learning (Peart, Rumbold and Fukar 2023).

At the University of Manchester the corresponding author has been involved in a variety of SaP projects over several years. In particular, the development of Peer Assisted Study Sessions in the mathematics department since the early 2000s (see the case study in Robinson et al. 2010). In this article we describe recent projects on feedback literacy and scholarly informed activities for abstract algebra teaching.

3. Feedback Literacy and Active Self-Feedback

Developing students' feedback literacy has been shown to support students' learning and enhance their ability to self-regulate their learning (Carless and Boud 2018). In June and July 2023, the corresponding author worked with colleagues in the mathematics department (Nikesh Solanki, Cesare Ardito and Rose Wagstaffe) and a student partner, Sophie Marshall, on a project looking at assessment and feedback literacy. The student partner was employed as a Student Experience Intern, funded by the University of Manchester. She had recently completed the first two years of an undergraduate programme in Mathematics and Philosophy.

3.1 Survey

The project team developed a survey that was sent to all progressing undergraduate Mathematics students. There were 75 students who completed the survey, a small proportion of the cohort, but this was not surprising given that it was distributed outside termtime. The survey was anonymous but students were asked to report their year of study and their predicted degree class. The survey asked a range of questions about how students used different forms of feedback.

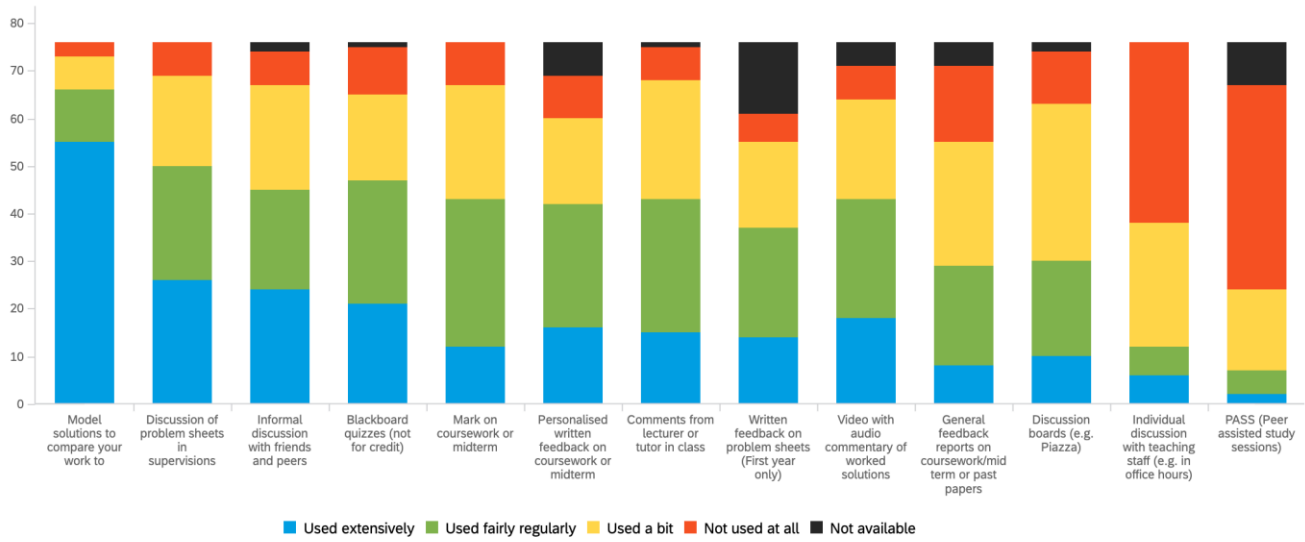

Figure 1. Summary of survey responses to the question: For each of the following sources of feedback, how much do you use them?

In one question, they were given a list of methods of feedback and asked how much they used them. The responses are given in figure 1. It was interesting to see that model solutions were used far more than other forms of feedback, suggesting that students were routinely making judgements about the quality of their own work by comparing it to solutions produced by their lecturers.

A later question asked students how often they felt confident judging the quality of their work without help from staff or peers. The results were broken down by current degree class grade (this information was self-reported by the students), see figure 2. These results suggest that students with higher grades may feel more confident self-assessing their academic work.

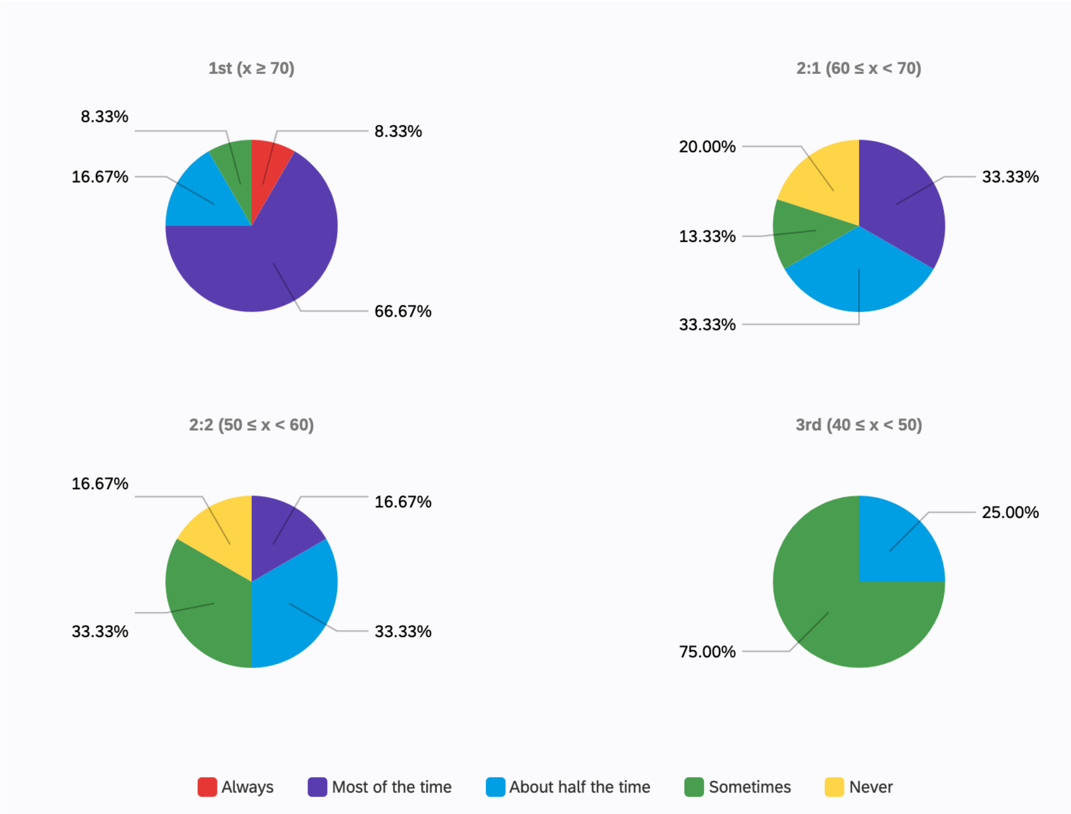

Figure 2. Summary of survey responses to the question: How often do you feel confident judging the quality of your work without help from staff or peers?

3.2 How to Study Maths Course

Using the survey results and the research literature, the student partner wrote a student guide on effective use of feedback and worked with the academics to prepare materials for a new study skills course called How to Study Maths. This course focuses on assessment and feedback literacy and addresses the 'hidden curriculum' in mathematics teaching (Orón Semper and Blasco, 2018). The hidden curriculum has been defined as "*what is implicit and embedded in educational experiences in contrast with the formal statements about curricula and the surface features of educational interaction*" (Sambell and McDowell 1998: pp391–392). The How to Study Maths course includes sessions on assessment and feedback literacy. In the assessment session, students see how exam questions are constructively aligned to the course units' intended learning outcomes and in the feedback session we explain the purpose of feedback and how students can use it effectively. The students are told that the sessions were co-created with a student partner to make them more relevant and encourage students to take ownership of their learning. This course has been delivered as six sessions across semester 1 for approximately 280 first year single honours mathematics students since September 2023.

3.3 Active Self-feedback

During the feedback literacy project, our student partner became particularly interested in a technique called ‘active self-feedback’. This feedback literacy method was developed by a colleague, Jennifer Rose, from the Alliance Manchester Business School (Nicol and Rose 2025). Active self-feedback is based on the theory of inner feedback, introduced by David Nicol (Nicol 2021). The idea is to make use of students’ natural ability to make comparative judgements by comparing their work with an exemplar such as a model answer, peer work, a mark scheme or an AI generated answer. These comparisons are then made explicit by the students using a short list of questions to which they record their answers.

This initial feedback literacy work led to a collaboration between the lead author, Jennifer Rose and Jen McBride (an academic in Psychology) in which we ran a cross-Faculty project demonstrating how active self-feedback could be used in a range of disciplines to support activities such as essay/report preparation, engineering design, note taking and mathematical proof writing. We were able to employ the same student partner, Sophie Marshall, to work with us for 12 months. The student partner took part in some of the activities, developed case studies with the academics and co-produced a staff and student training resource (Rose et al. 2025). This resource includes 18 case studies, including the use of active self-feedback to support the How to Study Maths assignments. These assignments linked to the live sessions and used the online tool peerScholar (peerScholar 2024) to facilitate peer feedback and active self-feedback. Students first submitted their own work and then they were able to compare their work with the anonymous submissions of two other students. The students then provided peer feedback and self-feedback by answering a short set of questions. At the end of the course in December 2025, students were asked to complete a survey and reflect on what they had learned from the active self-feedback process. Of the 285 students on the course, 169 completed the survey. Common themes that appeared in this reflection were

- there is more than one way to solve a maths problem.
- the importance of using words to explain the steps in a proof
- explanations should be clear and well-organised
- using precise language makes answers more concise but still correct
- the ability to judge how they are progressing academically compared to their peers.

4. Scholarly informed activities for abstract algebra teaching

During the summer of 2025, the corresponding author worked with a student partner, Sarah-Sonia (Sonia) Balan on a London Mathematical Society funded Undergraduate Research Bursary project. Sonia had recently completed the second year of the MMath Mathematics programme at the University of Manchester. She was particularly interested in exploring the pedagogical theories that could support teaching abstract algebra and we saw this as an opportunity to work together to develop scholarly informed teaching and learning activities.

Sonia interviewed six lecturers in the department who currently teach on abstract algebra course units. In these interviews she explored the challenges the lecturers face in their teaching and the pedagogies they have used to try and engage students. In the interviews Sonia was able to talk about her own and other students’ experiences of learning abstract algebra.

We explored the education literature and co-developed some teaching and learning activities based on pedagogies such as inquiry-based learning, concept images and example spaces, concept tests, active self-feedback and self-explanation training for proof comprehension.

Sonia produced a report summarising the theory and providing examples of the activities. This report has been shared with colleagues in the department and some of the methods have been adopted by lecturers this academic year.

5. Reflections

The corresponding author's experience of working with student partners has been very rewarding and fruitful. Academics and students bring their own expertise to the partnerships to create a deeper understanding of the interlinkage of teaching and learning to the benefit of all parties. Developing an effective partnership takes time and effort to overcome the academic-student power dynamic. It is important for students to be involved from the start to shape the direction and goals of the project. Regular communication is key to give student partners the confidence to challenge the academic and be involved in decision making throughout the project. If possible, it is important that the students are also involved in dissemination activities, although these may take place after the project is completed. Although the number of students that can be involved in these partnerships may be small, the quality of the interactions is rich, with an on-going dialogue across several weeks or months. The outputs of SaP projects may have more credibility with other students than those produced by staff alone, although we have not formally evaluated this.

Sophie and Sonia reflected on their experiences as student partners. Sophie commented:

"*Overall, I have found my six weeks working on assessment literacy and feedback to be an interesting, fulfilling and enjoyable experience, and I have had some brilliant opportunities for self-development, both as a mathematics student and professionally. My ability to work independently and manage myself, while also remain collaborative and ask for help where needed is by far the most significant area of personal development which I will take away from this internship.*"

Sonia observed that "*a key aspect of this project is the fact that its value lies on both sides, for lecturers and for students.*"

Sonia has written a blog reflecting on her experience of the project and at the LMS undergraduate summer school called 'The Summer I became a Mathematician'. This has been published in the December 2025 LMS newsletter and includes a link to the project report (Balan 2025).

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CASE STUDY

Involving students in co-creating an open educational resource in mathematics and statistics via enterprising education methods

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Abstract

This case study investigates the use of two enterprising education mechanisms at the University of St Andrews to facilitate student co-creation of mathematics and statistics support resources. It explores what these mechanisms are and how they work, and how these mechanisms have contributed to the establishment of an accessible and inclusive OER in mathematics and statistics co-created by students.

Keywords: students as partners, digital learning resources, accessibility, inclusivity, enterprising education, vertically integrated projects

1. Introduction

1.1. Students as co-creators of open educational resources in mathematics and statistics

An *open educational resource* (OER) is defined to be *'…learning, teaching and research materials in any format and medium that reside in the public domain or are under copyright that have been released under an open license, that permit no-cost access, re-use, re-purpose, adaptation and redistribution by* others' (UNESCO, 2026). OERs form a cornerstone of United Nations Sustainable Goal 4 (UN, 2025); examples include MIT OpenCourseWare, Khan Academy and Wikibooks (Nguyen, 2025). All of these contain sections on mathematics and statistics but tend to be skewed towards US use. In the UK, there have been several initiatives to provide authoritative OERs in mathematics and statistics, such as MathCentre (MathCentre, 2025), StatsTutor (Owen et al., 2010) and Helping Engineers Learn Mathematics (Harrison et al., 2009). However, none of these UK-based resources have involved students in their creation and rely on LaTeX-generated pdfs for distribution, compromising digital accessibility.

Involving students as co-creators of teaching resources is a wide area of both study and practice (Mercer-Mapstone et al., 2017), and students have been directly involved in co-creating OERs (Cox and Masuku, 2023). Co-creation activities specifically in mathematics and statistics can be found in (Cornock, 2021), (Cox and Masuku, 2023) and (Richard and Brady-Van den Bos, 2024). However, these were focused more on existing university courses, rather than the wider area of mathematics and statistics support. Involving students in co-creation of resources has also been shown to facilitate inclusivity of materials and draw awareness to EDI issues in education (Curtin and Sarju, 2021).

1.2. Mathematics and statistics support at St Andrews

Mathematics and statistics support at St Andrews is minimal. While there has been historic one-to-one support, provided by graduate teaching assistants (GTAs) on an ad hoc basis (Ahmed et al., 2018), this was discontinued in 2024 due to staffing concerns. Presently, any module-specific maths and stats support is provided by module teaching teams and not through a central support unit. Personal discussions with Directors of Teaching (DoTs) and students across the University, together with the observed anxiety surrounding mathematics and statistics as a service subject (Bromage et al., 2022), highlighted a need for comprehensive, inclusive, bespoke mathematics and statistics support for non-specialists in St Andrews.

1.3. Vertically integrated projects (VIPs) and enterprising education

The primary mechanism for this case study is a Vertically Integrated Project (VIP). These projects are designed to *'engage students in long-term, large-scale, multidisciplinary research as they work alongside faculty and graduate students to solve real-world challenges'* (VIP consortium, 2025). Evolving from the engineering-only EPICS program at Purdue in 2006 (Coyle et al., 2006), VIPs were fully established as a multi-disciplinary venture at Georgia Tech in 2009 (Baxter et al., 2011). Over 50 universities across the world now host VIP programmes, with three in the UK; Strathclyde, Bath, and St Andrews (Mitka et al., 2023). VIPs at UK universities almost exclusively focus on research projects, with some EDI-focused examples; but to date, no VIP in the UK solely focuses on co-creation of resources to support learning of a STEM subject. Together with the STEP programme (see Section 2.1), the VIP programme at St Andrews provide examples of mechanisms for *enterprising education*, defined as *'…the process of developing students in a manner that provides them with an enhanced capacity to generate ideas, and the behaviours, attributes, and competencies to make them happen'* (QAA, 2018). Students on the VIP programme at St Andrews typically agree that this endeavour develops their transferable skills under this umbrella of enterprise education (Mitka et al., 2023).

2. Mechanisms and participation

This case study investigates two mechanisms employed to involve students in creating accessible mathematics and statistics resources: the *Summer Teams Enterprise Programme* (STEP, Section 2.1) and the VIP programme (Section 2.2).

2.1. First mechanism: STEP

From (University of St Andrews, 2025a), STEP is:

"…an opportunity for undergraduate students to invest 7 weeks in participating in a fully-online skills development programme, where they will work on a real-life project designed and supported by University staff, gain virtual team-work experience in a group of diverse students, contribute to the University's learning and teaching through working on impactful outputs, and get this experience listed on their HEAR [Higher Education Achievement Report] *transcript."*

Staff are invited yearly to propose a STEP project, running between academic years. Staff do not directly supervise; projects are 'sponsored' by academics and administered by a GTA acting as a mentor. Any STEP project is self-contained and is expected to be completed in that summer. Continuing from (University of St Andrews, 2025a) *"The typical minimum time commitment is 4-6 hours/week over the course of 7 weeks of the programme"*; leaving 28-42 hours for students to complete the project.

The STEP project '*Creating supplementary learning resources in the School of Mathematics and Statistics'* was proposed and ran in 2023. Split into two teams and with one GTA between them, 15 students from a variety of years and disciplines participated in and completed the project.

2.2. Second mechanism: VIP

At St Andrews, the VIP scheme is run by the International Education and Lifelong Learning Institute (IELLI), a cross-discipline academic school of the University. From (University of St Andrews, 2025b):

"A …VIP is an ongoing research project led by an academic supervisor and made up of a team of students from any level of study (the 'vertical' aspect). The team of students can come from different subject areas with diverse backgrounds and skills across both arts and science. Students can earn credits and receive a grade for the project. They may be able to remain on the project for several semesters…."

With their line manager's permission, staff can design and supervise a VIP, to start in either Semester 1 (S1, September-December) or Semester 2 (S2, January-April). Each VIP is designed to run over several semesters. Staff have complete discretion over assessment structure, subject to approval by IELLI.

Students are invited to apply for at most two VIPs by IELLI twice a year, who handle these applications centrally. A list of applicants is then passed to the supervisor, who has full control over selection of students. The credits earned by a student are flexible, with course-loads to suit their degree programme (with 10 credits as a minimum). A student who takes 10 credits would be expected to spend 100 hours on the project.

Extending the above STEP project, the VIP *Creating accessible online mathematics and statistics resources* was established in September 2024, running in both S1 and S2. The students applied to participate in either S1, S2, or both. The selection criterion was enthusiasm for the project, with no reference to the student's wider grade record. In total, there were 13 students (observed 5M/8F) who took part in 2024/25, with 7 in each semester (see Figure 1). Enrolled student degree programmes varied from mathematics and computer science to cell biology and art history, bringing diverse perspectives to the VIP.

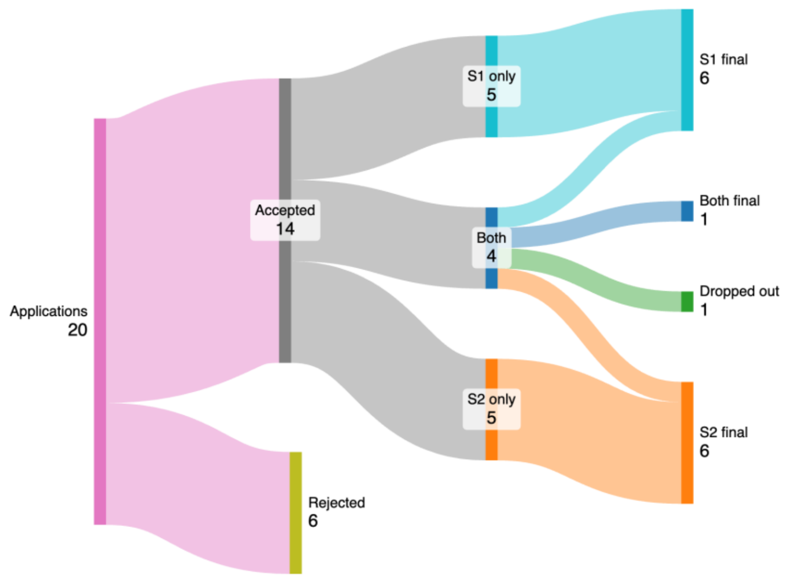

Figure 1: Flow of VIP students from application to participation in 2024/25.

The assessment structure is as follows:

- 20%=5×4% *reflective logs,* short written pieces reflecting on progress during a two-week period,
- 30% *group posters and presentation* at the semestral internal VIP showcase,

- 50%=40% *final portfolio* + 10% *final reflective log*, consisting of all the student's individual work for the project plus a longer reflective log summarising the semester.

These assessments are marked wholly by the project supervisor; as per School policy, they are vetted both internally and by an appropriate external examiner.

Importantly, the final portfolio need *not* contain any creation of resources. As VIPs emphasise interdisciplinarity, it is possible to contribute to the project in different ways other than writing materials; see Section 3.2 for more.

All 13 students enrolled in 2024/25 completed and passed the VIP.

2.3. Maximising impact

Given the congested market for OERs (Section 1.1), ensuring points of difference for student outputs is key. Here's how the project maximises impact:

Accessible: To create a truly accessible OER, a markup language was sought that has the best of all worlds: instant accessibility (such as html); printable material (such as pdfs); and editability (docx formats). The markup language Quarto provides all these from a single source file and integrates extensive documentation and website-building facilities (Figure 2). Accessible design principles (such as suitability for colour-blindness) were discussed and followed.

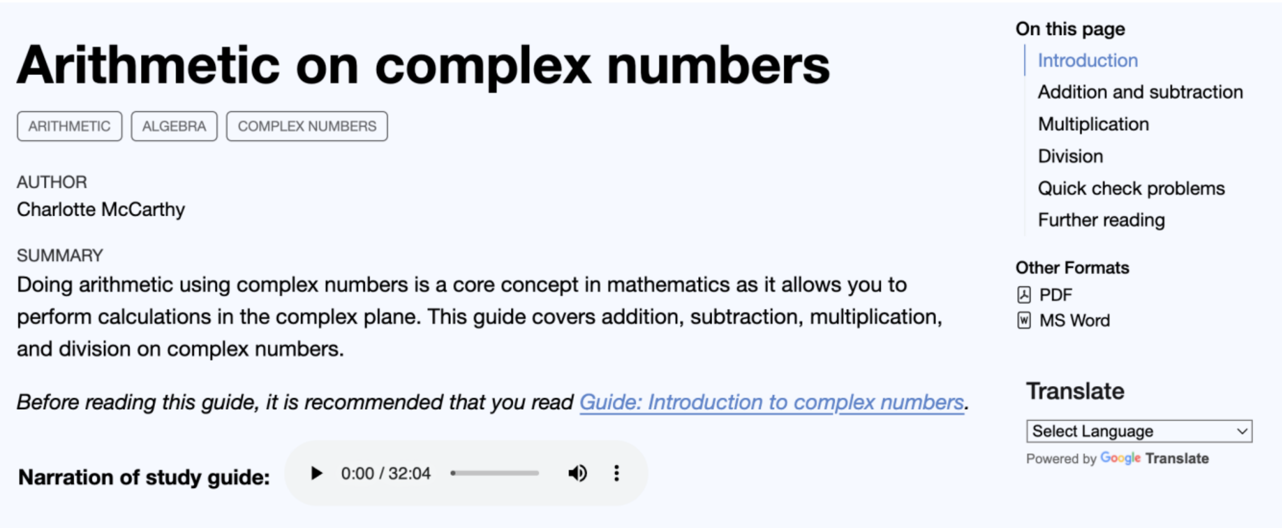

Figure 2: An example of Quarto website output on a html page. Access to pdf and docx outputs are on the right. The 'narration of study guide' is the result of a student-led project to provide downloadable mp3 narrations of materials.

Inclusive: Written in the second person ('you' not 'we'), materials use 'simpler' English than one may normally find in traditional learning resources. This includes avoiding jargon, context, and words like 'easy' and 'clear' which can alienate learners. The aim is to cater for those who may have specific learning difficulties, or who speak English as a second language. To ensure this, a house style guide --- inspired by the British Dyslexic Association style guide (British Dyslexic Association, 2023) --- was written before the STEP project began.

Free-to-use: The materials are hosted on a publicly available, free-to-use website called St Andrews Resources in Mathematics and Statistics (STARMAST, https://starmast.org). All resources are licenced under the terms of a Creative Commons CC-BY-SA 4.0 license, cementing the students' work as an OER.

Granularity: Resources are aimed to be as granular as possible, improving accessibility of information and ensuring a clean division of labour among student contributors. They consist of: *study guides* which introduce a single topic in mathematics/statistics with associated *question* and *answer sheets; factsheets* providing summaries of a single topic; *proof sheets* which go into more detail about where results come from; and *overviews* that bring together key ideas from many other guides.

Interactivity: The site makes use of interactive elements to assist learning. Each study guide has a set of automatically marked 'quick check' questions, enabling users to check their knowledge in real-time. The website enjoys free use of the Desmos API to produce bespoke interactive graphs. Generative AI is used to help develop interactive flowcharts and calculators.

2.4. Evaluation and data collection

No specific student feedback for the STEP project was made available.

The VIP project was evaluated using the standard St Andrews Module Evaluation Questionnaire (MEQ). This is a fully anonymised survey, running in both S1 and S2, containing Likert-scale and free-text questions.

Qualitative data were also obtained from the reflective logs written by the students themselves, detailing the students' feelings and reflections on their project work. Where these data have been sourced in this way, written consent has been sought and granted from the relevant student. These students retained the right to withdraw consent for usage up until submission of the paper, as well as receiving a final draft copy before submission.

3. Student outputs

3.1. STEP

The condensed nature of STEP, and lack of supervisory time with the project sponsor, meant that outputs were restricted to resource creation. These included guides, questions, and answers on topics in algebra, geometry, and trigonometry. The twelve topics covered provided a base for expansion, allowing the more open-ended VIP to build on the existing framework of the website.

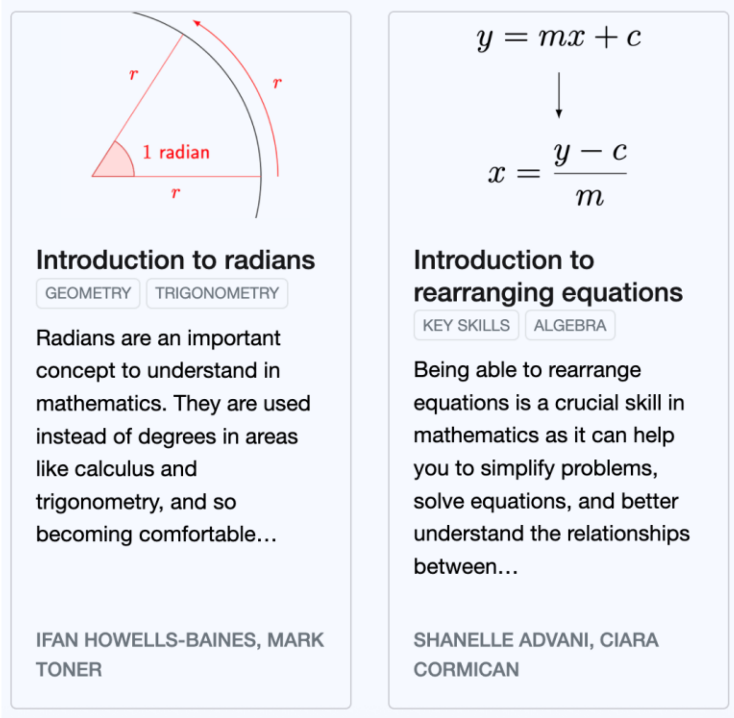

Figure 3: Two examples of the twelve study guides created by students on the STEP project.

3.2. VIP

The open-ended nature of the VIP, allied with a greater focus on interdisciplinarity, allowed the project to encourage a greater breadth of student outputs, including research into accessibility tools, website back-end work, and marketing.

At the start of each semester, each student met individually with the project supervisor to discuss how best they could contribute, allowing students to have agency over their work and to utilise their individual strengths. For instance, computer science students worked on the website back-end. Here are some more examples:

Materials: guides, questions and answers on topics ranging from rationalising the denominator to partial differentiation, setting up new types of content such as overviews and interactive calculators.

Website backend: domain name, emails, security, hosting, and analytics; search engine optimisation; custom website style based on accessible design principles; feedback boxes and mailing list setup with CAPTCHA (Figure 4).

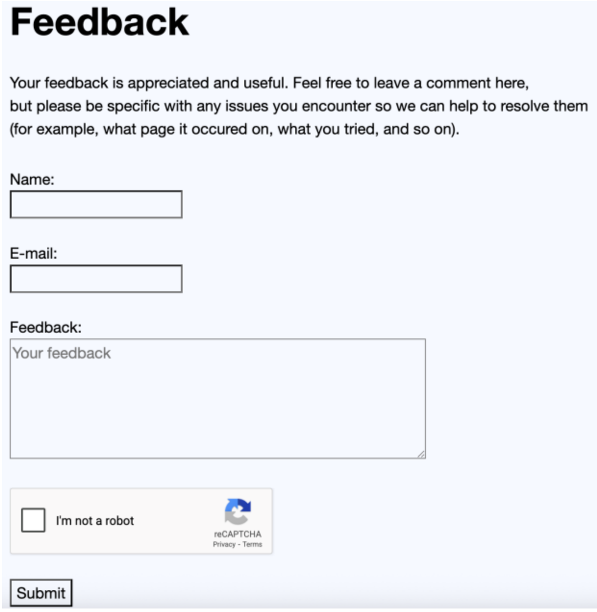

Figure 4: Custom feedback box, appearing on all materials.

Accessibility and interactivity: setting up partnership with Desmos, R&D of accessibility tools such as text-to-speech mp3 narrations (Figure 2), using generative AI to help develop interactive learning tools (Figure 5).

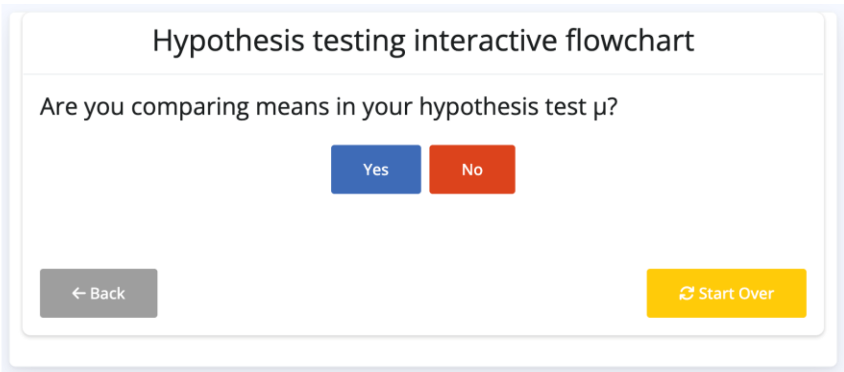

Figure 5: Hypothesis testing interactive flowchart, created with the help of R Shiny Assistant.

Marketing: developing a brand-kit (including logo and colour scheme) that provides a distinctive visual identity while following accessible design principles, establishing a social media presence (Figure 6).

Figure 6: (left) brand-kit created by the S1 team. (right) Instagram template for announcing the release of new material.

Student outputs are demonstrated at the VIP showcase, allowing students to promote their work using posters and presentations (see Figure 7).

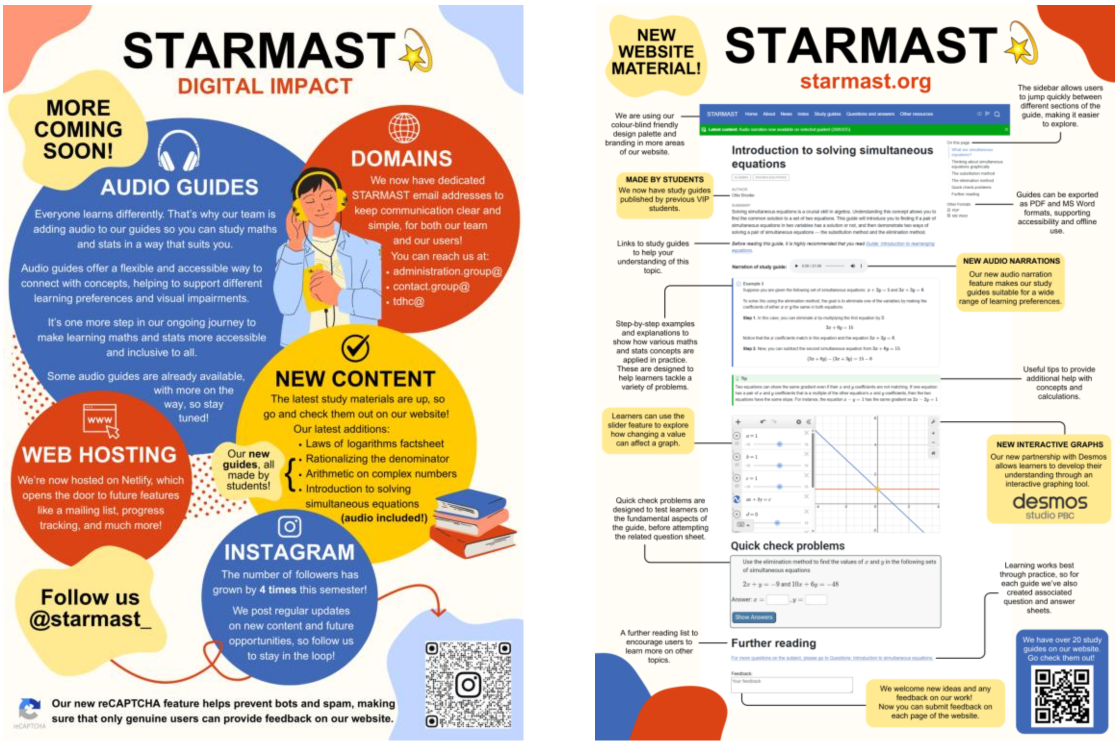

Figure 7: A pair of posters from the S2 2024/25 VIP conference.

4. Outcomes and discussion

4.1. Student and supervisor perspectives on the VIP

Student feedback on the VIP focused on a few strands. The first was on transferable skills that are common to enterprising education schemes:

'I have developed a whole host of valuable skills that I would never have had an opportunity otherwise' (MEQ)

'I also got to develop lots of transferrable skills including teamwork, presentation, time management.' (MEQ)

Students found the focus on accessibility useful:

'I also have a much better understanding of the considerations required when creating accessible documents.' (MEQ)

'Following STARMAST's style guide encouraged me to consider how even the tiniest of details in written content can affect the accessibility of the piece.' (reflective log)

'Looking ahead to a career as a secondary school maths teacher, this module … has made me more sensitive to the different needs of learners...' (reflective log)

There were some frictions with the project, particularly when it came to teamwork:

"Although much of the teamwork was constructive, there were difficult moments. During the VIP Conference preparation… several key elements were removed by others with little prior discussion. I felt disappointed and frustrated." (reflective log)

Overall, the students found the project to be a success, noting direct impact of the project:

'I genuinely believe that this project has been so successful, challenging, engaging and enjoyable that I would not change anything…' (MEQ)

'Absolutely loved this project… I loved that I could actually see direct consequences of the work I was doing…' (MEQ)

From a supervisory viewpoint, it has been incredibly rewarding to have students bring diverse perspectives on a single common goal and then enabling them to follow through on their ideas. The opportunity to emphasise transferable skills has been refreshing, and I am now incorporating these ideas in my everyday practice. As an educator used to standard chalk-and-talk delivery and traditional closed-book examinations, it has been an unfamiliar experience to assess reflective logs and group work, but one that I feel has made me a more well-rounded practitioner.

4.2. STEP vs VIP

The structure of the STEP project had its advantages and limitations in the context of the long-term planning of the project. A short, sharp project lends itself well to providing a single resource or (as in this case) a base for a longer-term project. All the requested resources were created, and the students appeared to be satisfied with their work.

However, this was not a collaborative activity – the hands-off supervision arrangement did not allow for clear communication between staff and students. Consequently, the resources were of inconsistent quality with some parts missing or inaccessible. This then led to a huge staff time investment preparing resources for publication; time that could have been better spent communicating to students about *how* to create accessible and inclusive resources.

The VIP, with its open-ended nature and hands-on supervision, is more suited to a longer-term project. Weekly contact allows students to discuss issues in resource creation with the supervisor in real-time, facilitating co-creation. Any issues could then be ironed out at the point of inception; *teaching* students how to write. Allied to the fact that students receive a grade and credits for their work as opposed to a certificate, this results in a significantly higher-quality output than the STEP project – although resources still require significant editing time ahead of publication on the website.

Common to both STEP and VIP is a focus on enterprise and entrepreneurship. Throughout both STEP and VIP, students were encouraged to use the project parameters as an initial framework to research and develop their own ideas for impact. This approach particularly suits the open-ended VIP, contributing to an incredible breadth of outputs (see Section 3.2). As students can take the project across multiple semesters/years, there is a possibility that they can work on larger ideas that would not be possible in STEP; an example was the creation of downloadable mp3 narrations of study guides.

STEP and VIP facilitated different parts of a large undertaking. The STEP project (short, sharp, self-contained) is ideal for creating a 'proof-of-concept'. The VIP then expanded this; once a framework is in place, the students use their creativity and the flexible structure of the VIP to stretch the limits of what is conceivable.

4.3. 2025/26 and beyond

The VIP project in S1 2025/26 has evolved from a proof-of-concept stage to an active part of the University community, where strategic goals now rely on feedback by end-users. For instance, after discussions with DoTs at St Andrews, STARMAST has now been adopted by three academic schools and IELLI for mathematics and statistics support. Any topics highlighted were worked on; this has resulted in the production of twelve study guides in S1 2025/26. Other student initiatives this term have been audits of website accessibility and analytics, an outreach strategy, a custom search-engine, and video content. There has been a greater emphasis on teamwork to avoid the friction of 2024/25, with a team-building exercise run early in the semester. Measuring the impact of resources by quantitative analytics data and qualitatively surveying end-users (students, tutors, teachers etc) is a natural further topic.

Interestingly, all the concepts above are more commonly found in a business environment rather than an academic one. It seems only fitting that the use of enterprising education methods has led to a functioning enterprise, where students are adequately compensated for their work. I am very excited to see the continued progress of the VIP, particularly regarding the creativity and enthusiasm of participating students.

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CASE STUDY

Transforming Quantitative Research Projects: Empowering Students with Generative AI

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Abstract

This case study explores the integration of generative AI into a large-scale undergraduate business research module at the University of the West of England (UWE), Bristol. Delivered to over 300 students annually, the module 'Introductory Business Research Project' supports second-year learners conducting both qualitative and quantitative research. The quantitative methods section of the module delivery includes a targeted lecture with guided prompt engineering, and dedicated quantitative methods tutorials facilitated by a team of statistics experts. These sessions focus on survey design, data preparation, and analysis interpretation; encouraging students to critically engage with AI-generated outputs. Our experience was that students found generative AI particularly helpful for structuring work, selecting statistical tests, and sourcing references. The approach has led to deeper engagement, reduced reliance on repeating basic support, and improved confidence among students with varying levels of statistical background. However, challenges include inconsistent staff adoption, and limited student transparency in reporting AI use.

Keywords: Artificial Intelligence, Generative AI, Statistics, Quantitative Research, Undergraduate.

1. Introduction

The use of generative AI within mathematics and student research is fraught with risk including but not limited to: the propagation of incorrect or fabricated results; erosion of conceptual understanding; diminished academic integrity; overreliance on opaque tools, bias in generated explanations; and the weakening of students' ability to reason, prove, and communicate ideas independently (Alper, 2026; Klowden & Tao, 2026). However, generative AI tools will be present for the long term, so it is important to embrace discussion and offer solutions now (Alper, 2026; Klowden & Tao, 2026). The growing consensus in the literature is that generative AI can be considered as a tool to aid in education rather than replace educators; with careful design of pedagogy the risks can be reduced while benefits can be enhanced (Samala *et al.*, 2025).

A tailored support model was introduced for students undertaking introductory business research projects. As part of a second-year business research module in the UWE Bristol Business School, students are required to develop a research question, collect data, conduct analyses, and report their findings. Delivered to over 300 students per run, the first generative AI enhanced iteration was delivered in 2024 (see Section 2 for full details).

UWE Bristol is a member of the GenAIOzUK survey study led by Coventry University (Owen *et al.*, 2025), with local institution distribution and ethical approval. This study sought to gain student perceptions of generative AI usage for undergraduate and postgraduate students with some element of statistics learning in their studies. Findings from the GenAIOzUK survey (Owen *et al.*, 2025) are presented in Figure 1 and Figure 2. Responses are from 724 higher education students across 8 universities in the UK and Australia, as at 26/3/2025.

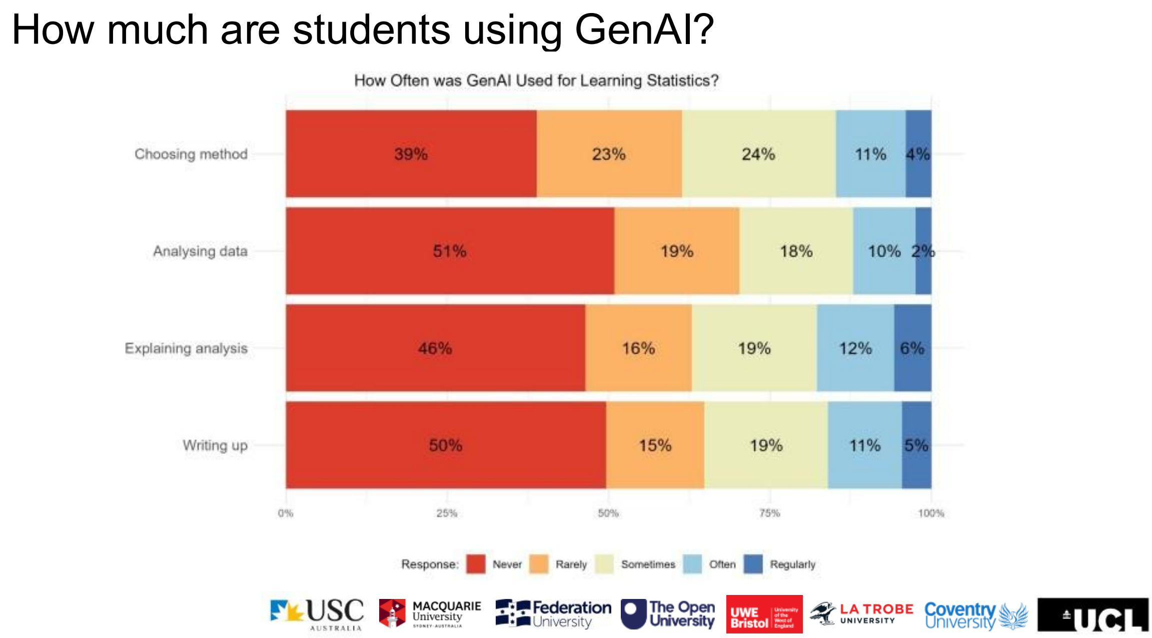

Figure 1. Student awareness, as presented at RoSE E-Conference (Owen *et al*., 2025).

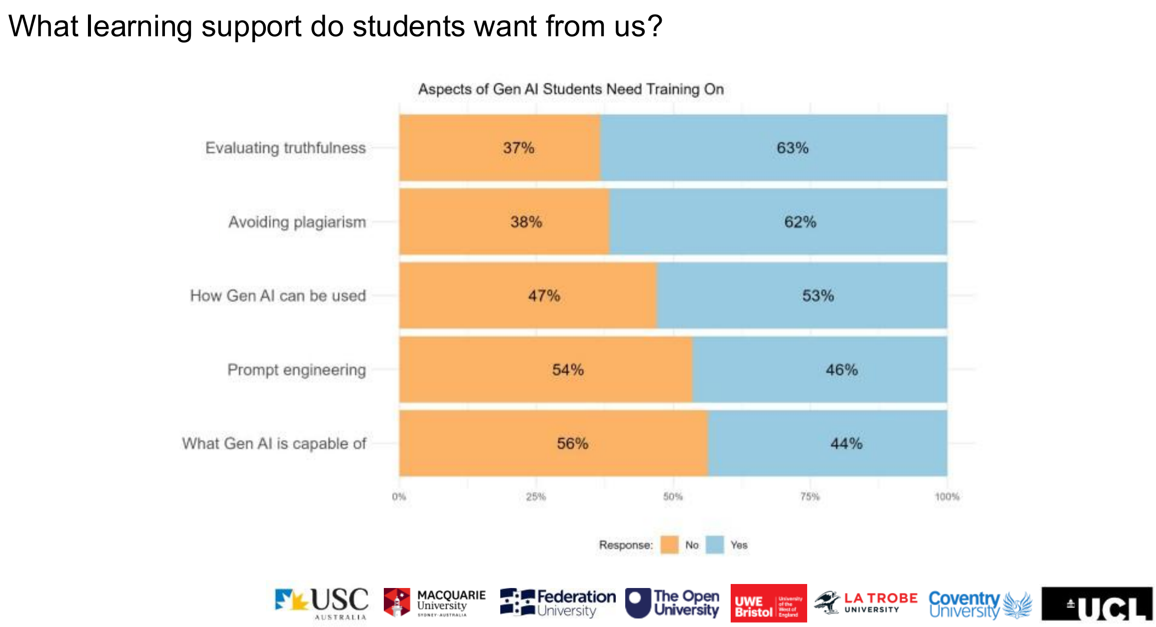

Figure 2. Student support requirements, as presented at RoSE E-Conference (Owen *et al*., 2025).

Figure 1 shows limited awareness of the potential role of generative AI in quantitative methods. This indicates that there is scope for increasing student awareness of the support that can be provided by generative AI. The need for academic support relating to learning enhanced by generative AI is further demonstrated in Figure 2. This indicates that in many cases approximately half of all students surveyed would benefit from further training on appropriate use of generative AI. Concerns around evaluating truthfulness and ensuring academic integrity are prevalent. Large-scale survey evidence from undergraduate statistics students in the UK and Australia shows that, despite widespread awareness and use of generative AI, many students report low trust in its outputs, anxiety about academic misconduct, and uncertainty about how to use the tools productively, highlighting the need for structured, guided approaches rather than ad-hoc adoption (Shaker, Owen *et al.*, [in press]). The GenAIOzUK study also demonstrated that generative AI usage is associated with reductions in statistics anxiety and increase in confidence while studying statistics (Shaker, Dunn *et al.*, 2026). Student confidence improves when generative AI validates their proposed analytical approaches or recommends familiar techniques, while providing additional guidance for statistical methods across a broad range of contexts. Together, these findings motivate development of structured support models incorporating generative AI in teaching and learning.

The implemented support model is grounded in two key principles: encouraging both the ethical use, and the effective use of generative AI tools. Ethical use refers to how students engage with generative AI in ways that align with academic integrity, transparency, and fairness. This includes acknowledging when and how AI has been used, avoiding plagiarism, ensuring that AI-generated content is not misrepresented as original student work, and being mindful of biases or inaccuracies in AI outputs. Effective and correct use focuses on how well students can apply AI tools to enhance their research process, learning and cognitive thinking. This involves utilising AI appropriately for tasks such as formulating hypotheses, refining research questions, exploring data analysis techniques, or interpreting statistical output, without over-relying on the technology or misapplying its capabilities.

The activity formed part of normal teaching practice and is reported here as reflective scholarship.

2. Case study detail

The statistical tools needed for the project are introduced in earlier first-year and second-year modules. Students enter with varying levels of foundational knowledge of these methods depending on prior engagement. Previous module deliveries often relied upon repeating foundational material. The integration of generative AI to support the staff-student experience changes the emphasis from teaching basics to higher-level engagement.

At the start of this second-year project, students are given a one-hour lecture on appropriate and effective use of generative AI. Students then work in small groups to complete their quantitative research projects and are offered twelve one-hour timetabled sessions with a tutor. Attendance for these sessions is not mandatory nor formally recorded.

Of the twelve weekly tutorial sessions, nine are facilitated by subject area specialists, while three are led by quantitative methods specialists. It is in preparation for, and during these quantitative methods sessions delivered by a team of statistics experts, that students are particularly encouraged to explore the use of generative AI. The three tutorials, are broadly split between:

1) study / survey design;
2) preparing data for analyses;
3) analyses / interpretation.

ChatGPT was used in the examples provided to students in the first iteration, as the best-known generative AI support tool at that time. However, in future iterations Microsoft Copilot is used, as supported and licensed by the university.

The lesson plan for the three quantitative methods tutorials includes beginning each session by reviewing preparatory work of students that have engaged with generative AI, then the academic discussing within the individual groups while they continue working on their project. Links to university wide general principles and resources are signposted to students, with the teaching focus on the context specific use within quantitative research.

Figure 3 summarises the lecture; it gives the students an idea of aspects which they could engage with generative AI, with additional appropriate cautions given during the lecture and tutorial discussions.

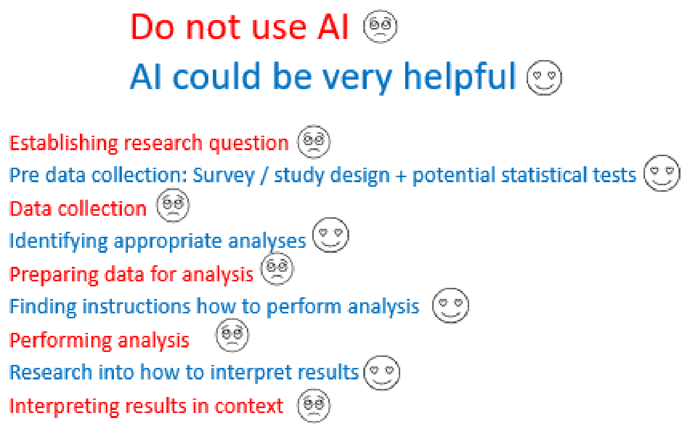

Figure 3. Slide from UMCDMA-15-2 lecture series.

Figure 3 gives students the clarity that integrated use of generative AI is permitted and encouraged for research and exploration in learning and assessment, akin to a 'green light' traffic signal from the strategy options introduced by Grove (2025).

Students are guided to consider their research question in terms of response variable and explanatory variables, so that they can generate appropriate prompts for generative AI. Students are provided examples of prompt generation for choosing appropriate statistical tests (see Figure 4 and Figure 5). The guidance provided builds upon the success of 'Stats Clinic', a statistics drop-in support service (Derrick & Weir, 2025). These prompts were developed through many hours of author experimental trial and error in ChatGPT (GPT-4) with several example scenarios, using prompts by Owen (2023) and Goodale (2024) as a starting basis.

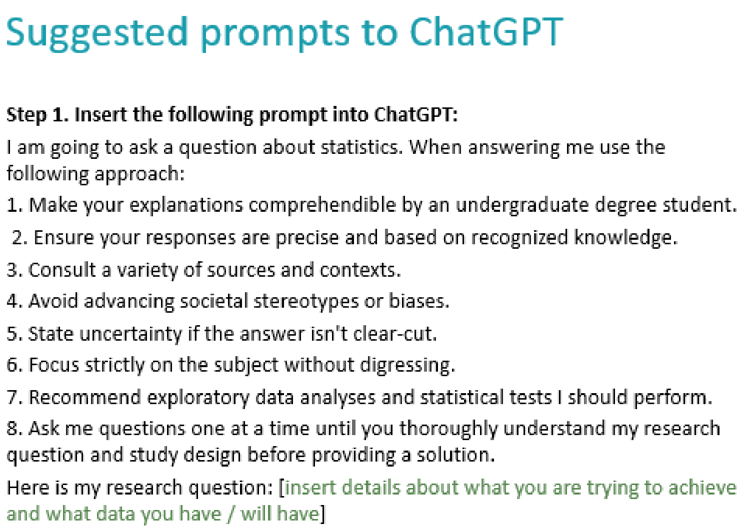

Figure 4. Slide from UMCDMA-15-2 lecture series.

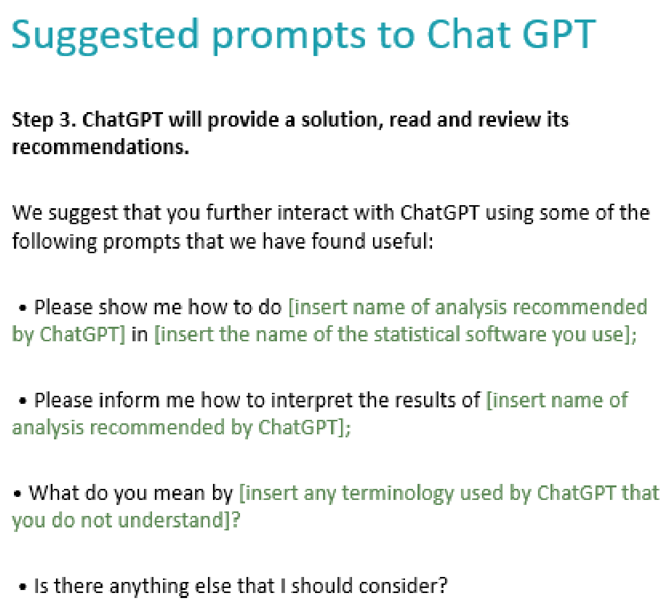

Figure 5. Slide from UMCDMA-15-2 lecture series.

The prompts are discussed with the students including discussion of additional prompts that may be useful. Generative AI help is poor where the student does not know the basics such as their research question or structure of their data. Students are encouraged to learn this point via attempting to prompt generative AI to assist with their analyses; and then identifying any poor responses that are due to student lack of engagement with, or refinement of, the recommended prompts.

Tutors provide demonstration of good and poor interaction with generative AI, including discussion of improvement. The importance of the mantra '*garbage in, garbage out'* is strongly emphasised. This highlights the idea that flawed, poorly thought-out, or irrelevant inputs such as unclear research questions, poorly designed survey questions, or poorly relayed to generative AI will inevitably lead to unreliable or meaningless outputs, regardless of how advanced the analysis tools or methods may be.

As part of the module ethos to encourage students to engage with the discussion around appropriate generative AI support, students were encouraged to complete the GenAIOzUK survey. It is observed that the act of answering the survey was a good teaching method, prompting students to consider and learn how they can use generative AI appropriately and effectively within project work.

3. Discussion

Students generally responded positively to the teaching delivery enhanced with generative AI, expressing during tutorials that they enjoy discussing the outputs, and receiving validation for relatively autonomous work. There is a shared sense among the teaching team that the groups which actively engaged in the learning approach are making meaningful progress in both their understanding and quality of their project work. Rather than revisiting basics via didactic teaching, students were able to critically interpret AI-generated outputs and build upon them, leading to richer learning experiences. A key learning point demonstrated is that students need some understanding of the topic so that generative AI can be used effectively as an assistance tool, rather than a poor replacement for the student researcher.

While 'optional' attendance is not a new feature to the module, the risk of low attendance is observed. Although overall attendance was similar to previous years, those who did attend made more meaningful use of the sessions. Tutors also noted a decline in the number of basic support requests received ad-hoc via email or otherwise, indicating that the AI assisted approach may be helping students with lower confidence in numeracy to work more independently. At the same time, more students appeared to pursue and achieve advanced learning goals, suggesting the model not only supports weaker students but also facilitates stretch goals for stronger students.

Students that reported using generative AI during the module stated that it was useful. Within classes, recurring themes of areas where students found generative AI useful were structuring of work, finding appropriate statistical tests, and sourcing appropriate references or materials to review further. Students asked to sum up their experience of generative AI, were mostly positive, with the most frequently occurring statements including ‘useful’; ‘helpful’; and ‘tool’. However, a smaller number of students responded negatively to the use of generative AI, with expressions of ‘inaccuracies’ and ‘cheating’. These findings are consistent with those from the GenAIOzUK survey (Owen *et al.*, 2025).

The module leader, who is not part of the statistics delivery team but has oversight of the module and assessment submissions, reflects that there are more students using the correct tests or at least coming to a decision about which to use than a few years ago. However, few students stated details about how they utilised generative AI in either of the two requirements for assessment - a report and a personal reflection. The lack of transparency relating to the support that generative AI provided in final assessment submissions is something that we plan to resolve by adding to the reflection requirements of the assessment, and module review. Students appreciated the transparency given from our explanations of where using generative AI is encouraged or discouraged. We recommend fully setting out terms and conditions of both appropriate use and citation of generative AI in each learning activity and assessment as per Grove (2025).

A significant challenge has been coordinating a team of staff to ensure consistent delivery, particularly given the limited staff training in generative AI and the lack of consensus around its appropriate use. The varying levels of staff engagement with these processes are therefore understandable. Some staff followed the provided lesson plan closely, embraced the technology, and incorporated their own relevant ideas. Meanwhile, a few members of staff remain hesitant, preferring more traditional teaching approaches. These challenges are common across the higher education sector (Alexander and Davies, 2025). A key recommendation is to focus on building both staff consensus and training. As per the approach within this module, training should go beyond simply endorsing ethical use of generative AI. Training must also equip staff with the skills to teach with it effectively themselves, particularly in prompt engineering and critique of output. This is increasingly important as the academic role shifts toward actively training students in the effective and responsible use of generative AI.

With academic learning of generative AI being self-taught and self-researched, there are things the authors have identified that could have been done differently regarding the integration of generative AI within this module. For example, already some of the prepared classroom activity for this module is outdated, including the use of ChatGPT rather than other generative AI tools. In addition, we have begun using a Microsoft Copilot agent as an interactive AI assistant, which has in-built suggested prompts and instructions provided by academic staff to guide the responses that the tool generates, similar to that presented by Owen and Sanchez Andalco (2025). As generative AI tools evolve, the guidance we give students within the classroom and supporting materials needs to be continually monitored and evolve accordingly.

While over-reliance on generative AI is expected to pose challenges in the coming years (Lee *et al.*, 2025), students who participate in course directed discussion are well positioned to develop a more balanced use of the technology.

Further work is in progress to generalise the guidance for the use of generative AI within any student research project, including exploration of the use of Microsoft copilot agent discussed above.

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CASE STUDY

Addressing Generative AI fear and inertia: A three year ongoing journey

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Abstract

This case study examines changes introduced in an undergraduate statistics course following the release of ChatGPT in November 2022. Our primary aim was to support students in making informed and ethical decisions about their personal use of generative AI (GenAI). Survey data collected from students and teaching staff indicate that both groups are more positive about the ethical and practical implications of GenAI compared to peers within the School of Mathematics and Statistics. For students, greater engagement with GenAI appears linked to reduced anxiety and improved confidence in learning statistics, which may contribute to observed reductions in withdrawal rates. Teaching staff reported increased understanding of GenAI's potential and confidence in their role in guiding students toward its responsible use as a learning aid. These findings highlight the ongoing shifts driven by GenAI and the impact of specific actions taken to support students and staff to incorporate GenAI into students' learning strategies.

Keywords: Generative AI, Learning aid, students, change, retention.

1. Introduction and Background

Since the launch of ChatGPT in November 2022, GenAI has provoked mixed reactions across higher education (HE). Student use of GenAI continues to rise (Freeman, 2025) and reliable detection is acknowledged as challenging (Hardie et al., 2024). Since work by Davis (1989) there has been substantial literature on how to encourage students to adopt new technologies, but GenAI introduced a different environment—one requiring both technological and cultural change—which students have often been quicker to embrace than institutions.

Emerging research explores GenAI's role in HE (James & Andrews,2024; Grove, 2025), but practical accounts of guiding students in its ethical and individual use remain limited. This paper reports on an initiative, over three years, aimed at encouraging students to critically consider their engagement with GenAI. Students may decide to use GenAI as a study support tool, to help them tackle their formative assignments, or choose not to use it at all.

The context is a distance-learning institution delivering a second-year, 30-credit undergraduate statistics course to approximately 600 students per cohort. Students access printed materials, online tutorials, forums, and assessments via a virtual learning environment (VLE). Teaching is provided by around 30 Associate Lecturers (ALs), each supporting a tutor group of approximately 20 students. A central team set assignments, examinations and design and organise any course changes.

2. Methodology

The delivery model for this distance-learning course relies on teaching by ALs, making their engagement critical to influencing student behaviour. Previous research suggests that lecturers' attitudes toward GenAI are shaped by their own usage and views on learning (Caellos et al., 2024; Kaplan Rakowski et al., 2023). Consequently, to understand ALs' views and practices, the central team constantly engaged with the ALs through surveys and informal discussions via forums and online meetings.

To support ALs, the central team provided guidance and resources, including examples of GenAI outputs for assessment tasks and optional “second opinions” on suspected misuse. A proforma was introduced for all assignments to encourage students to acknowledge GenAI use and facilitate conversations with ALs. A sustained “nudge” approach (Thaler, 2008) was adopted to build AL confidence and acceptance of GenAI. ALs were formally surveyed twice, with the second survey contributing to a broader survey of ALs across the Mathematics and Statistics school in 2025.

Direct communication with students, by the central team, was higher than usual to provide timely and consistent guidance. Student surveys included participation in a multinational survey in 2024–25 which also included students on two other courses at the University. The proformas provided information on student use of GenAI – both in assignments and as a learning aid when studying course materials.

2.1 In course guidance

Written guidance for students, tailored to the course, was first issued in September 2023 preceding most University-wide guidance. This guidance has been updated annually to reflect changes in students’ engagement with GenAI tools, developments in the tools themselves, and the evolving institutional position. From September 2023, the central team provided recorded tutorials on GenAI use, and for the 2024-25 cohort, students also received a short video of ALs outlining potential applications of GenAI.

All assignments are available on the VLE before the course begins. For the 2025 cohort, assignments included tasks requiring students to critically evaluate GenAI-generated outputs. These tasks were designed to encourage reflection on responsible GenAI use and to enable ALs to formally offer feedback on use of GenAI.

Guidance distributed to students was shared with ALs, alongside additional AL-specific guidance. Confidence and awareness among ALs have grown over time. Currently, the central team provides tutorial materials emphasising the importance of critically verifying GenAI outputs against module content, which ALs use in early tutorials.

2.2 Acknowledging use of GenAI

The October 2023 cohort was permitted to use GenAI in all formative assignments, with an expectation that any use of GenAI would be acknowledged. Acknowledgement proved challenging for students. To address this, a structured proforma was introduced in 2024–25 and refined for the October 2025 cohort (see Appendix one). The proforma now serves to:

- Remind students that GenAI is available and may support their learning in various ways.
- Provide a simple, consistent mechanism for acknowledging GenAI use.
- Offer insight into patterns of student engagement with GenAI.
- Indicate whether ALs are engaging with students about GenAI use.

For the 2024–25 cohort, written feedback based on proforma data was shared with students (Appendix two). For the 2025–26 cohort, similar feedback was presented in graphical form (Figure

1). ALs received comparable information for their tutor groups. This approach aimed to increase transparency, encourage discussion, and reassure students that choosing **not** to use GenAI is entirely acceptable.

2.3 Collection of student and AL views

Asynchronous forums within the VLE are integral for both students and ALs. For students, an additional forum dedicated to GenAI discussions was created for each cohort. For ALs, views on specific aspects of GenAI were gathered through their forum and explored further during live online meetings.

These forums provided informal feedback, complemented by surveys in both the 2023–24 and 2024–25 presentations. Student surveys were anonymous: conducted via the VLE in 2023–24 and as part of a multinational study in 2024–25 (Shaker et al., 2025). This latter survey also included students from a third-year economics course and a large first-year, service-mathematics course, enabling internal comparisons within the university. Additionally, an online focus group with a small group of students allowed deeper exploration of how GenAI supports their study practices.

Tutor surveys were distributed directly to ALs, with results shared and discussed via the AL forum. Subsequent inclusion of some identical questions in an ALs survey across the School of Mathematics and Statistics enabled comparisons of AL perspectives. Other courses in the school, at the time, did not allow the use of GenAI in formative assignments.

3. Results

3.1 Student acknowledgement and differential use of GenAI

Proforma data revealed consistent differences in GenAI usage between qualification groups. In 2024–25, over half of students following an economics qualification reported using GenAI in their fifth assignment, compared with only 20% of students on mathematics/statistics qualifications (Table 1). Across all groups, GenAI use increased as the year progressed, with overall acknowledgement rising from 25% to 35%. For the 2025–26 cohort, even higher levels of GenAI use were reported with 47% reporting use in their first assignments. (Figure 1).

Table 1: Percentage of students indicating GenAI use in assignment: 2024-25 cohort.

	Assignment number				
Qualification group	**1**	**2**	**3**	**4**	**5**
Mathematics and Statistics	16%	22%	21%	23%	20%
Data Science	31%	36%	39%	44%	43%
Economics	32%	45%	44%	49%	52%
Open /Other quals.	16%	23%	25%	23%	33%

The proforma was revised for 2025–26 to capture additional detail on how students use GenAI both for assignments and in helping then to understand course materials. Approximately one-third of students reported using GenAI as a study aid (Figure 1) with the highest percentage being amongst the economics students. Figure 1 also shows that a consistently higher percentage of students, at around half, reported using GenAI in assignments with economics students again being the highest users.

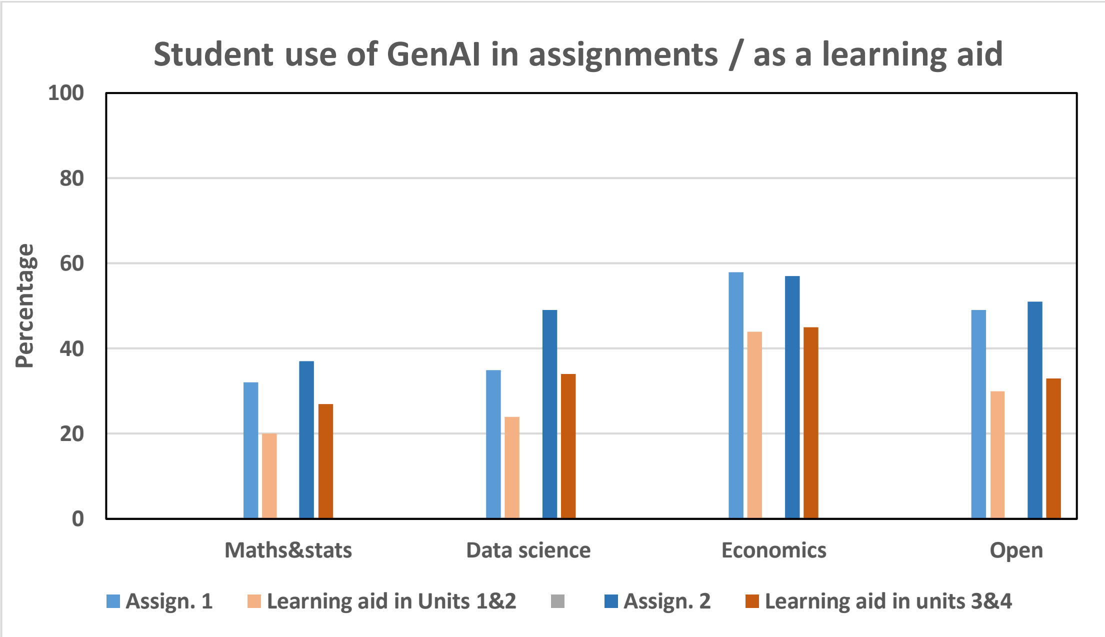


Figure 1: Percentage of students recording use of GenAI in assignments and/or as a learning aid by qualification group: 2025-26 cohort.

3.2 Student increased confidence, decreased anxiety and increased retention

Students on a third-level economics course and first-year mathematics course, as well as those on this course, took part in the multinational survey in 2024-25. This enabled us to compare this course to other similar courses in the university. Students on the other two courses were not permitted to use GenAI in assignments.

Figure 2 shows the higher usage of GenAI on this course and a higher reported increase in confidence as a result of using GenAI. Students on this course also reported a higher decrease in anxiety as a result of using GenAI.

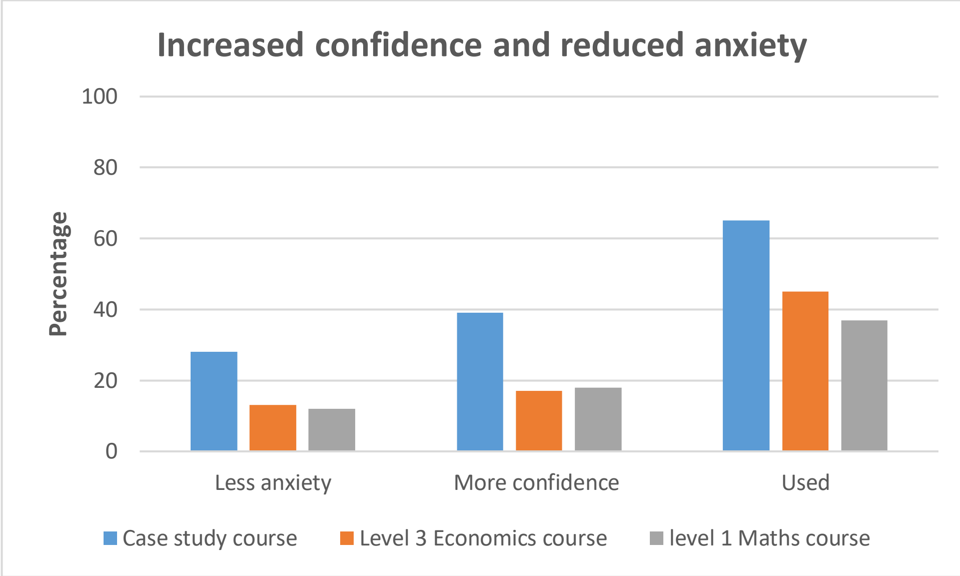


Figure 2: Percentage of students reporting reduced anxiety and increased confidence as a result of using GenAI.

Anxiety and confidence may be linked to performance (Paechter et al., 2017) and this may be a factor in the increased retention observed on this course. The school offers one other 30-credit, second-level statistics module, and one 30-credit applied mathematics course (other courses are 60 credits). Figure 3 shows that retention on this course, compared to the others, was higher in 2023 and 2024. These are the first two cohorts allowed to use GenAI on this course whereas the other courses did not permit GenAI use in their assignments.

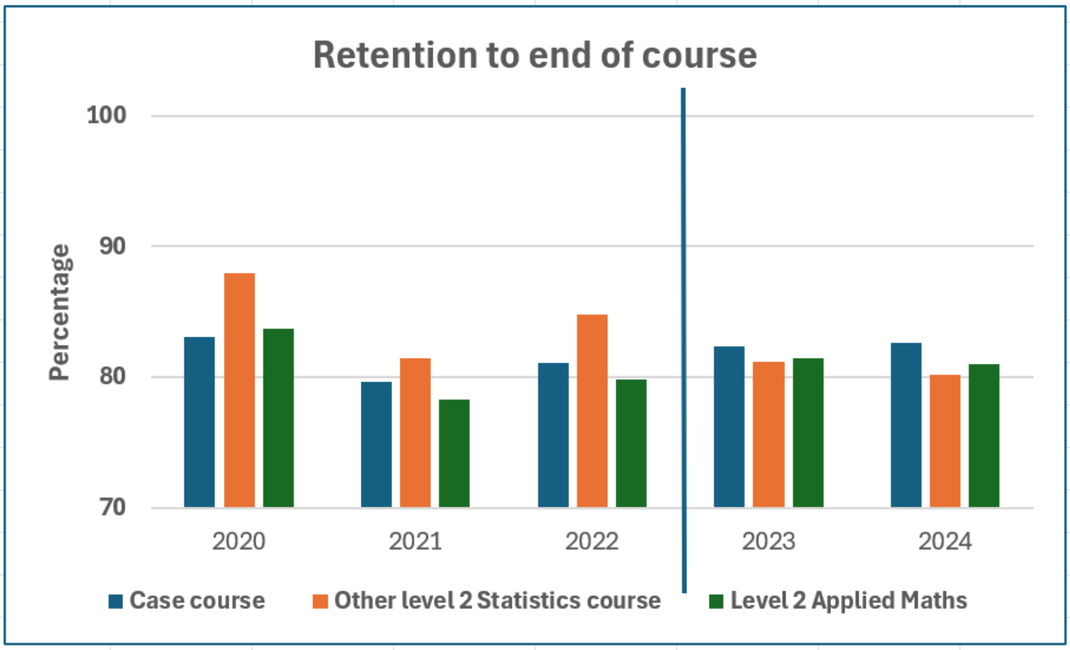


Figure 3: Percentage of students retained on Level 2 courses.

3.3 Students' concerns

Initially, as with the acknowledgement of use of GenAI, students were reluctant to answer an anonymous questionnaire or offer their views. This apprehension has been decreasing and this is apparent when looking at results from the multinational survey. The students on this course were higher users of GenAI (Figure 1) than those on the other two courses and as Table 2 shows, they expressed less anxiety about the impact on their learning. Across all the students, though, uncertainty about permissible boundaries was evident, with most students worried that GenAI use could lead to accusations of academic misconduct.

Table 2: Percentage of students who agree/ strongly agree that they are concerned about aspects of using GenAI.

Percentage who agree/strongly agree	**This course (n=74)**	**Level 3 economics (n=47)**	**Level 1 mathematics (n=79)**
Using GenAI for assessments undermines the value of a university education	41%	43%	37%
I am concerned that GenAI might limit my ability to learn my subjects.	41%	55%	44%
I am anxious about using GenAI for fear of being accused of academic misconduct.	50%	68%	65%

3.4 Associate Lecturers' views

ALs were initially very concerned that any potential use of GenAI was open to abuse, they considered that its use should be banned, and training should be provided to detect its use. An early study (Hardie et al., 2024) established that, in mathematics, training actually resulted in an increase in false positive rates and hence was counterproductive. This helped us adopt a position that, as GenAI use was not detectable and as assignments were formative, we should proactively explore the positive advantages of GenAI.

ALs, whilst largely committed to promoting a position where students use GenAI as a learning aid, remain concerned about the wider associated issues. All thirty ALs on this course took part in a survey in March 2025 and 40% then took part in a similar survey across all ALs in the school in August.

Table 3: Percentage of ALs expressing concerns about student use of GenAI: August 2025.

Percentage very concerned that	Als on this case study (n=29)	Other ALs in school (n=87)

Using GenAI for formative assessments undermines the value of a university education	17%	44%
Using GenAI for summative assessments undermines the value of a university education	38%	79%
Will limit student ability to understand materials	34%	47%

4. Discussion and Conclusions

The emergence of GenAI has been at a pace far exceeding that of previous technological shifts. HE institutions are responding but students have generally adapted far more quickly than their universities. For the institution, the central team, the ALs, and the students, this period has required considerable adjustment, and early reactions to GenAI were not universally positive.

Gaining an understanding of AL and student perspectives—through surveys, forum interactions, and online synchronous discussions—has been essential in developing a shared sense of direction. The principle of supporting students to make informed, autonomous decisions about their learning aligns well with the University's broader approach. Like ALs, many students initially expressed concerns about how GenAI might affect their learning or the perceived credibility of a university qualification. Acknowledging these concerns allowed us to shift away from warnings and restrictions, and towards encouraging students to critically assess whether GenAI could offer benefits for their own learning.

The introduction of a straightforward proforma for students to acknowledge their use of GenAI in assignments provided valuable insight into differing patterns of engagement. In broad terms, GenAI usage was higher by students without strong backgrounds in mathematics or statistics. Students studying subjects such as economics, combined STEM, or the Open degree—groups that historically often encountered challenges with mathematical content—appeared to gain confidence from using GenAI as a learning aid or “study buddy”. These observed differences in use reinforced the view that many students will make their own informed choices about how and when to engage with GenAI.

Notably, our retention rates increased over the case study period, particularly when compared with other mathematics and statistics modules. While assessment and examination scores did not show significant changes, the slight reduction in withdrawals suggests that some students who might previously have disengaged now felt able to continue. This supports a longstanding but previously anecdotal impression that a few students were leaving, not due to inability, but due to declining confidence in managing the course demands. GenAI may have helped reduce this loss of confidence for some learners.

Students on this course report a higher usage of GenAI and an increase in confidence due to their use of GenAI. ALs are more positively inclined towards GenAI than their peers are now willing to engage with students around the appropriate use of GenAI. A small minority—approximately 10%—continue to feel that supporting students in the effective use of GenAI does not fall within their remit.

Sustained communication and a flexible, collaborative approach have been central to bringing ALs and students to a broadly shared position. However, the changing nature of GenAI, its evolving accepted areas of use across HE and within employment, mean we will have further still to travel.

5. Future work

In 2026, we will launch a student-led project, recruiting two students to design and produce resources that demonstrate how GenAI can be used as a study-support tool in mathematics and statistics. The central team will continue to produce resources and additional student communications, designed by their peers, will further help students to make their own informed choices about use of GenAI.

Currently all course assignments are formative followed by an examination. In 2027, the final assignment is planned to become summative. GenAI would be allowed in that summative assignment but would still not be allowed in the final examination.

In 2023-24 the central team shared GenAI produced assignment solutions with ALs, to helps them judge whether a student's work might rely on unacknowledged GenAI. In 2025-26 this approach has been recommended by the department's Academic Integrity lead, to increase consistency in Academic Conduct referrals. Additionally the guidance provided for this course, with modification, will be incorporated into wider guidance for the school as more courses allow the use of GenAI.

6. Ethics statement

The student surveys had full Student Research Project Panel and ethics approvals. The tutor survey had Staff Survey Project Panel approval.

7. Acknowledgments and disclosure

To the School of Mathematics and Statistics for enabling the course to be a pilot in 2023-24 and hence trial the use of GenAI with students.

To eSTEeM (internal) for funding of continuing work in 2025-2026.

GenAI (CoPilot) has been used to improve clarity of expression in preparation of this paper.

8. Appendix One

M248 25J: TMA proforma for generative AI use

Please use this proforma at the beginning of your TMA to indicate how/if you have used generative AI.

I have used Generative AI in this TMA (such as Copilot, Gemini or ChatGPT) to help with the following:

[please tick all that apply]

☐As a starting point or inspiration with a part of the TMA
e.g. to understand wording in the TMA.

☐To improve my own work
e.g. with style and phrasing.

☐As a learning aid when studying the materials for this TMA
e.g. when working through examples.

☐I did not use generative AI to help me with my TMA answers

9. Appendix Two: Feedback to students and ALs

Feedback for 2024-25 cohort placed on student forum re use of Gen Ai

Hi all

Many thanks for the proformas that you include with your TMAs. Please continue to do so for TMA05,TMA05 and TMA06.

At many Universities you would have the opportunity to directly discuss with other students how, if at all, you were using Gen AI as an study aid. We have a forum on "Tips and tricks: Using Gen AI on M248" which is for to post anything you want. But the module team and tutors wanted to let you know that

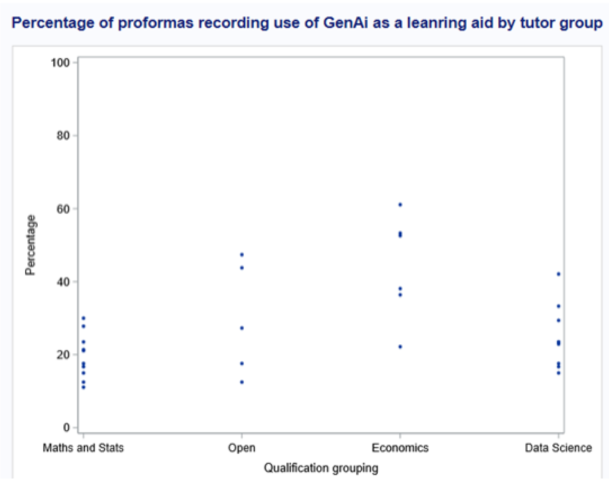
-around 90% of you are now including the proforma automatically with your TMA. Thank you. Please continue to do so and your tutor might continue to remind you before TMAs are due

*- around 30% of you are using Gen AI is **some** way and this varies by qualification group. The lowest percentage of usage is amongst the Maths and Stats students at 19% and the highest at 44% amongst the Economics students, 39% of data science students and 28% of those of you on Open degree/Stem Open/other and or no stated qualification, say in the proformas you have used Gen AI*

- 15% of you have said you used GenAi as a starting point /inspiration for the TMA and just slightly more at 18% said you used it to improve your own work.

Feedback for 2025-26 cohort placed on student forum re use of GenAI

After first assignment



You might be interested in some feedback on how your peers, as a group of M248 students, are using GenAi .

On M248 you do not ***need*** to use GenAI but can if you want. It can potentially both help you understand the materials and get started/ improve your TMAs. You cannot use GenAi in the M248 exam and you cannot use GenAi in TMAs or the exams on most other Maths&Statistics modules.

This chart has one dot for each tutor group of which there are just over 30. The tutor groups are arranged into the four broad categories that we also use for tutorials. The groups are of students taking qualifications in Data Science; :Economics ; Maths/Statistics and Open/combinedSTEM/ other/ no qualifications. The chart shows Economics students tend to use GenAi as a learning aid more than Maths and Stats students.

10. Appendix three: Examples from the 12 pages of guidance to the cohort 2025-2026 cohort of students on M248.

How might Generative AI be helpful to me on M248?

September 2025

We want to help and encourage you to use Generative AI (GenAI) responsibly as an aid to your studies on M248.

- GenAI, like Co-pilot, ChatGPT and Gemini, can be a great tool to help you study and complete your M248 assignments.
- Use GenAI alongside asking your tutor for help.
- You can use GenAI to improve your writing when you are placing your answers back in context, or explain ideas you might be struggling to understand, or perhaps to generate examples where you feel a little more practice would help you grasp an idea. It can help you check your work and to make revision more productive.

BUT

- You need to use it responsibly and within the University guidelines at GenAI for students
- You are responsible for your work, and you need to check anything that GenAI suggests. It is true it gets things wrong sometimes so you need to critically check. Critical thinking is one of the highly rated skills of University graduates.
- Don't be overly reliant on using GenAI.

BECAUSE

- You cannot use GenAI in the final M248 exam.

1 How do I access GenAI?

There are lots of free GenAI tools available. In this guidance document, we show examples that use Copilot or ChatGPT.

ChatGPT is free. Search for "ChatGPT" and register.

Copilot comes with Microsoft 365 to which you have free access as a student. On studenthome look under the heading LINKS on the right hand side to get a free Microsoft 365 account. If you use the Microsoft Edge browser, and are logged in to your student account, you will see the Copilot icon at the top of your student home page - click on it and Copilot opens.

Another GenAI tool that you may come across is Gemini. Gemini output often appears at the top of a Google search results page.

2 When can I use GenAI in my M248 studies?

The University policy for GenAI for students explains the different categories of GenAI use in assessment.

The M248 TMAs are Category 2 - this means you may use GenAI to help you complete the TMAs.

The M248 exam is Category 1 - this means the use of GenAI is not allowed in the exam.

4 Do I have to use GenAI?

No! You don't need to use GenAI. All the knowledge you need for M248 is contained within the module materials. There are examples and exercises throughout the module books, practice quizzes available on the module website, as well as screencasts (videos) and a full tutorial timetable.

However, GenAI does present opportunities to enhance your study and learning:

- If you're struggling with a particular topic, GenAI could help you master it.
- If you want to explore outside of the module materials, GenAI can help with this.
- It can help you to develop skills in critically evaluating the output (this is a very important skill for study - and employability).

5 Using GenAI for study support

GenAI can act as a study buddy. It can write for any type of audience you want - for example, as bullet points, or technically, or chatty and friendly. You can keep asking to explain something until you are happy you have got the idea, and you can ask it to generate examples if you want more practice on a topic that you are finding tricky. For example, you can ask it to take on the role of an undergraduate science student and ask it to help you explain a concept. One of the roles it can take on is the Socratic method which is explained in section 5.2.

6 A final note about using the module materials vs GenAI

GenAI tools, like Co-pilot, ChatGPT and Gemini, present an opportunity to explore the world of statistics, and it can be a great tool to help you learn and study statistics. On M248, you **may** use it to help you prepare your TMAs.

However, please note that all the knowledge and skills that you need to complete M248 successfully are contained within the the M248 module materials. You have the textbooks, the handbook (containing useful summaries of each unit, probability tables and other summarised information from the course), and the module website which has practice quizzes, screencasts, and the forums. There is also a comprehensive timetable of regular tutorials covering all topics.

Remember that your TMAs on this module are assessing what you know about the statistical techniques covered within the module materials. Always refer to the module materials to check GenAI output. If you aren't sure, you can also ask your tutor or post on the module forums.

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RESEARCH ARTICLE

Generative Artificial Intelligence in University Mathematics Instruction: Faculty Use and Future Prospects

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Abstract

Generative artificial intelligence (GenAI) is increasingly influencing university teaching, yet research on how mathematics faculty perceive and adopt these tools remains limited. This study investigates four key areas related to GenAI use in higher education: faculty AI literacy, intelligent technological pedagogical content knowledge (TPACK), perceived trust in GenAI outputs, and overall acceptance of GenAI in mathematics instruction. An online survey was administered to mathematics faculty in Saudi universities. The results show that ChatGPT is the most widely used GenAI tool among participants, indicating its central role in current instructional practices. Findings also reveal generally positive attitudes toward GenAI, alongside cautious levels of trust, particularly regarding the accuracy of AI-generated mathematical solutions. Acceptance of GenAI was found to be closely associated with higher levels of AI literacy, stronger intelligent TPACK, and greater perceived trust. Overall, the study provides insight into faculty readiness for GenAI integration, highlighting both opportunities and ongoing challenges. This exploratory research contributes to the growing literature on GenAI adoption in higher education and offers guidance for professional development initiatives aimed at supporting ethical, effective, and pedagogically informed use of GenAI in university mathematics instruction.

Keywords: university mathematics, GenAI, ChatGPT, TPACK, trust, acceptance.

1. Introduction

1.1. Background

The term artificial intelligence (AI) is commonly used to describe machines capable of mimicking aspects of human intelligence, including cognitive functions such as problem-solving, reasoning, and learning (IBM Data & AI Team, 2023). Recent advances in AI have been driven in particular by large language models (LLMs), which are designed to generate human-like text by learning patterns from vast amounts of data. One of the common examples of such models is the Generative Pre-trained Transformer (GPT) developed by OpenAI. ChatGPT is a widely used, user-friendly interface built on GPT technology, making GenAI tools easily accessible to the public. Alongside ChatGPT, a growing range of GenAI software interfaces has emerged, contributing to the increasing presence of GenAI in educational contexts, including university mathematics instruction.

In mathematics education, GenAI can support problem-solving, lesson preparation, and enhance student engagement through interactive and adaptive learning resources. Despite these potential benefits, adoption is not automatic. Faculty readiness, confidence, and trust in GenAI play a central role in determining how widely these tools are used.

Recent research has also highlighted growing interest in understanding how faculty and students perceive the role of GenAI in higher education. For example, Kim et al. (2025) reported generally positive attitudes toward GenAI among university faculty and students, while also identifying concerns related to reliability, ethics, and effective integration into teaching practice. These findings suggest that although GenAI is increasingly accepted in higher education, questions remain regarding its pedagogical use and responsible implementation.

Recent studies have also reported mixed findings regarding the educational impact of Generative AI in higher education. While AI tools are often perceived as useful for supporting learning, debugging, generating explanations, and improving efficiency, concerns remain regarding over-reliance, inaccuracies, and the potential impact on students' independent problem-solving and critical thinking skills (Lepp and Kaimre, 2025). These findings suggest that although GenAI offers important educational opportunities, its effective pedagogical integration remains an ongoing challenge.

This study is grounded in the Technology Acceptance Model (TAM) developed by Davis (1985), a well-established framework for understanding how users accept or reject new technologies. According to Davis (1989), perceived usefulness and perceived ease of use are the two core factors that strongly influence individuals' decisions to adopt a technology. However, focusing solely on these factors may not fully explain educators' acceptance of GenAI, given the advanced and transformative nature of these tools.

The concept of intelligent technological pedagogical content knowledge (TPACK) suggests that educators require more than general technical skills; they also need AI-related pedagogical knowledge to use GenAI effectively (Celik, 2023). AI literacy is similarly important, as teachers need to understand how AI works, its limitations, and its ethical implications (Laupichler et al., 2022). Beyond knowledge, trust in GenAI tools plays a critical role, as educators are more likely to adopt these technologies when they perceive them as reliable and safe (Nazaretsky et al., 2022). This study investigates mathematics faculty experiences with GenAI in Saudi universities by examining AI literacy, pedagogical integration (intelligent TPACK), perceived trust, and acceptance.

1.2. Research questions

The following research questions were considered.

RQ1 (AI Literacy): How familiar and confident are university mathematics faculty in identifying, using, evaluating, and guiding the use of GenAI?

RQ2 (Intelligent TPACK): How do university mathematics faculty integrate GenAI into their teaching within the technological pedagogical content knowledge (TPACK) framework?

RQ3 (Perceived Trust): To what extent do university mathematics faculty trust GenAI outputs in mathematics instruction?

RQ4 (Acceptance): What factors are associated with the acceptance of GenAI among university mathematics faculty?

2. Method

2.1. Design and administration of survey

An online survey was designed using a mixture of open-response, multiple-choice, and Likert-scale questions. Survey items were adapted from and inspired by the study of Al-Abdullatif (2024), particularly in relation to faculty perceptions, AI literacy, and technology acceptance. Participants were recruited using purposive sampling through university email lists and direct communication with heads of mathematics departments at Saudi universities, who were asked to circulate the survey among faculty members teaching undergraduate mathematics courses. The study targeted instructors teaching foundational mathematics subjects across a range of disciplines, including mathematics majors and service courses for engineering, computing, and science programmes. Faculty teaching mathematics-related courses outside mathematics departments were also eligible to participate where they were involved in teaching these foundational subjects. Responses from participants who did not teach foundational mathematics courses were excluded from the final analysis.

Particular emphasis was placed on foundational subjects such as calculus, linear algebra, discrete mathematics, and principles of statistics, which are identified in the Education and Training Evaluation Commission (ETEC) framework as core knowledge units in undergraduate mathematics programmes (ETEC, 2024). By focusing on these courses, responses could be compared more directly, which would be difficult when including a broader range of subjects. This restriction does skew the results toward courses which typically have larger classes and are taught in the earlier years.

In Saudi higher education, foundational mathematics courses are typically delivered through a combination of lectures, tutorials, and problem-solving sessions, particularly in programmes serving engineering, computing, and science disciplines. These courses often involve medium- to large-sized classes and place strong emphasis on procedural fluency, conceptual understanding, and assessment through coursework, quizzes, and examinations.

For each construct (AI literacy, intelligent TPACK, perceived trust, and acceptance), composite scale scores for each construct were calculated by averaging responses across the corresponding Likert-scale items. Negatively worded items within the perceived trust construct were reverse coded prior to analysis to ensure that higher scores consistently reflected higher levels of trust. Spearman's rank correlation analysis was then used to examine relationships among the four constructs, as the data were ordinal in nature and the sample size was relatively small.

The study was conducted in accordance with the ethical guidelines of the Saudi Electronic University (CSTS-202510-001, issued on 17 November 2025). Informed consent was obtained from all participants prior to data collection. The survey questions are provided in the Appendix. The datasets generated and/or analysed during the current study are not publicly available due to privacy considerations.

2.2. Analysis of responses

The analysis primarily employed quantitative methods, supplemented by qualitative interpretation of the open-ended responses. The survey included demographic questions followed by Likert-scale items measuring four constructs: AI literacy, intelligent TPACK, perceived trust, and acceptance of GenAI tools, with responses recorded on a five-point scale from Strongly Disagree to Strongly Agree (see Appendix).

Internal consistency of the survey scales was assessed using Cronbach's alpha. The Acceptance scale showed excellent reliability ($\alpha = .91$), while the AI literacy ($\alpha = .87$) and intelligent TPACK ($\alpha = .86$) scales demonstrated good reliability. The perceived trust scale yielded lower reliability ($\alpha = .63$), which was acceptable given the exploratory nature of the study and the small number of items. Composite mean scores were computed for each construct and used in the quantitative analyses.

Descriptive statistics were used to address RQ1–RQ3, and Spearman's correlation analysis examined associations between acceptance and the key factors for RQ4. The survey also included two open-ended questions inviting participants to share recommendations and identify challenges or concerns; these responses were analysed using content analysis to identify emergent themes.

This process enabled the qualitative data to be reduced and summarised into categories reflecting participants' perspectives (Ingleby, 2012).

3. Results

Between 30 November and 30 December 2025, approximately 120 faculty members were invited to participate, of whom 55 completed the survey, representing a response rate of approximately 46%. The study was exploratory in nature and involved participants representing a range of undergraduate mathematics teaching contexts. Question 2 was used to identify the courses taught by participants during the 2024–2025 academic year. The distribution of courses indicates that most responses came from instructors teaching core mathematics subjects. When combined, participants who taught Calculus only (25%), Linear Algebra only (27%), or Discrete Mathematics only (22%) accounted for 74% of the sample, reflecting the study's emphasis on foundational mathematics instruction. In comparison, 26% of participants reported teaching statistics-related courses, such as Principles of Statistics, Quantitative Methods, or Operational Research. Overall, these findings confirm that the sample predominantly represents faculty teaching foundational mathematics courses, aligning with the intended focus of the study.

Question 3 asked participants which GenAI tools they had used in their teaching or academic work. ChatGPT was the most frequently reported tool, used by over 80% of participants, indicating its central role in current instructional practice. Other commonly reported tools included Mathway and Wolfram Alpha, although these were used less frequently. Participants also identified additional platforms through the open-response option, including Gemini, Copilot, Manus, Symbolab, and institution-specific AI systems.

As multiple responses were permitted, the findings reflect frequency of use rather than exclusive use. Approximately one-fifth of participants who reported using ChatGPT also indicated use of at least one additional tool, most commonly Wolfram Alpha or Mathway. This pattern suggests that ChatGPT may complement, rather than replace, more specialised mathematical systems, with different tools supporting different aspects of mathematical problem-solving and instructional preparation.

3.1 AI Literacy (RQ1;Survey Q4)

AI literacy was assessed using four items capturing faculty self-reported confidence in identifying, using, evaluating, and guiding the use of GenAI tools in mathematics teaching (see Figure 1).

Overall, responses indicate moderate levels of perceived AI literacy among participants. Many faculty members reported confidence in recognising and using GenAI tools, suggesting a degree of familiarity with these technologies in their teaching practice. However, responses related to evaluating AI-generated outputs and guiding students in their use showed similar distributions, with substantial proportions of participants selecting neutral responses.

These findings suggest that participants generally perceived themselves as reasonably familiar with GenAI tools, while also expressing some uncertainty regarding more advanced evaluative and pedagogical aspects of AI use. Given that the items measured self-reported perceptions rather than objective AI literacy, the findings should be interpreted cautiously.

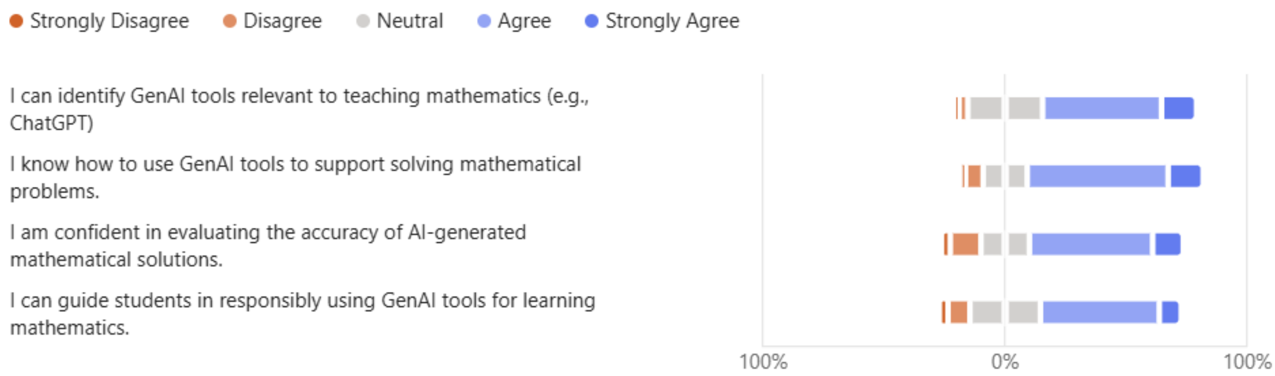

Figure 1. Responses to AI literacy items (Q4), showing faculty familiarity and confidence in identifying, using, evaluating, and guiding the use of GenAI in mathematics teaching.

3.2 Intelligent TPACK (RQ2; Survey Q5)

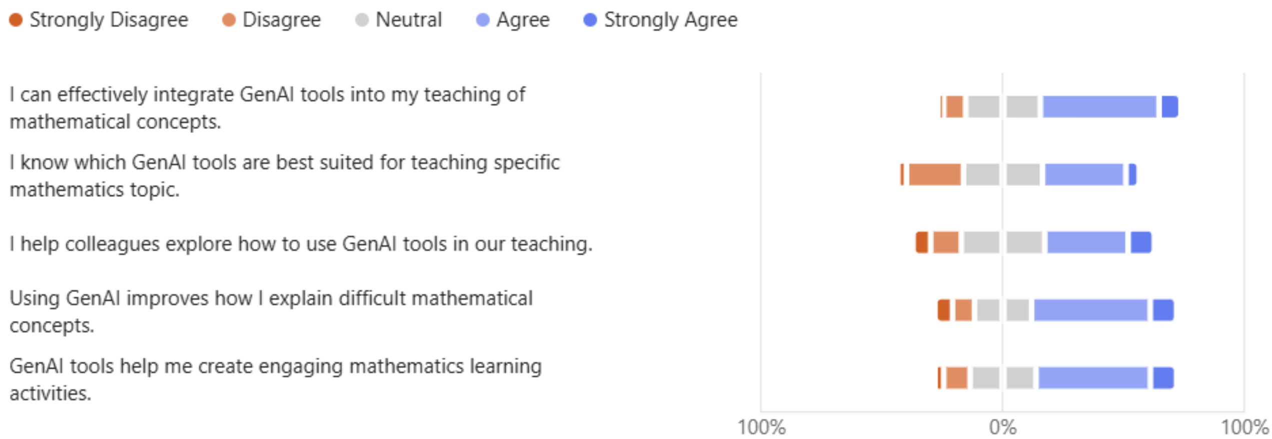

Figure 2. Responses to intelligent TPACK items (Q5), illustrating faculty confidence in integrating and applying GenAI within the mathematics teaching context.

Intelligent TPACK was assessed through items examining faculty confidence in integrating GenAI into mathematics teaching, including selecting appropriate tools, explaining concepts, and designing learning activities (see Figure 2).

Overall, responses suggest moderate levels of pedagogical confidence in using GenAI. Many participants indicated that they are able to incorporate GenAI tools into their teaching and use them to support explanation and learning activities. However, this confidence was not uniformly strong across all areas.

A consistent feature across the items was the relatively high proportion of neutral responses, indicating uncertainty in applying GenAI within specific pedagogical contexts. This was particularly evident in relation to selecting appropriate tools for different mathematical topics and designing effective learning activities. These patterns suggest that while faculty recognise the potential of GenAI, they may lack clear strategies for aligning its use with subject-specific teaching goals.

Taken together, the findings indicate that GenAI is being adopted at a practical level, but its integration within the technological pedagogical content knowledge framework remains developing rather than fully established. This highlights the need for targeted support that focuses not only on tool use, but also on pedagogical decision-making and subject-specific application.

3.3 Perceived Trust (RQ3; Survey Q6)

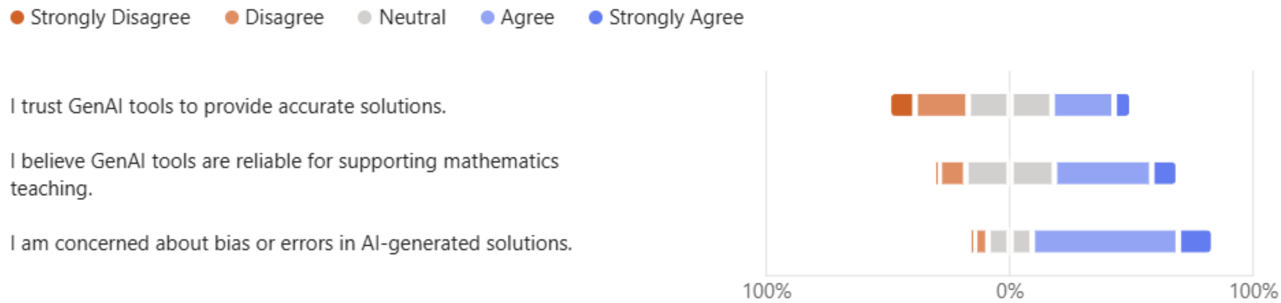

Figure 3. Responses to perceived trust items (Q6), illustrating faculty trust in GenAI outputs and concerns about accuracy and bias.

Perceived trust was assessed through items examining faculty confidence in the accuracy and reliability of GenAI outputs, as well as their concerns about potential errors or bias (see Figure 3).

Overall, responses indicate cautious and conditional trust in GenAI tools. While some participants expressed confidence in the reliability of AI-generated outputs, this was accompanied by a substantial level of uncertainty, reflected in a high number of neutral responses. This suggests that trust in GenAI is not firmly established, but remains tentative. This cautious level of trust may be explained by widespread concerns regarding errors and bias in AI-generated outputs.

Faculty appear willing to use GenAI tools, but emphasise the importance of verifying outputs and applying critical judgement. Taken together, these findings suggest that faculty trust in GenAI is cautious rather than unconditional. Instructors appear willing to use these tools in their teaching, but remain aware of their limitations, particularly the risk of errors or bias. As a result, they recognise the need for careful verification of AI-generated outputs.

3.4 Acceptance (RQ4; Survey Q7)

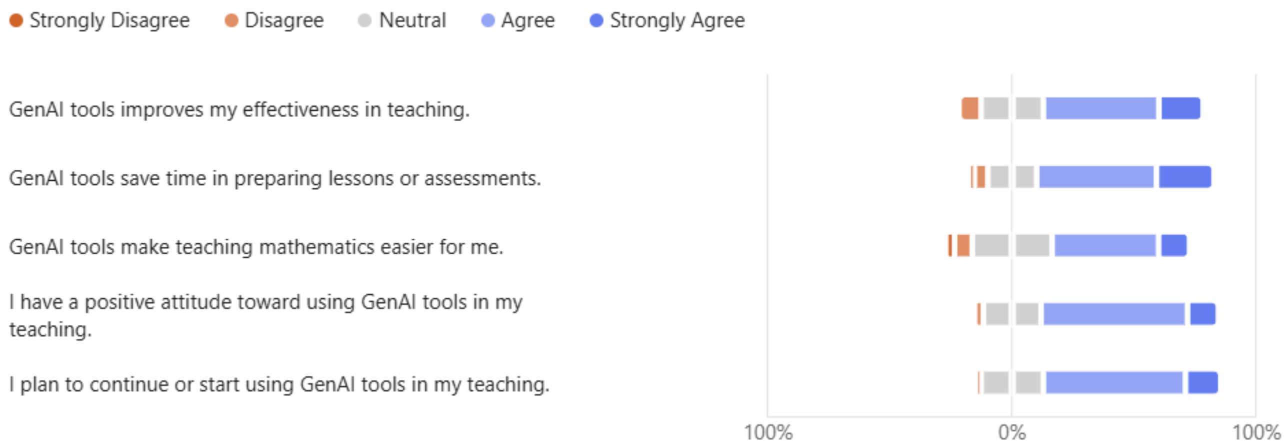

Figure 4. Responses to acceptance items (Q7), showing faculty attitudes toward and intentions to use GenAI in mathematics teaching.

Acceptance of GenAI was assessed using five items measuring perceived usefulness, ease of use, attitudes, and intention to use GenAI tools (see Figure 4). Overall, the findings indicate high levels of acceptance among participants. Most faculty expressed positive attitudes toward GenAI and reported intentions to continue or expand its use, particularly in relation to improving teaching efficiency and supporting instructional tasks. For example, around two-thirds of participants agreed that GenAI improves teaching effectiveness and saves time in lesson preparation, suggesting that these tools are already perceived as valuable in practice.

However, this high level of acceptance should be interpreted with caution, as it does not necessarily reflect strong confidence in the pedagogical use or reliability of these tools. Rather, acceptance appears alongside a degree of uncertainty, particularly when it comes to evaluating AI-generated outputs and integrating them effectively into teaching.

To address RQ4, Spearman's correlation analysis showed that acceptance was significantly associated with AI literacy ($\rho = 0.378$, $p = .004$), intelligent TPACK ($\rho = 0.558$, $p < .001$), and perceived trust ($\rho = 0.574$, $p < .001$). These findings suggest that sustained and meaningful adoption of GenAI depends not only on positive attitudes toward the technology, but also on faculty confidence in evaluating and integrating these tools effectively within teaching practice.

Responses to the open-ended questions provide additional insight into how faculty are engaging with GenAI in practice. Among the responses that provided sufficient detail for interpretation, several recurring themes emerged. Some responses were brief or general in nature and were therefore not included within the main thematic categories discussed below.

The most common theme involved instructional preparation, including lesson planning, generating teaching materials, and designing assessments, with participants noting that GenAI can reduce workload and support efficient content creation. One participant specifically described using GenAI for "lesson planning and step-by-step solutions of any problem." A second theme focused on the use of GenAI to simplify complex mathematical concepts, for example by generating step-by-step explanations, visual representations, and personalised learning materials. One participant explained that ChatGPT was useful for constructing comparisons between mathematical concepts, such as differentiation and integration, by presenting similarities and differences visually on a single page. The same participant also described using ChatGPT to connect complex mathematical topics to real-life situations, including generating visual explanations for mathematical induction by illustrating the base case and inductive step through practical examples. These responses suggest that some faculty are beginning to explore more pedagogically meaningful applications of GenAI.

A smaller group emphasised the importance of cautious and limited use, particularly at the undergraduate level, highlighting that GenAI should function as a supportive "co-teacher" rather than a replacement for instruction. This perspective reflects an awareness of both the potential and limitations of these tools.

Concerns raised by participants further reinforce this cautious approach. Faculty frequently highlighted issues related to the accuracy of AI-generated mathematical outputs and the risk of student over-reliance. Several participants noted that GenAI can sometimes generate incorrect or misleading explanations or solutions, particularly for multi-step mathematical problems, and therefore emphasised the importance of carefully verifying AI-generated content before using it in teaching. Participants also expressed concern that some students may rely on AI-generated answers without fully understanding the underlying mathematical concepts, particularly when using tools such as ChatGPT as shortcuts for completing assignments. As a result, respondents stressed the importance of emphasising mathematical reasoning and problem-solving processes rather than focusing solely on final answers. In addition, a small number of participants highlighted concerns regarding unequal student access to AI tools and digital devices outside the classroom. These concerns align with earlier findings on perceived trust and help to explain why high acceptance coexists with uncertainty. Overall, the results suggest that faculty are willing to adopt GenAI, but expect its use to be guided by careful evaluation, pedagogical consideration, and appropriate instructional practices.

4. Discussion and conclusions

This study provides evidence that university mathematics faculty in Saudi universities are actively engaging with generative artificial intelligence (GenAI) and recognise its potential to support teaching. While acceptance is generally high, confidence in evaluating AI-generated outputs and integrating these tools pedagogically remains uneven, reflecting a gap between functional use and deeper instructional understanding.

These findings are consistent with established perspectives on technology adoption, particularly the Technology Acceptance Model (Davis, 1989), which emphasises perceived usefulness as a key driver of adoption, while more recent research highlights the importance of AI literacy, pedagogical knowledge, and trust in shaping meaningful integration of AI in education (Laupichler et al., 2022; Nazaretsky et al., 2022). Together, these factors appear central to moving beyond surface-level use toward more effective and informed practice, extending prior studies by showing how these factors interact specifically within mathematics instruction.

Although the study is situated within the Saudi higher education context, the results reflect broader challenges associated with the rapid adoption of AI in teaching, suggesting relevance beyond this setting. Overall, the study contributes to the growing body of research on GenAI in education by providing empirical insight into faculty perspectives and identifying key areas for professional development and future research. It also highlights the need for structured support to ensure that GenAI is integrated in ways that enhance, rather than replace, meaningful mathematical learning.

4.1 Concluding remarks

This study examined the use of Generative AI in university-level mathematics teaching within Saudi higher education during the 2024–2025 academic year, capturing faculty perspectives on its opportunities and challenges. Participants represented a range of teaching contexts, including mathematics departments and service courses in engineering, computing, and the sciences. Although the study involved a relatively modest sample, it was intended as an exploratory investigation of current faculty perceptions and practices relating to GenAI use in mathematics instruction.

A key limitation of the study is that the findings are based on self-reported data and may not fully reflect actual classroom practices or the full diversity of institutional contexts. Future research involving a broader range of institutions and departments would provide a more comprehensive understanding of GenAI adoption, alongside further investigation into how institutional policies and professional development can support effective and responsible integration of GenAI in mathematics education.

5. Appendix

The survey questions are given below.

2. Courses taught in the academic year 2024-2025 (Select all that apply):

- A first course in Linear Algebra
- A first course in Calculus
- Discrete Mathematics
- Other (Please specify)

3. Which GenAI tools have you used? (Select all that apply):

- ChatGPT
- Wolfram Alpha
- Symbolab
- Mathway
- Other (Please specify)

4. AI Literacy

Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree

- I can identify GenAI tools relevant to teaching mathematics (e.g., ChatGPT).
- I know how to use GenAI tools to support solving mathematical problems.
- I am confident in evaluating the accuracy of AI-generated mathematical solutions.
- I can guide students in responsibly using GenAI tools for learning mathematics.

5. Intelligent TPACK

- I can effectively integrate GenAI tools into my teaching of mathematical concepts.
- I know which GenAI tools are best suited for teaching specific mathematics topics.
- I help colleagues explore how to use GenAI tools in our teaching.
- Using GenAI improves how I explain difficult mathematical concepts.
- GenAI tools help me create engaging mathematics learning activities.

6. Perceived Trust

- I trust GenAI tools to provide accurate solutions.
- I believe GenAI tools are reliable for supporting mathematics teaching.
- I am concerned about bias or errors in AI-generated solutions.

7. Acceptance

- GenAI tools improve my effectiveness in teaching.
- GenAI tools save time in preparing lessons or assessments.
- GenAI tools make teaching mathematics easier for me.
- I have a positive attitude toward using GenAI tools in my teaching.
- I plan to continue or start using GenAI tools in my teaching.

8. Recommendations

Can you share any recommendations for using GenAI to support teaching mathematics? (e.g., benefits or future use)

9. Challenges

Any concerns or challenges with GenAI that colleagues should know? (e.g., issues you've faced or things to avoid)

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CASE STUDY

Smarter, not harder: AI-enhanced assessment design, marking, and feedback

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Abstract

In today's fast-paced academic environment, Generative AI (GenAI) offers a powerful opportunity for STEM educators to work smarter – not harder. This article explores how GenAI can streamline the entire assessment lifecycle: from designing complex, discipline-specific assessments and creating detailed marking rubrics to automating feedback and using transcription tools like Whisper to deliver rich, personalised responses efficiently. Drawing on hands-on experience developing curriculum and assessments for a Data Scientist Degree Apprenticeship at the University of Nottingham, we'll discuss examples that show how GenAI can uphold academic rigour while significantly reducing time spent on repetitive, manual tasks. Rather than replacing academic judgment, these tools enhance it—freeing up time to focus on teaching, innovation, and student support.

Keywords: Apprenticeship, Data Science Generative AI, Assessment.

1. Introduction

Academic practice is entering a transformative era driven by Generative AI (GenAI). It is no longer a futuristic concept, but it is a daily reality for students and educators, reshaping how students learn and how academics teach, design assessments, and deliver feedback. In apprenticeships, on-the-job learning is central, and the shift is especially visible: learners are already deploying AI tools in real workplace contexts, and institutions must bridge policy, pedagogy, and practice to keep pace.

At the University of Nottingham, our Level 6 Data Scientist Degree Apprenticeship integrates mathematics, statistics, software engineering, AI, and machine learning, with authentic, work-based projects at its core. Over the past two to three years, GenAI has become a persistent theme in our teaching, employer reviews, and assessment conversations. In particular, we have observed that apprentices are encouraged to use AI responsibly at work, provided they follow organisational guidance and protect confidentiality. Against this backdrop, a persistent tension emerges: How do we maintain academic standards while staying aligned with the rapid changes shaping industry and society?

It is increasingly likely that graduates will need fluency in AI to remain competitive and drive innovation in their fields. In a recent survey from the Digital Education Council, a global alliance of universities and industry representatives focused on education innovation, it was found that 86% of students globally are regularly using AI in their studies, with 54% of them using AI on a weekly basis (Digital Education Council, 2024). In addition, AI-related jobs are growing 3.6 times faster than all UK jobs, and 64% of CEOs expect major reskilling within three years (PwC, 2024). This is not limited to STEM courses either, 50% of UK business leaders say Arts and Humanities graduates will play a critical role in harnessing AI tools, highlighting the need for all disciplines to embed data and AI skills (Universities UK, 2024).

In this article, we argue that GenAI should support, not replace, academic judgment. Used well, it can cut down repetitive tasks in creating teaching resources and assessments. We show this through examples from our programme: designing assessments that reflect real workplace tasks; creating rubrics that ensure consistent, clear marking; and teaching apprentices to document AI use, justify methods, and assess model risks. Ultimately, graduates need AI fluency to lead innovation ethically, which means embedding AI in the curriculum while strengthening critical thinking and professional judgment.

2. Policy, Practice, and the Responsible Use of AI

At the University of Nottingham, the use of Generative AI in teaching and assessment is still evolving. Currently, staff adoption tends to be ad hoc, with no single source of truth or shared repository of best practice. While there are policies in place, practical examples of how to integrate GenAI effectively remain limited, normally shared through in-house seminars and workshops.

Our Quality Manual addresses AI under “Academic Integrity”. It defines False Authorship as submitting work generated or improved by software not permitted for that assessment. This includes tools such as ChatGPT, Copilot, DeepSeek, DALL-E, and similar. The Quality Manual also states that a student should be able to find the permitted use of GenAI for each assessment they encounter but, ultimately, students are responsible for checking and seeking clarification.

Staff are encouraged to use Generative AI to improve marking and feedback, but with caution. Current guidance emphasises three principles: data privacy, meaning only Microsoft Copilot is approved for university use; transparency, requiring staff to inform students how AI has been applied in marking or feedback; and consistency, with a mandatory common statement on AI use included in all coursework assessments from September 2025. An example used on the Data Science apprenticeship can be seen below:

> *“You may use AI (including proof reading tools / large language models, coding copilot tools) during the completion of this coursework. However, you must clearly explain how you used the tools.*
>
> *The tools should be used to improve your development of the knowledge, skills and behaviours and to make your coursework more efficient to deliver, so you can do more than would otherwise have been possible. You should not use AI to avoid the need to develop the knowledge, skills and behaviours.*
>
> *For avoidance of doubt, failure to acknowledge when and how you have used AI will be considered to be ‘false authorship’ under the university’s misconduct regulations, and you risk having a misconduct case brought against you.”*

These policies aim to balance innovation with integrity, but the challenge remains: moving from compliance to confident, consistent practice. To support this, we share examples from our programme that demonstrate practical ways to integrate GenAI responsibly into teaching and assessment.

3. Embedding GenAI into the assessment cycle

Our approach to embedding Generative AI within the Data Scientist programme was guided by the existing assessment cycle. Rather than treating AI as an isolated tool, we considered how it could add value at each stage of the process: assessment design, assessment marking, assessment feedback, and student reflection. A summary of this approach can be found in Figure 1.

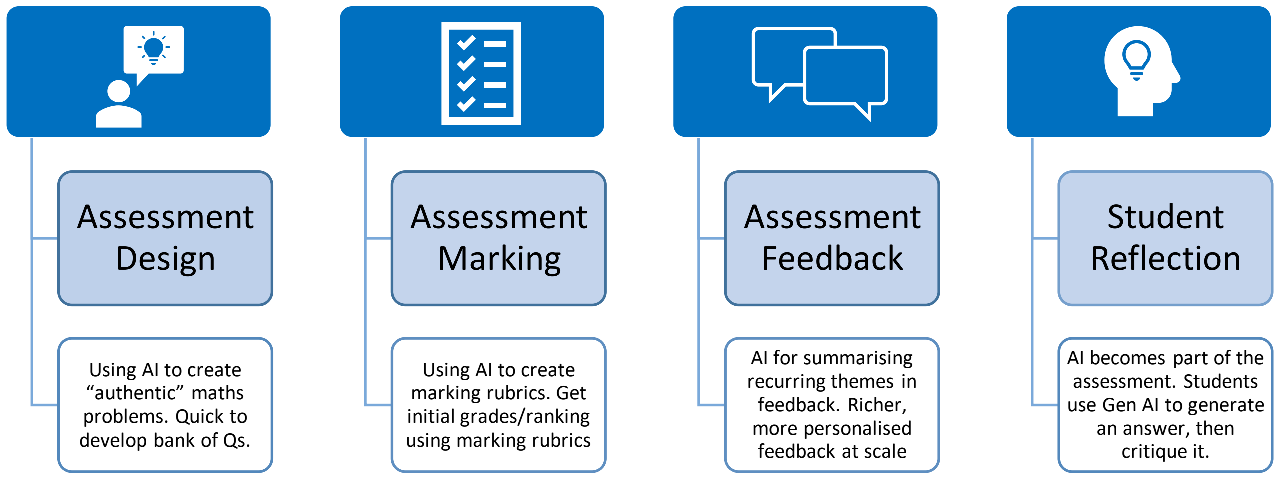

Figure 1: Embedding AI in the assessment cycle

3.1. Assessment Design

On the degree apprenticeship programme, we have adopted the use of authentic assessments that replicate real workplace tasks. Using this style of assessment offers an approach to bridge the gap between academic learning and professional practice while enabling learners to apply subject knowledge and develop essential workplace behaviours and skills (Symonds & Mott, 2024). Instead of traditional exams and coursework, we use synoptic, progressive assignments that reflect real job tasks—such as business case reports, presentations, and portfolios. A key challenge is ensuring these assessments are relevant across diverse sectors where apprentices work, including pharmaceuticals, finance, utilities, e-commerce, and logistics. One way we've addressed this is by using GenAI to transform abstract, highly mathematical questions into applied business problems. For example, instead of asking students to complete a truth table using logical operators, we frame the task around detecting fraudulent transactions: if certain conditions are met—such as 'X and Y' or 'P or Q'—the system flags potential fraud. This approach helps apprentices apply mathematical logic in realistic scenarios while developing problem-solving skills. Once a single scenario is created, GenAI makes it straightforward to generate equivalent questions in different contexts, such as pharmaceuticals or logistics. This means we can assess the same underlying learning outcomes while tailoring the framing to the apprentice's sector, ensuring both authenticity and consistency.

Another way we have used GenAI is to create multiple-choice questions for the apprenticeship End Point Assessment (EPA). One component of the EPA is a 30-question Knowledge Test which we also replicate at the end of each year as a summative assessment. This requires a large, varied question bank that avoids repetition and includes questions at different levels for each stage of study (Year 1, Year 2, Year 3, EPA). To populate this bank, we used Microsoft Copilot to generate questions by feeding in sample items written by the programme team and prompting the tool to cover all "Knowledges" covered by the occupational standard. Creating this bank manually would demand significant staff time, but GenAI has made the process quick and efficient and, moreover, it allows us to easily update and expand the bank as the curriculum evolves.

While GenAI significantly reduces the workload, some refinement of outputs is still necessary. Human verification and quality assurance remain critical to maintain academic integrity. For example, when generating multiple-choice questions, Copilot frequently selected "option b)" as the correct answer. If left unchanged, this pattern could allow students to guess answers without applying knowledge or reasoning. Similarly, in creating context-based mathematical questions, GenAI often produced numerical values that were too obvious or simplistic, reducing the level of challenge and relevance. To ensure appropriate complexity and authenticity, manual adjustments to values were required before finalising the questions. These examples highlight that while AI accelerates the process, academic oversight is essential to ensure fairness, rigour, and alignment with learning outcomes.

3.2. Assessment Marking

While we have explored AI for assessment design, its role in marking is currently supportive rather than autonomous. We have not yet used AI to grade student work, academic judgment remains essential, but we have found it invaluable for creating detailed marking rubrics that promote consistency and clarity. This is particularly important on apprenticeship programmes, where assessments are authentic to the workplace and can involve complex, multi-step tasks. Apprentices need to understand exactly how learning objectives will be evaluated, and clear rubrics make this possible. On the Data Science programme, we use grid-based rubrics that map each learning outcome to specific performance levels, making 'what good looks like' explicit. This approach helps students interpret feedback, self-assess, and focus their efforts effectively, while ensuring fairness and transparency across modules.

Criteria	Hard Fail (<30%)	Fail (E Grade, 30%)	Pass (D Grade, 40%)	C Grade (50%)	B Grade (60%)	A Grade (70%)	A+ Grade (80%+)
Understanding of Organisation	*Shows no understanding of organisation or data science role.*	*Limited or incorrect understanding of organisation; lacks clarity in purpose of data science.*	*Basic understanding of organisation and purpose of data science pipeline; lacks depth or specificity.*	*Clear understanding of organisation and pipeline purpose; some gaps in specifics.*	*Solid understanding of organisational context, pipeline purpose, and goals.*	*Thorough understanding of organisation, with clear relevance of pipeline to goals.*	*Insightful, detailed understanding; aligns data science pipeline with organisational goals in a sophisticated manner.*
Description of Data Science Pipeline	*Lacks pipeline description; does not address stages or sequence.*	*Vague, inaccurate description; misses most pipeline stages.*	*Basic description of pipeline stages with major gaps or inaccuracies.*	*Adequate description covering main pipeline stages; lacks detail or depth in one or two areas.*	*Detailed, accurate description of each pipeline stage, though some minor gaps.*	*Comprehensive, accurate description; clear sequencing of stages and roles.*	*Well-articulated and sophisticated pipeline description; connects stages seamlessly, reflecting real organisational flow and purpose.*
Application to Specific Scenario	*No scenario provided or scenario lacks relevance to organisation.*	*Scenario barely relates to organisation; limited connection to pipeline.*	*Scenario provided with basic relevance to organisation; some limited connection to pipeline stages.*	*Relevant scenario with clear application to each pipeline stage; some lack of depth in specifics.*	*Scenario is relevant, applied effectively across all pipeline stages with examples.*	*Highly relevant scenario with specific, well-integrated examples across pipeline.*	*Richly detailed scenario that fully exemplifies pipeline; integrates specific methods/tools with strong organisational insight.*
Stakeholder Engagement	*No mention of stakeholders or their role in the pipeline.*	*Minimal reference to stakeholders; unclear role or relevance.*	*Basic identification of stakeholders; limited explanation of their influence or interaction.*	*Clear mention of key stakeholders; some explanation of their influence on pipeline stages.*	*Detailed description of stakeholders and their roles; connection to each stage of pipeline.*	*Insightful analysis of stakeholder roles; demonstrates how stakeholder needs influence pipeline decisions.*	*Excellent, discussion of stakeholders; shows a deep understanding of stakeholder impact and how needs are integrated into pipeline stages.*

Figure 2: Example of marking rubric created autonomously with GenAI

GenAI has helped to streamline the creation of these rubrics. We use AI tools to produce an initial draft with clear, outcome-aligned statements, reducing the time required to create them manually. These are then reviewed and refined by staff to ensure that the statements reflect each grading boundary appropriately. This ensures consistency across the programme and frees staff to focus on higher-value tasks. Students appreciate the transparency this provides, as they can see exactly how their grade was determined and benefit from consistent expectations across all assessments.

3.3. Assessment Feedback

Recently, we have introduced oral feedback as an alternative way to provide richer, more personalised responses to students, recognising that students prefer audio feedback and find it more comprehensive and global than written comments (Cavanaugh & Song, 2014). However, oral feedback can be difficult for students to revisit and reflect on later. To address this, we use Whisper AI to transcribe spoken feedback and summarise key points, ensuring accessibility and creating a permanent record for review. Beyond individual feedback, we combine these transcripts with Copilot to identify common themes across the cohort, producing summary reports that highlight recurring strengths, frequent challenges, and priority areas for development. Shared alongside individual feedback, these reports help students benchmark their performance and focus on improvement. This approach not only saves time compared to writing feedback manually but also enhances its quality, accessibility, and impact.

3.4. Student Reflection

To bridge academic learning with workplace practice, we have asked students to use GenAI to generate solutions to specific mathematical assessment problems and then critically evaluate the output's accuracy and suitability. This exercise goes beyond technical critique: students must decide whether the output is trustworthy, identify limitations, and suggest improvements. They then write a short statement outlining how they would present this solution to a line manager—explaining whether it should be used as-is, adapted, or rejected, and why.

This mirrors real-world scenarios where professionals increasingly rely on AI tools for data analysis and decision-making but remain accountable for the quality and integrity of outputs. By requiring students to justify their recommendations, we develop skills in risk assessment, ethical use of AI, and clear communication—competencies essential for STEM roles. Ultimately, this reflective approach reinforces to our students that AI is a powerful assistant, not a substitute for human judgment. It prepares students to engage critically with technology, ensuring they can harness the power of AI effectively and responsibly in professional contexts.

4. Key Takeaways

We have trialled several ways of using AI to streamline the teaching and assessment cycle in the Data Science Degree Apprenticeship, and so far, the results have been highly positive. These approaches have saved staff time and resource while enhancing student success and engagement. Students report that AI-supported feedback and authentic assessments improve clarity and relevance, and staff value the efficiency gains without compromising academic rigour.

In the workplace, our apprentices report that AI use is permitted and often encouraged, which means our responsibility extends beyond teaching technical skills. We must equip students to use AI responsibly, critique outputs, and communicate best practice. This ensures they can not only apply AI effectively but also educate their organisations on ethical and productive use. Institutional guidance will continue to evolve, so staying informed and sharing best practice is essential. The message is simple: don't be afraid to experiment. By embracing AI thoughtfully, we prepare graduates for a future where human expertise and technological innovation work hand in hand.

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RESEARCH ARTICLE

Scottish Maths Support Landscape: What Does It Look Like in 2024-25?

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Abstract

The Scottish Maths Support Network (SMSN) conducted a first survey of maths and stats support provision in Scottish Higher Education Institutions in 2016. At the time, the SMSN reported the number of institutions offering maths and stats support, the staffing of such services, the type of service offered, and the groups it targeted. Since then, the Higher Education sector generally, and the maths and stats support community particularly, has gone through significant challenges and transformations. To examine how maths and stats support practice in Scotland has evolved, the SMSN ran a new survey in 2024-25, expanding our earlier study by investigating in more detail: maths and stats support posts in Scotland (requirements, types of contracts, additional duties), services' organisational structure, and specific maths and stats support activities (such as use of diagnostic tests and foundation maths courses). In this paper, we present our methodology and results, showing how Scottish maths and stats support has changed, and our recommendations for its future.

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

1. Introduction

1.1 Mathematics and Statistics Support

University wide mathematics and statistics support is typically defined as “a facility offered to students…in addition to their regular programme of teaching” (Lawson et al., 2003), meaning that it does not usually bear credit and is usually non-compulsory. This definition appears consistently across national reviews, including Perkin, Croft and Lawson’s 2012 UK survey, which notes the widespread establishment of structured learning support services across the sector (Perkin et al., 2013). Similar formulations appear in the broader international literature (e.g. Ní Fhloinn et al., 2014; Jacob and Ní Fhloinn, 2019), which emphasise support as an institutional mechanism to assist students with diverse quantitative needs. In this study we discuss mathematics and statistics support *services* (known hereafter as MSS or simply “support”) rather than *centres* in order to capture the breadth of services offered.

Support provision has grown substantially in response to changes in student preparedness, the evolving nature of the “mathematics problem”, and the broadening range of disciplines requiring mathematical skills (Lawson, Grove and Croft, 2020). The previous SMSN survey of provision in Scotland (Ahmed et al., 2018) further shows how support has diversified locally to accommodate national policy drivers and widening participation goals. The separate investigations for Scotland are important: Scottish school-leaving exams (Highers and Advanced Highers) are typically taken at age 16–18 and allow university entry after one year fewer than A-levels in the rest of the UK. Scottish undergraduate degrees usually last four years, compared to three years in England, Wales, and Northern Ireland, reflecting the broader entry level and curriculum.

This report builds upon and updates previous work in Scotland (Ahmed et al., 2018), charting the evolution of MSS across the country. The authors felt that due to the changing landscape of student support, shifts in institutional priorities — perhaps more pertinent than ever in the current financial climate of UK Higher Education — and the lasting effects of the COVID-19 pandemic, it was time to re-evaluate the state of MSS in Scotland. This shift occurs in a context where student experience plays a crucial role in university funding; the Scottish Funding Council (SFC) considers metrics such as number of students enrolled, programme demand, and student retention. Therefore, ensuring students have high-quality teaching and support experiences can impact financial allocations via student recruitment, which is in turn influenced by the National Student Survey (NSS) and student recommendations. Excellence in teaching and support have become essential elements in delivering high-quality student experiences.

1.2 Principles of Effective Provision

Effective support is characterised by accessibility, inclusivity and alignment with the needs of diverse student groups. Evidence from institutionally written regulatory documents demonstrates that universities increasingly view support as contributing to retention, achievement, employability and widening participation (Croft, Grove and Lawson, 2022). Numerous studies highlight the need for proactive outreach, noting that many students under-utilise MSS provision unless specifically encouraged (Marr and Grove, cited in Bowers, 2013), and that support centres act as safe, low stakes spaces for those seeking help (Solomon, Croft and Lawson, 2010).

Formative, dialogic approaches dominate effective practice; MSS centres have been shown to enhance confidence, problem solving and metacognitive skills through personalised feedback (Ní Fhloinn et al., 2014; Lawson et al., 2020). Transition studies indicate that active learning pedagogies within support, such as guided problem solving and collaborative tasks, improve adjustment to university level mathematics (Gallimore and Stewart, 2014).

Collaboration remains a defining feature of the UK support landscape. Practitioners have “collaborated… almost from the outset” (Lawson, 2021) within national networks such as **sigma** (https://www.sigma-network.ac.uk/) and SMSN (https://www.scottish-msn.org.uk/), enabling shared resources, peer learning and consistency of practice across institutions. This collaboration underpins multiple good practice guides (e.g., Green 2012 on student feedback systems) that inform quality enhancement. Despite this, pockets of MSS can often exist in isolation and one of the goals of this survey was to identify as many of these pockets as possible, to obtain a complete picture of what is available to students at Scottish HEIs.

1.3 Developments in the Last Decade

Recent studies document rapid diversification of provision through digital, hybrid and extended hours models, prompted by structural changes in Higher Education, changes in student expectations and the growth of data rich curricula (Lawson et al., 2020). Sector level surveys demonstrate substantial growth in provision: the 2012 audit showed near universal adoption of some form of support (Perkin et al., 2013) and the 2018 survey confirmed increasing uptake and widening institutional investment (Grove, Croft & Lawson, 2020).

MSS is also increasingly conceptualised as contributing to equity and belonging. Student perception studies report gains in confidence, sense of legitimacy and participation (Ní Fhloinn et al., 2014), while identity-based analyses highlight how support can mitigate feelings of marginalisation (Solomon, Lawson and Croft, 2011). The Royal Society's Mathematical Futures Programme (2024) argues more broadly that quantitative and data literacy are essential for citizenship and social inclusion and situates university-based support as part of a wider educational ecosystem addressing national quantitative needs.

It is important to note that sector wide financial pressures and constrained budgets may influence the capacity of universities to expand or sustain support provision at previous levels. Reports emphasise that staffing, space and digital infrastructure require ongoing investment, and that resource limitations risk widening inequalities in how support is accessed and delivered across institutions.

1.4 Evidence Gaps

Despite considerable expansion, research repeatedly identifies gaps in the evaluation evidence base. Reviews highlight challenges in collecting robust data, including inconsistent usage metrics, insufficient longitudinal tracking, and limited capacity to assess cost effectiveness or the impact of sustained engagement. A systematic scoping review by Mullen, Howard and Cronin (2024) identifies potential biases in existing studies and stresses the need for more rigorous study designs, diversified methodologies and cross institutional collaboration.

The Scottish context remains comparatively under-examined. Ahmed et al. (2018) show that while Scottish institutions have well developed support structures, systematic evaluation remains limited and inconsistent, particularly in relation to long term outcomes, alignment with widening participation strategies and transfer of learning into discipline modules.

1.5 Contribution of the Present Study

This survey provides a sector snapshot combined with longitudinal alignment to earlier UK wide and Scotland specific studies, including the SMSN comparative study (Ahmed et al., 2018) and *sigma*'s national audits (Perkin et al., 2013, Grove et al., 2020). It addresses identified gaps in the literature by generating new evidence on staffing arrangements, delivery modes and institutional positioning within Scottish Higher Education. It extends the previous SMSN study by considering diagnostic tests and bridging courses which might previously have not been considered in a conversation about support provision. This study aims to contribute to the growing evidence base of national and international findings that show MSS has become a fundamental component of university support (Lawson et al., 2020; Croft, Grove and Lawson, 2022).

2. Methodology

2.1 Survey Design

Our survey was designed in Microsoft Forms for ease of collaborating and sharing across a cross-institutional team. Since the survey was a follow-up from the 2016 survey (Ahmed et al. 2018), it was designed to include the same themes so that we could accurately assess the changes over time, although often including more detailed questions than the previous survey to obtain a more complete picture. We broke the survey down into several topics:

- General information (including the institution and role of the survey participant, and whether or not their institution provides MSS);
- Staffing (details of who provides MSS, including the types of contracts, training offered and additional duties);
- Types of support (identifying the range of support on offer such as classes, appointments, drop-ins, as well as diagnostic testing and bridging courses);
- Who uses the support? (including which cohorts are offered maths and/or stats support and who the largest user groups are);
- Organisation (including where maths and/or stats support sits within the university structure and how it is funded);
- Final thoughts (areas for improvement and a final question whether they knew of any other sources of MSS at their institution).

For those who answered that their institution did not provide MSS, we included a single question asking them to select why this was the case. While some questions throughout the survey were multiple choice, many were left as open text-entry boxes to allow participants to freely report any nuances at their institution. Since not all support is centralised, we further expected (and hoped) to get multiple responses from individual institutions reflecting the different pockets of MSS being offered to students. While this makes collating all the data more difficult (particularly where responses contradict each other), we felt this was important to get a complete picture of MSS at Scottish Higher Education Institutions (HEIs).

2.2 Delivery

The research was approved by the Physical Sciences & Engineering Ethics Board of the University of Aberdeen on 15 October 2024 (application ID: 3672726). Once approval was received, the survey was sent out via email to:

- Those who filled out the 2016 survey on MSS on behalf of their institution;
- Contacts within the MSS community and maths departments across Scottish HEIs;
- The SMSN mailing list;
- The ScotHELD mailing list (a network for learning developers working within HE in Scotland, whom MSS workers often work alongside).

Particular care was taken to ensure that the survey was sent to someone at each of the 19 HEIs in Scotland. We assessed the initial responses in January 2025 and contacted further individuals to fill in any gaps we could identify. The survey was also advertised at the annual SMSN meeting (which was held jointly with the Scottish Universities Physics Alliance (SUPA)), and at a meeting for those interested in starting a network in Teaching and Learning in Scottish HE Mathematical Sciences. We officially closed the survey in August 2025 and stopped accepting new responses.

2.3 Analysis

Analysis of the data was divided up amongst the project team by theme, and wherever possible, was compared to data from the previous study in 2016. In some cases where responses were contradictory, further enquiries were made to establish the correct response. Where there were multiple responses per institution, due to MSS being offered in more than one place, there were occasionally contradictions. These were usually small issues that were easily cleared up when we followed up with the respondents via email.

3. Results

The survey received 25 responses, representing 16 of the 19 Higher Education Institutions (HEIs) in Scotland. Of the 16 HEIs, 13 responded that they provide mathematics and/or statistics support (MSS) in some form, although in one of these cases the response indicated that the service exists only in name and is not running. HEIs with no provision cited a lack of perceived need (for two specialised institutions, for the Arts and for Music) or lack of funds to provide an MSS service.

3.1 MSS positioning within institutional structures

3.1.1 Structural Positioning

To determine where MSS services are positioned within each institution's structures, respondents were asked 'Where does the maths and/or stats support sit within the university structure?'. Multiple options were provided, along with a free text area for elaboration if needed. Since several institutions had more than one maths/stats support service, the total number of responses exceeds the number of institutions that offer some form of support.

Figure 1 shows the responses, which demonstrate most support is delivered by maths departments. However, in institutions with more than one support offering, the most common arrangement is a central service, in Academic Service, alongside a bespoke service in a department (maths or otherwise).

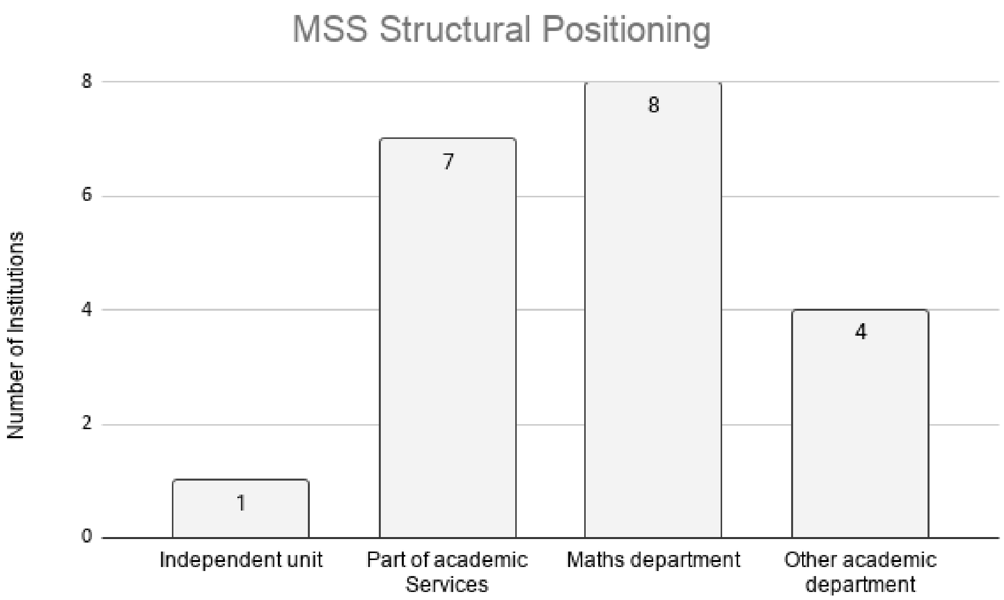

Figure 1: Structural positioning of MSS within institutions that provide the service. Note that some institutions have pockets of MSS in more than one location.

3.1.2 Physical Positioning

The survey looked to discover where, physically, MSS sessions were held and whether services had dedicated space for their student interactions. Figure 2 shows that most MSS services used multiple spaces across campus and six institutions reported that they provide online sessions (not online self-study materials but live support sessions via virtual meeting platforms). Only five institutions had a dedicated space for delivering MSS, although one institute reported a ‘mix of space’ without specifying which types. Note that 6 institutions reported using online space to deliver sessions; this is consistent with work done by Gilbert et. al. 2025 showing a rise in online support post-pandemic.

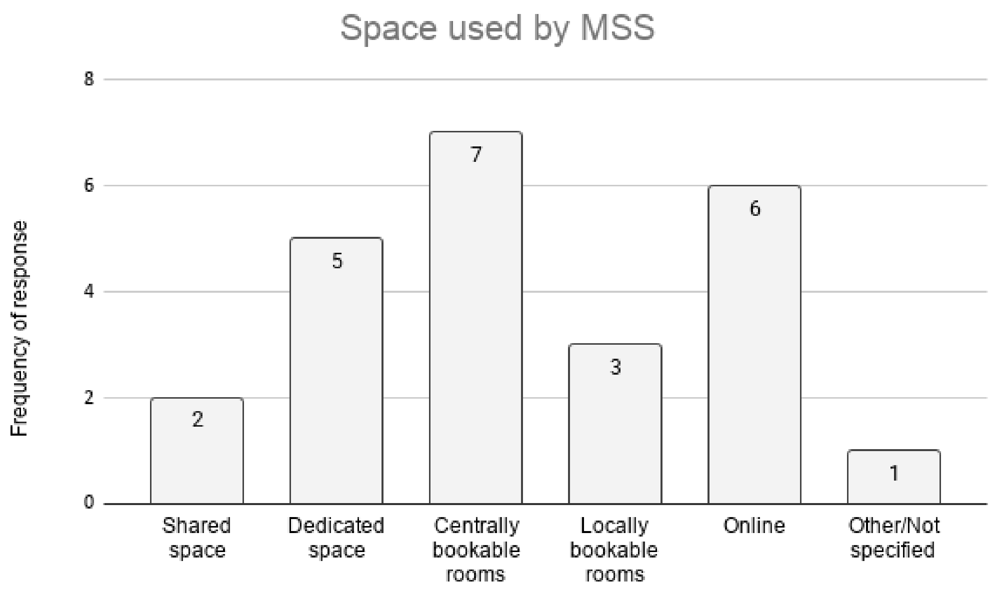

Figure 2: Mix of physical space used for running MSS activities across institutions that provide the service.

3.1.3 How are MSS services funded

Given the changing landscape of student support in HE and institutional priorities the survey looked to probe how MSS is funded by the institutions that provide this service. Four respondents indicated that there were multiple sources of funding, this is most likely due to the spread of MSS across directorates/departments as shown in the Structural Positioning section above.

As shown in Figure 3, most MSS is centrally funded or funded from a departmental budget (maths and others). Two respondents gave no answer to this question, and are recorded as such, but from the response to other questions it can be inferred that these institutions offer support funded by departmental budgets or as part of staff duties.

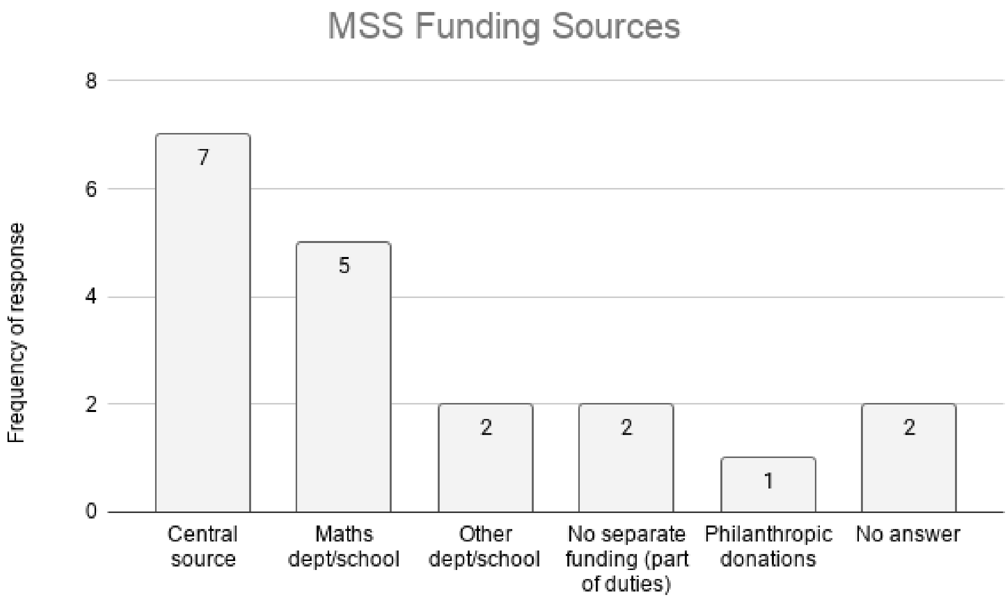

Figure 1: Variation in how institutions fund MSS services across the landscape.

3.2 Staffing Models

Mathematics and statistics support across Scottish Higher Education Institutions (HEIs) is delivered through a range of staffing models, reflecting both historical development and local institutional priorities. The data indicate that 8 out of 13 institutions offering MSS have at least one member of staff whose primary role is maths and/or stats support, and of those, half were on professional services contracts, while half were on traditional academic contracts. These differing contractual arrangements can have implications for role expectations, career progression, and integration with academic teaching activity. In all cases where the maths support was situated alongside other central learning development services, these dedicated MSS staff were on professional service contracts despite still requiring a high level of subject-specific expertise.

Even where dedicated MSS staff are present, there are often others involved in the provision of maths and/or stats support, including postgraduate students and staff members who carry out MSS as an additional duty. The number of institutions using each type of staff is shown in Figure 4.

Figure 2: Graph showing how MSS is staffed in Scottish HEIs.

In terms of employment security, most institutions report that their mathematics and statistics support staff are employed on permanent contracts. This suggests a level of institutional recognition of the ongoing need for such provision. Nevertheless, a minority of services remain dependent on fixed-term contract arrangements, particularly where provision is relatively new or partially funded through short-term initiatives. This variability may affect service sustainability and long-term strategic planning.

Across the sector, institutions consistently identify strong subject knowledge as essential for MSS roles. A degree in mathematics, statistics, or a closely related quantitative discipline is almost universally required. In several cases, postgraduate qualifications are specified, particularly where staff are expected to support postgraduate students or provide advanced statistics guidance.

Teaching experience is frequently cited as either essential or desirable. This reflects the pedagogical nature of MSS, which often involves diagnosing conceptual misunderstandings, adapting explanations to different disciplinary contexts, and supporting students with varying levels of mathematical confidence. The emphasis on teaching experience also highlights the blurred boundary between formal teaching and informal academic support within these roles.

Provision for training and continuing professional development (CPD) varies across institutions but generally combines formal and informal approaches. Many support staff have access to institutional teaching and learning development programmes, such as postgraduate certificates in academic practice, even when employed on professional services contracts. Attendance at external conferences and networks, including mathematics and statistics support–focused events, is also commonly reported and plays a key role in maintaining professional currency.

As shown in Figure 5, an interesting addition to the dedicated MSS staff remit over the years has been the variety of additional duties that are carried out. These include teaching, tutoring, marking, supporting students with additional IT skills. Also included were memberships of committees, involvement in outreach activities, pedagogic research and accessibility support, often irrespective of whether staff are on academic or professional services contracts.

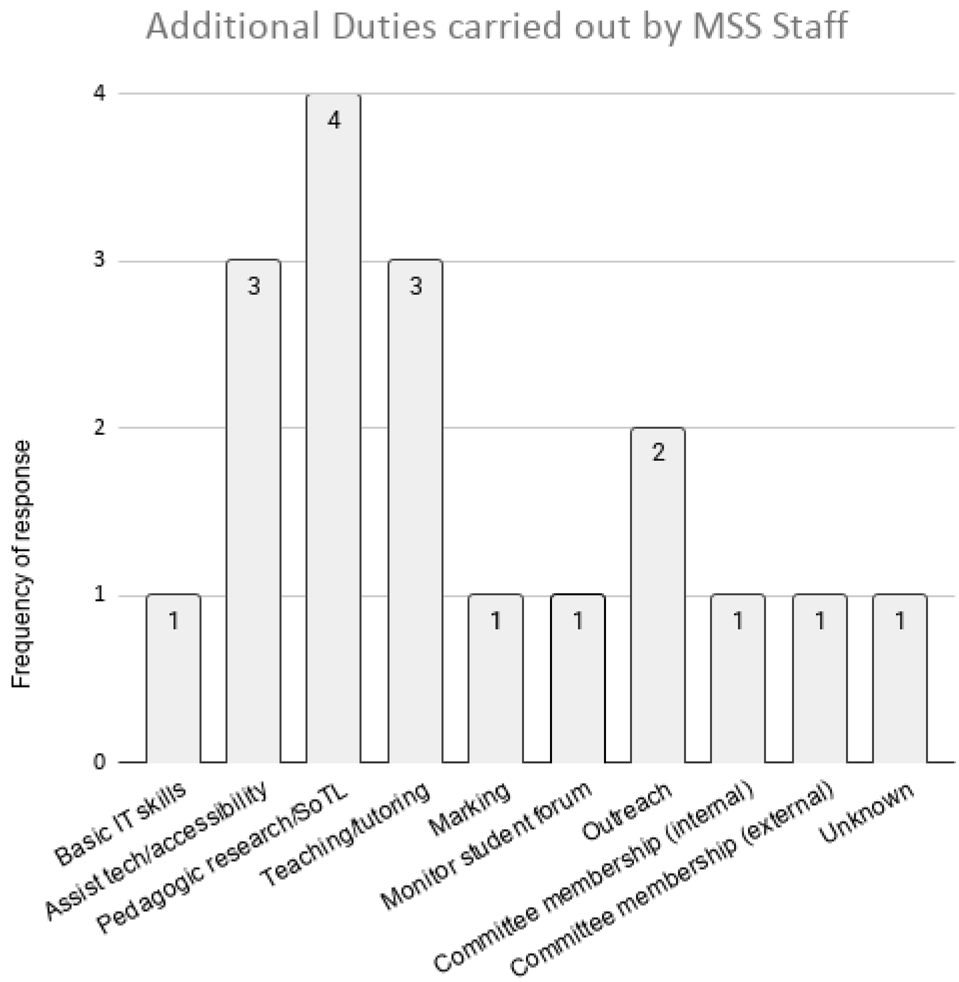

Figure 3: Graph demonstrating the additional duties carried out by dedicated MSS staff in Scottish HEIs.

Where teaching assistants or postgraduate tutors contribute to MSS training is most often delivered internally by existing support staff. However, the data suggest that the extent and formality of such training is inconsistent, ranging from structured induction programmes to more ad hoc guidance.

Overall, the data reveal a diverse professionalised landscape of MSS in Scotland. The prevalence of permanent contracts and dedicated staff suggests that such provision is now viewed as a core component of institutional student support. However, disparities remain in staffing models and the consistency of training provision.

These findings broadly align with trends reported elsewhere in the UK (Lawson, Grove and Croft, 2020), while also highlighting the influence of local context on service design. In particular, the positioning of MSS within professional services structures raises important questions about role identity, recognition, and integration with academic departments.

3.3 Methods of Support

Each institution was asked what types of support they offered, and a table of the results is shown in Table 1 of Appendix B. Almost every institution which offers MSS offers either one-to-one appointments and/or drop-in sessions, demonstrating that these activities are a core part of MSS in Scotland. The only institution which did not offer either, included offering drop-ins as their key desired improvement. Online asynchronous resources are equally common and are the activity that has seen the biggest increase since 2016 (see Figure 6). This is unsurprising in an increasingly digital world, and when students are balancing part-time work or caring responsibilities with their studies. It must be noted that in section 3.1.2, 6 responding institutions reported the use of online space which suggests that synchronous online support was also given. It is a limitation of this survey that the "Methods of Support" question did not break down 1-1 Appointments, Drop-in Sessions and Classes/Workshops into online, in-person or both in order to quantify the synchronous online MSS offered.

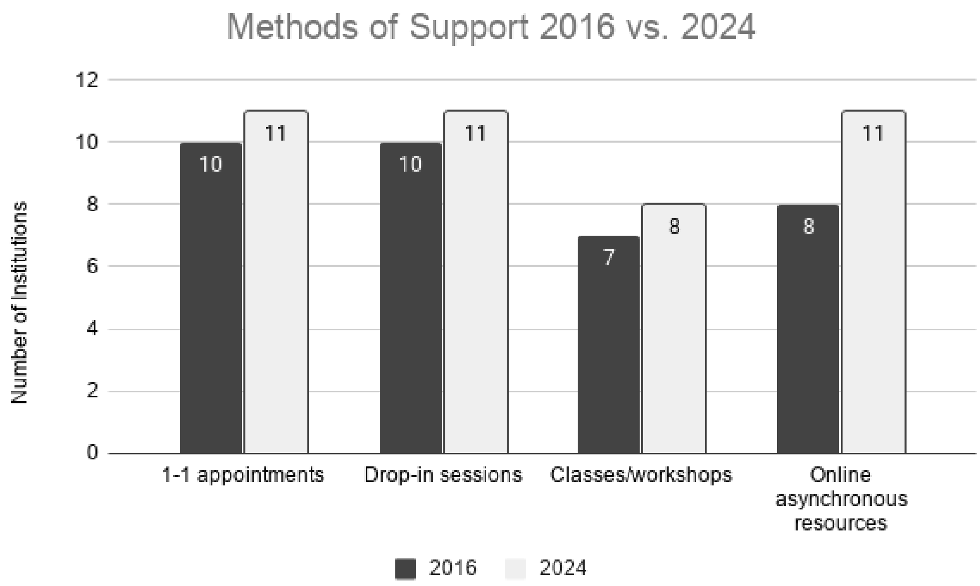

Figure 4: Graph demonstrating the number of Scottish HEIs offering different types of MSS in both 2016 and 2024. In both years, the total number of institutions offering any MSS was 13.

Other than the increase in online asynchronous support, Figure 6 shows only a slight increase in the methods of support offered between 2016 and 2024. However, this does not tell the whole story as there have been shifts between universities on what is being offered. One institution was offering MSS in 2016 but no longer is, and another institution has gone from no support to offering the full range of support we asked about to all students.

In addition, neither Figure 6 nor Table 1 reflect the fact that, within some institutions, certain methods of support are only open to certain cohorts. For example, one institution reports offering drop-in sessions only for students on courses in the School of Mathematics and Statistics, while appointments are only available for students not in that school. Another institution indicated that all of its MSS was only available locally in certain schools, and hence many students have no access to MSS at all.

In the 2024-25 survey, we distinguished between classes held by MSS for specific courses (often referred to as embedded MSS see e.g. Mehbali and Roberts (2017)), and those classes that are open to all students. We see that the embedded approach is more popular, with 8 out of the 13 MSS services offering those, compared to only 6 out of 13 offering open classes. The embedded approach can make it easier to reach more students (MSS goes to them, rather than waiting for students to reach out to MSS), which may account for why this is the case.

Another area explored in the 2024-25 survey that was not included in the 2016 survey was transitions. It is often highlighted that students are arriving at university ill-equipped for the mathematical demands of their course, and so we included questions in the survey focussed solely on the support offered at this point.

Six institutions offer a maths diagnostic test to their students. These were most commonly (4 out of 6) focussed only on students who are pursuing a maths degree, but there were also optional basic numeracy tests, and bespoke tests for economics and engineering students.

Seven institutions have also introduced at least one bridging course, aiming to mitigate the negative effects of a student starting university with a weak level of mathematics for the degree they arrive to undertake. The majority are held online, but there were differences in whether they were held before term began or alongside semester one, and differences whether they were optional or compulsory. They were also offered to a more diverse range of cohorts including those from across STEM, as well as graduate apprentices, and in one case, to any student who does not already have an SQA National 5 Mathematics Qualification (equivalent to GCSE). Perhaps this is deemed a less intimidating option for non-mathematics students than presenting them with a diagnostic test.

Overall, the core provision of MSS remains one-to-one appointments and drop-ins, with an increase in online asynchronous resources. Provision is varied from institution to institution, and even within institutions where MSS is offered locally. In some cases, the multiple responses we received from a single institution were contradictory, and this was discovered to be due to a diversity of offerings within the same institution.

3.4 Users of MSS in Scotland

In 2024-25, all MSS in Scotland worked with undergraduate (UG) students (centralised as well as departmental services), 12 MSS worked with postgraduate taught (PGT) students (all centralised MSS worked with PGT students while 5 departmental services did), 9 MSS worked with PGR students (6 central MSS and 4 departmental MSS), 5 and 6 extended support to foundation programmes and staff respectively (with 4 centralised MSS working with either categories, and 1 and 2 departmental services working with foundation programmes and staff respectively) (see Figure 7). Details of the responses from the institutions are shown in Table 2 of Appendix B.

In 2016, all Scottish MSS already worked with UG students, and this is perhaps not surprising as MSS was historically set up to work with pre-honours students (Lawson, Grove and Croft, 2020). We see that in 2024-25, MSS continues to be uniformly offered to UG, further indicating that MSS has become an established service for undergraduate studies. We also see that, in comparison to 2016, more MSS in Scotland extend their services to PGT, PGR and staff. As we had not specifically asked about Foundation levels in 2016, it is hard to conclude for this category of users.

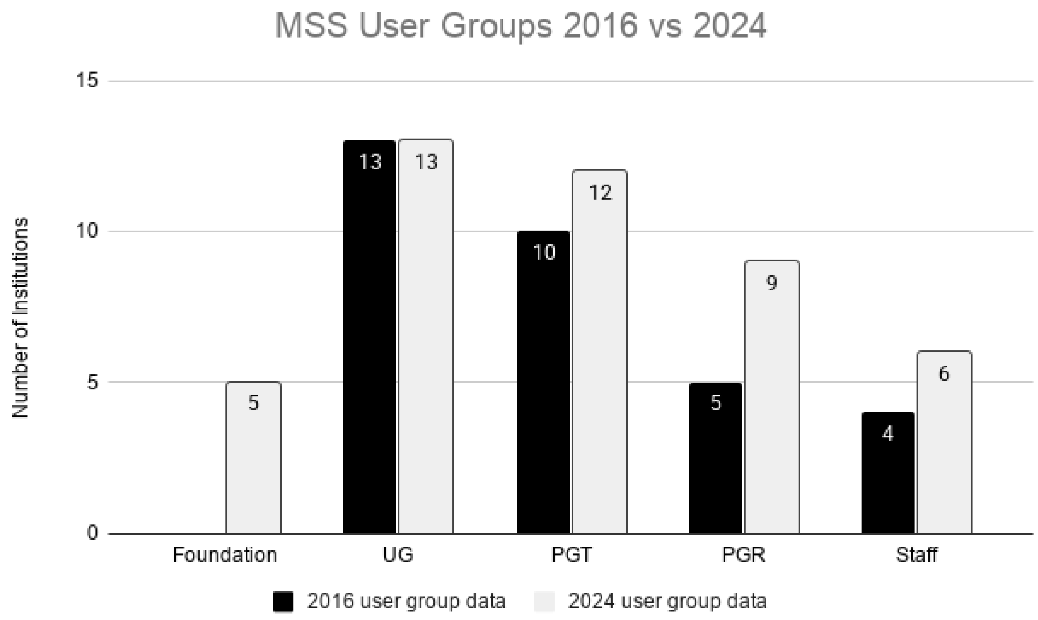

Figure 7: Number of MSS who opened their service to foundation, UG, PGT, PGR students and staff in 2016 and in 2024. In both cases, the number of institutions offering any MSS was 13. Data about foundation programmes was not collected in 2016, so only the data for 2024 is shown.

Participants were asked to explain whether MSS was open to all disciplines, or restricted to only some, in an open text question. Analysis of responses shows that 10 MSS are open to all disciplines without discrimination (all central services are non-discriminate, and 3 departmental services are non-discriminate).

Further, participants were asked to indicate, in open text questions, which were the largest user groups of MSS, when applicable, and the largest user groups of stats support, when applicable. STEM disciplines (Mathematics, Engineering and the Physical Sciences), and Business and Economics were identified as the largest user groups for MSS. Social Sciences, Psychology, Business & Economics, Life and Health Sciences, as well as STEM subjects were reported as the largest user groups of stats support. In 2016, Engineering, Health Sciences and Business Studies were found to be the largest user groups, although the survey did not differentiate between maths support and stats support users then.

These results show that MSS is increasingly offered to students from all levels of study, from foundation level to postgraduate research level, including staff in some settings, as well as a wide range of subjects. Users in Scotland now come from Social Sciences (including Psychology and Economics) and Life Sciences (including Health Sciences) disciplines, as well as the Physical Sciences disciplines, which constituted the historical user groups (Lawson, Grove and Croft, 2020). We note, however, that centralised MSS offer indiscriminate support to all levels and disciplines in greater proportion than departmental services. Offering university-wide support also means that MSS practitioners must be able to tackle very diverse pedagogic situations, to teach at very different levels and in very different contexts. It highlights, therefore, the need for well-qualified staff and a good integration with departments across institutions.

3.5 How are MSS services advertised

Given that MSS practitioners frequently encounter students who are unaware of services or do not consider them applicable, all institutions understandably employ multiple advertising strategies for their MSS services. Multiple options were given as a response to this question as well as a free text area for other methods to be highlighted. The results are shown in Figure 8.

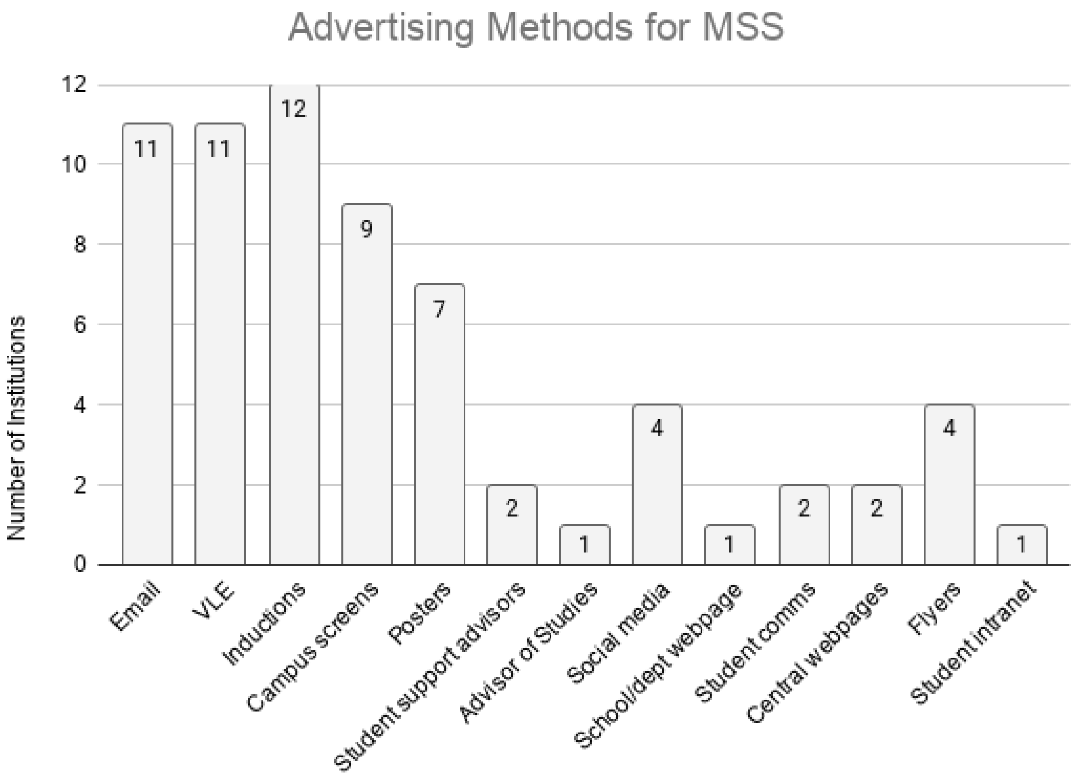

Figure 5: Variety of advertising methods used to make students aware of the availability of MSS services.

In addition to the survey question, the authors did a public search (using Google search engine) for each institution that reported that they have a MSS provision, to find out if information regarding the service was publicly available i.e. not within a password protected VLE or intranet site. The data shows that 3 institutions have no publicly available information on MSS while all others advertised MSS under a central support webpage; all but two of the webpages came under some variation of student/academic/skills support banner. The two other webpages were direct links to an MSS dedicated webpage/site. Table 3 in Appendix B below shows the results, and gives the links found (as of November 2025) – the websites are split into two categories (1) a website directly for the service and, (2) information about the service on a more central website.

3.6 MSS Wishlist

To gain insights into how practitioners felt MSS could be improved, respondents were asked ‘How do you think your service could be improved? What would be on your service wish list if you have more resources?'. A total of 16 respondents commented, and three main themes emerge from the answers: staffing, service structural and physical positioning and service delivery.

Despite many Scottish institutions having MSS staff employed on permanent contracts (see Section 3.2), staffing remains an area that practitioners would like to improve on. Five respondents wished for more staff in MSS. One respondent noted that increased staffing would allow, in particular, to open MSS outside the usual business hours, and thus cater for non-traditional students, such as students with caring responsibilities. Another respondent, however, mentioned the difficulty to recruit staff with the necessary specialised skills for an MSS role, showing that the staffing of MSS is not solely a financial issue.

As noted in Section 3.1, a significant portion of MSS in Scotland are run by departments. Three respondents called for a central MSS to be developed in their institution. These participants noted that central services would ensure that MSS can be accessed by students from all disciplines, and indeed, we show that central MSS cater for a wider range of disciplines (see Section 3.4). Beside the structural positioning of MSS, the physical space of MSS was mentioned by five participants: either the MSS in their institution did not have a dedicated MSS space, or the space allocated was too small.

Finally, expansion of service delivery, such as increased number of workshops, implementation of drop-in sessions, as well as the development of discipline-tailored sessions and resources were noted as areas of possible improvement by five respondents.

4. Discussion

The first survey of the MSS landscape in Scotland was conducted in 2016. Given the changes that the Higher Education sector has undergone in recent years, it was timely to conduct a subsequent survey to study how MSS might have evolved across the nation.

The number of institutions offering maths and/or stats support has remained the same. One institution, however, has stopped offering support while another, which offered no support in 2016, now offers a comprehensive service to all students. Some institutions also now host several support services when they had a single support in 2016. There have been some changes, therefore, but the fact that the number of Scottish universities with MSS has not decreased in the past eight years is a good indication that MSS has become an essential feature of Scottish Higher Education.

In comparison with 2016, MSS is now offered increasingly to all levels of study, as well as staff. We also know from this survey that the majority of services see visits from students from a wide range of subjects. This supports the finding that MSS practitioners are required to hold relevant subject qualifications and teaching experience, as they will need to support students and teach in many different contexts and situations. We also see that MSS practitioners now take on a variety of duties, including outreach activities, accessibility roles, and pedagogic research, often regardless of whether they are on a professional services or academic contracts. This highlights the importance of CPD and participation at practitioners and network conferences, and further, the need to maintain the strong national and international networks. In Scotland, many are able to access internal and external development opportunities. This is positive and, we hope, will continue to be the case in future.

One-to-one appointments and drop-in sessions continue to be popular modes of MSS delivery in 2025, as it was in 2016. Asynchronous online resources have experienced the largest increase, perhaps not surprisingly, following the COVID-19 pandemic, and given the rise of online education. We also identified in 2025 that embedded MSS (Mehbali and Roberts, 2017), was very popular. This raises the question of the ability of MSS to work alongside academic disciplines, and in turn, the structural position and funding of MSS in universities. In Scotland, the majority of MSS are run by mathematics departments, and the next most common are units within academic services, with an equal number of services funded by a department or school (maths or otherwise) or funded centrally. If embedded support initiatives are identified as an efficient support approach (Lawson, Grove and Croft, 2020), it might be that a service located and funded centrally would be best able to develop these, as it would have the freedom to work across the institution, and perhaps, not be seen by disciplines as belonging to a department or School.

While we asked respondents information about where MSS sessions are taking place in their institution, six respondents specified 'online' in the 'other' category. As we have not asked further details about the online synchronous delivery of MSS in this survey, we are unable to say whether 'online' means online appointments, online or hybrid workshops, or online or hybrid drop-ins. We also cannot comment on how significant online MSS is in relation to in-person MSS, and whether this is addressed to specific cohorts (e.g. online and distance learners). In the authors' experience, on-campus students prefer in-person support, however, further examination of who, and when, is using online MSS could be the subject of future studies.

This present study examined MSS provision without discriminating between maths and stats support. While we asked participants to report the number of hours for maths and stats support separately, answers indicated that some MSS provide a total number of hours for both maths and stats support, while in other institutions, there is a specific provision for maths support, and/or a specific provision for stats support. It would be interesting to examine in more details how maths and stats support may differ in Scottish institutions in a future study, especially as more disciplines put a greater emphasis on data science and analysis.

In conclusion, the role of MSS practitioner is a multi-faceted one that requires specialised knowledge and abilities (Croft, Grove and Lawson, 2022), and recruiting staff with the right expertise can be challenging, as a participant to the survey mentioned. MSS will often work with a wide range of disciplines and pedagogic situations. The particular characteristics of the role must be recognised by managers, and should inform the model adopted for MSS.

In 2025, MSS continues to be part of the Scottish Higher Education system. Services have expanded to include more levels of study and a wide range of disciplines, particularly central MSS, and have embraced the development of online asynchronous resources following the COVID-19 pandemic. We see positive signs that many are on permanent contracts, with adequate qualifications and experience, and have access to relevant professional development. We hope that this will continue to be the case despite the financial difficulties that institutions are facing.

5. Appendices

Appendix A: A copy of the survey

General Information:
Name:
Role:
Institution:

1. Does your institution offer Mathematics and/or Statistics support?
   ☐ Yes (go to Staffing section)
   ☐ No (go to Question 2)

2. Why does your institution not offer Mathematics or Statistics Support? Please select all that apply:
   ☐ Maths/Stats support not required
   ☐ Lack of funding
   ☐ Lack of support from senior management
   ☐ Other:
   END SURVEY

Staffing:

3. Do you have any staff whose primary role is to provide Maths and/or Stats support?
   ☐ Yes (go to Question 5)
   ☐ No (go to Question 4)

4. Who provides your Maths and/or Stats support? Please select all that apply:
   ☐ Additional duties for more general teaching staff
   ☐ Postgraduate students (GTAs) for Maths support
   ☐ Postgraduate students (GTAs) for Stats support
   ☐ Other:
   (go to Question 14)

5. Please provide more details of how your Maths support is staffed. Please select all that apply:
   ☐ Dedicated staff
   ☐ Postgraduate students (GTAs)
   ☐ Additional duties for more general teaching staff
   ☐ Other:

6. Please provide more details of how your Stats support is staffed. Please select all that apply:
   ☐ Dedicated staff
   ☐ Postgraduate students (GTAs)
   ☐ Additional duties for more general teaching staff
   ☐ Other:

7. Please state total FTE for Maths Support:

8. Please state total FTE for Stats Support:

9. For dedicated Maths & Stats support staff, what type of contract are they on?
   ☐ Professional Services
   ☐ Academic Teaching & Research
   ☐ Academic Teaching & Learning/Scholarship
   ☐ Unknown

☐ Other:

10. For dedicated Maths & Stats support staff, what length of contract are they on?
    ☐ Permanent
    ☐ Fixed term
    ☐ Mixed
    ☐ Unknown
    ☐ Other:

11. Which of the following are in the essential criteria for the post of maths/stats support adviser?
    ☐ Maths or quantitative science degree
    ☐ Postgraduate degree in maths or quantitative science
    ☐ Teaching qualification
    ☐ Teaching experience
    ☐ Software experience (please list any essential software in the “Other” box)
    ☐ Other:

12. What training/professional development is available to your staff? E.g. support to become fellows of AdvanceHE, funding for conferences/travel, teaching development courses such as PGCAP.

13. What additional duties do the Maths and/or Stats support staff carry out? E.g. outreach, pedagogic research, accessibility.

14. If you employ teaching assistants, do you offer any training? And if so, who delivers it?

Types of Support:

15. What types of support are on offer? Please tick all that apply:
    ☐ 1-1 appointments
    ☐ Drop-in sessions
    ☐ Classes/workshops for any student
    ☐ Classes/workshops for specific courses
    ☐ Online asynchronous resources
    ☐ Other:

16. How many hours a week of Maths appointments are generally available?

17. How many hours a week of Stats appointments are generally available?

18. How many hours a week of drop-ins do you offer during term-time?

19. Does your institution use a diagnostic test to assess the mathematics ability of level 1 students?
    ☐ Yes, for maths students (go to Question 20)
    ☐ Yes, for other STEM students (go to Question 20)

☐ No (go to Question 21)
☐ Other: (go to Question 20)

20. Please provide details of which students receive a diagnostic test:

21. Does your institution offer a bridging course or other mitigation for students whose starting level of mathematics is weak for the degree they arrive to undertake?
☐ Yes (go to Question 22)
☐ No (go to Who uses the Support? section)

22. Please describe who this course is for and what format it takes:

Who uses the support?

23. Who can use the service? Please select all that apply:
☐ Foundation (pre-undergraduate)
☐ Undergraduate (UG)
☐ Postgraduate Taught (PGT)
☐ Postgraduate Research (PGR)
☐ Staff
☐ Other

24. Is Maths and/or Stats support open to all schools/disciplines/levels, or open to some only? Please provide details.

25. What is/are your largest user group(s) for Maths Support?

26. What is/are your largest group(s) for Stats support?

27. Do you record attendance?
☐ Yes
☐ No

Organisation:

28. Where does the maths and/or stats support sit within the university structure?
    - ☐ Within the maths department
    - ☐ A central unit by itself
    - ☐ In a central unit with other learning development services
    - ☐ Other:

29. Where do the maths/stats support sessions take place? Please select all that apply:
    - ☐ Dedicated space
    - ☐ Shared space
    - ☐ Centrally bookable rooms
    - ☐ Locally bookable rooms
    - ☐ Other:

30. Can you please comment on how your maths/stats support service is funded?

31. How do you publicise the service? Please select all that apply:
    - ☐ Student inductions
    - ☐ Emails
    - ☐ Campus screens
    - ☐ Posters
    - ☐ Flyers
    - ☐ VLE pages for certain courses
    - ☐ Social media
    - ☐ Other:

Final Thoughts:

32. How do you think your service could be improved? What would be on your service wish list if you have more resources?

33. Are you aware of any other maths and/or stats support provided within your institution? And if so, who by?

END OF SURVEY

Appendix B: Tables of responses

Table 1 - Methods of Support: a table of Scottish HE institutions and their responses to which methods of maths and/or stats support they offer. Note that for institutions where there are several services (i.e. departmental and central services, or several departmental services), the answers from the different services have been collated in the table below. Moreover, 'Y' means that form of support is offered to at least one student cohort, not necessarily that it is available to all students.

Institution	1-1 Appointments	Drop-ins	Classes for specific courses	Classes for any student	Online asynchronous resources
Abertay University	Y	Y	Y	Y	Y
Edinburgh Napier University	Y	Y			
Glasgow School of Art					
Heriot-Watt University	Y	Y	Y	Y	Y
Queen Margaret University			Y	Y	Y
Robert Gordon University	Y		Y		Y
The Royal Conservatoire of Scotland					
University of Aberdeen	Y	Y	Y		Y
University of Dundee		Y			Y
University of Edinburgh	Y	Y	Y	Y	Y
University of Glasgow	Y	Y	Y	Y	Y
University of the Highlands and Islands (Inverness)	Y	Y	Y	Y	Y
University of St Andrews	Y	Y			Y
University of Stirling					
University of Strathclyde	Y	Y			Y
University of the West of Scotland	Y	Y			
Total	**11**	**11**	**8**	**6**	**11**

Table 2 - MSS support user groups: user groups to which maths and/or stats support is offered to, for Scottish institutions which have a maths and/or stats support service. Note that for institutions where there are several services (i.e. departmental and central services, or several departmental services), the answers from the different services have been collated in the table below.

Institution	Foundation	UG	PGT	PGR	Staff
Abertay University		Y	Y		
Edinburgh Napier University	Y	Y	Y	Y	
Heriot-Watt University	Y	Y	Y	Y	
Queen Margaret University		Y	Y	Y	
Robert Gordon University		Y	Y	Y	Y
University of Aberdeen	Y	Y	Y	Y	Y
University of Dundee		Y			
University of Edinburgh		Y	Y	Y	Y
University of Glasgow		Y	Y		
University of the Highlands and Islands (Inverness)	Y	Y	Y	Y	Y
University of St Andrews	Y	Y	Y		
University of Strathclyde		Y	Y	Y	
University of the West of Scotland		Y	Y	Y	Y
Total	**5**	**13**	**12**	**9**	**5**

Table 3 - Publicly available information on the provision of MSS: This table shows the availability of information on MSS services at institutions that provide such a service.

Institution	Maths support website	Central support website
Abertay University	No	No
Edinburgh Napier University	No	https://my.napier.ac.uk/library/study-and-research/study-skills#:~:text=If%20you%20need%20help%20with,(0)%20131%20455%202236
Heriot-Watt University	www.mathsgym.hw.ac.uk	https://www.hw.ac.uk/uk/services/is/skills-development/study-support.htm
Queen Margaret University	No	No
Robert Gordon University	No	https://www.rgu.ac.uk/life-at-rgu/support-advice-services/study-support-services#anchor-3
University of Aberdeen	No	https://www.abdn.ac.uk/students/academic-life/academic-skills/#panel101984
University of Dundee	https://learningspaces.dundee.ac.uk/asc/maths-and-stats/#:~:text=Maths%20Caf%C3%A9,explore%20problems%20and%20find%20solutions	No
University of Edinburgh	No	https://maths.ed.ac.uk/studying-here/undergraduate-study/student-support
University of Glasgow	No	https://www.gla.ac.uk/myglasgow/sld/about/team/mathsandstats/maths/
University of the Highlands and Islands (Inverness)	No	https://www.inverness.uhi.ac.uk/study/student-support-services/the-bothy/
University of St Andrews	No	https://www.st-andrews.ac.uk/ceed/study-skills/mathsandstatisticssupport/
University of Strathclyde	No	https://www.strath.ac.uk/studywithus/strathlife/academicsupport/
University of the West of Scotland	No	No

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CASE STUDY

Developing pedagogical research methods at Durham University

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Abstract

In this article, we examine the challenges faced by Education-track staff as they begin to conduct scholarship and/or pedagogical research. These may include a lack of familiarity with qualitative research methods; uncertainty or lack of confidence when choosing and applying theoretical frameworks; and inconsistent Departmental or University resources for conducting this research. We outline the approach we have taken in the Education and Pedagogy Group at Durham: a series of linked, concurrent research projects, using the same methodologies and approaches (in this case, focus groups and thematic analysis). We discuss the benefits and challenges of this approach, and make some recommendations for how other groups could apply it in their own contexts.

Keywords: Qualitative research, building scholarship capacity, methodological case study.

1. Introduction and context

Education-track staff[i] are an emerging group within academic departments: in the UK, the proportion of academic staff on education-focussed contracts has increased from 25% in 2015 to 36% in 2024 (Perrot, 2025). In the Maths department at Durham University, and many others around us, this increase coincides with a shift away from temporary contracts and towards permanent academic positions. Correspondingly, our workload has shifted away from high-volume teaching and now includes more educational innovation and leadership, with a new expectation that we should begin to undertake scholarship and/or pedagogical research (Bull et al, 2025).

Defined as scholarship “aimed at understanding and improving discipline-specific teaching and learning” (Dolan et al., 2018), Discipline-Based Education Research (DBER) can be a useful framework for Education-track academics in this context. It represents an interdisciplinary challenge for us: our training and expertise lie in mathematical fields, rather than in social sciences. In many ways, we are extremely well-placed. As experienced educators, we have deep and nuanced understandings of our topics and their particular challenges. We maintain networks with other education-focussed academics, fuelling our awareness of discipline-specific pedagogical developments. As a result, we are “uniquely placed to bring to bear [our] deep familiarity with the subject, allied to [our] pedagogical content knowledge, in order to play an integrated role” (Galloway and Hernandez-Martinez, 2017). In contrast to our colleagues in Education departments, we also have direct contact with mathematics students, giving us insight into their learning; how they view their education, their peers, or emerging technologies; and the effects of small changes in format or content.

On the other hand, undertaking this work does not only require discipline-specific knowledge. Evans' model of the "integrated academic" identifies seven key factors for high-quality education research, including Research Methodology Expertise, Data Analytic Competence, and Critical Pedagogy (Evans et al, 2021). For many of us, working with theoretical frameworks, ethical conventions, evaluative practice, and both qualitative and quantitative methodologies is outside our comfort zones, lying in the less-familiar territory of social sciences. While this is not an uncommon position – Dolan et al describe "self-teaching by reading and professional development" as a primary way in which DBER researchers can develop education research skills (Dolan et al, 2018) – there is little existing literature providing experiential perspectives on *how* to go about this retraining.

Currently, Mathematics departments are facing new and pressing questions, including how to maintain teaching quality with changing staff-student ratios; how to react to generative AI while preserving educational integrity; and how to provide for diverse and changing needs within the student body. While these questions are faced by all teaching staff, it is our experience that education-focused staff in particular are the ones asked to consider them. Framing this existing work as DBER can help us to make sure that it is robust, collaborative, and has a broader reach, attaining the "pragmatic" quadrant of Evans et al.'s typology of pedagogical research (Evans et al., 2021). Additionally, given that our research time is often less protected than that of our research-and-education colleagues, it is pragmatic to use our existing work as the basis for scholarship through DBER.

However, it can be difficult to know how to begin a first DBER project. In the rest of this article, we outline an innovative approach taken by a group of education-track academics in the Mathematics department of a large, research-focused University. As of 2025-26, this Department numbers approximately 110 staff. Within this, the Education and Pedagogy group numbers ten permanent education-track staff; one teaching fellow; five affiliated PhD students, and around five interested education-and-research staff.

We present this paper as a capacity-building and methodological case study. We hope that it will form a blueprint for other academics beginning their DBER careers, and provide some of the guidance that we would have liked to receive. We have chosen to include the reasoning behind some of the decisions taken in the first stages of the research project, in the hope that it will prove helpful to other researchers in our position.

2. Methodology

We organised concurrent research projects, based around similar research questions and using collaboratively established research protocols. At some stages, we worked together as a whole group; for other parts, each sub-group worked independently. See Figure 1 for a detailed timeline of the project.

Figure 1. A figure indicating the different stages of the collaborative research project, demonstrating which parts were done collaboratively and which were done as a whole group. It also shows the anticipated and actual timelines of the project.

By working both collaboratively and separately on our projects, we were able to build experience of scholarship projects from beginning to end. Our chosen approach enabled all members of the team to develop pedagogical research skills and take ownership of their own projects, while maintaining a group structure that encouraged progress and continued motivation from all members. We feel that this approach has two key advantages over a larger shared project. Firstly, as a large group, we were able to involve many more people in the project without it becoming too complicated or unwieldy. Secondly, it ensured that every member of the group had the opportunity to engage in every stage of the process equally, avoiding a scenario where each person became an "expert" in one aspect without being exposed to others.

2.1 Research questions

A key early decision was the choice of research questions. By devising a suite of linked, but distinct, research questions, we hoped to achieve three goals: first, to answer pressing questions being asked in our department; second, to enable all group members to take ownership of an individual project; and third, to maintain as much coherence as possible between the methodologies of the different strands. Our overarching research question was therefore

RQ: How do students use resources?

This question, in different forms, was of interest to many members of the group, whether they were involved in developing accessible html resources, discussing a new departmental policy about student use of generative AI, or working to optimise the staff time and workload involved in different teaching activities. By selecting a version of this question that interested them particularly, each group member was invested in the research for its own sake and not only as a learning exercise.

In group discussion, we established a total of nineteen possible versions of the research question, ranging from "How do students interact with support classes" to "How do students use generative AI". From this list, and based on individual interests, we formed three pairs, each working to answer one of the following research questions.

RQ1: How do students use feedback?

RQ2: How do students use lecture notes?

RQ3: How do students use external resources?

While there is plenty of excellent research into these questions – see, for example, Ni Shé et al, 2017 – we felt that the context had changed sufficiently to require re-examination. Our students receive both written and computer-generated feedback on their work and have access to lecture notes and external resources in a huge variety of formats. Gaining extra understanding of the current state of students' approaches to these resources would be both timely and informative.

The decision to work in pairs, rather than individually, was carefully taken. We wanted to prioritise questions that were directly relevant to current discussions in the department, and that were likely to lead to high-quality research. Working in groups also meant that there was more opportunity for additional members of the wider group to participate in ways that worked for them, joining or leaving the project as needed.

2.2 Focus groups

We decided to prioritise a qualitative research method in this project. As some members of the group with more statistical backgrounds had quantitative experience, we felt that the group's energy was best dedicated to learning a skill that would be new for everyone. We also felt that it would be most practical to choose a methodology involving relatively few students. We had a relatively small budget to pay participants for their time; previous large surveys had produced relatively low response rates. This led us to two primary protocols: semi-structured interviews and focus groups. Because we hoped to understand a range of student perspectives on the questions, without generating longer transcripts than we were prepared to analyse, we selected focus groups as our main research protocol. Given the budgetary and time constraints, we elected to run one focus group per "theme" (with an additional session, dedicated to postgraduate students, for the external resources theme). While best practice suggests that one should run multiple focus groups, we chose to balance this consideration against the practicalities of the project. Our primary aim was to gain valuable experience for future research projects.

Each focus group was led by two staff members: one was designated the "speaker" and the other the "note-taker". This meant that almost everyone was able to participate in a focus group, even if they did not lead it. In future iterations of this project, we plan to ensure that group members who took "note-taker" roles will also take a turn to lead a session.

We recruited undergraduate students studying Mathematics or Mathematics and Statistics degrees, using an “expression of interest” form that did not distinguish between the three possible themes. Each focus group invited six students to participate; on the day between five and six students attended each one. As noted in Section 1.3, when allocating students to topics we avoided placing students with researchers they knew well or had worked with closely, although inevitably some students had crossed paths with the researchers in the past.

We broadly followed the focus group protocol outlined in (Brown and Edmunds, 2011). We found this to be an accessible and helpful resource as first-time researchers in this context. For each of the three topics, we planned an introductory warm-up activity and around four “key questions” to ask the students.

The warm-ups consisted of a prompt, which students were asked to answer using post-it notes, either listing elements of good feedback, ways in which lecture notes are used, or different external resources that might help them to study. We hoped that these activities would encourage students to think about the research questions on their own terms, without being influenced by our opinions. Following this activity, the researchers asked students a series of questions, referring to their previous answers and leading to more guided discussions of each research topic.

The timing of the questions and the discussion was one area which all the researchers found particularly challenging. Reflecting afterwards, we felt that “finding the balance between letting students say their own things, and trying to keep them on topic, is harder to achieve than [we] realized” and that we had not been sure when it was best to let students keep talking, and when it would be better to move them onto the next question. This is an area we hope to develop in future focus group projects.

We recorded each focus group using Microsoft Teams, which automatically produces a transcript. These transcripts were edited by the researchers, for clarity and to distinguish between the individuals speaking at each point. Although our early estimates for how long each stage of the project would take were almost universally too short, this was particularly true for transcription. We wanted to ensure that all members of the group would gain experience in every stage, but assigning different parts of the transcript to different group members and then re-unifying our approaches was a particularly time-consuming task. We agreed to take a verbatim transcription approach, but remove filler words which could “detract from the content of the interviewee’s words and…make the interviewees appear less articulate than they really are” (MacLean et al, 2004).

To analyse our data, we used thematic analysis. It is a widely-used technique, (see, eg, Iannone and Miller, 2018 or O’Neill and Padden, 2022), which we therefore felt would provide us with a highly transferable skill for later research projects.

We followed the approach described in Braun and Clarke, 2006, which comprises six stages: familiarise yourself with the data; generate initial codes; search for themes; review themes; define and name themes; and produce the report. As we noted above, almost all of these stages took longer than we anticipated at the beginning of the project. We used an inductive coding approach, to “let the data speak for themselves”, with nVivo as our primary coding software.

2.3 Ethical research

A particular novelty for most of the participants in this project was that this research required directly collecting and analysing data from people, requiring ethical approval. Although this seemed intimidating at first, the structure of the project made it a particularly effective learning experience. As a very standard focus group project, there were no unusual or difficult ethical concerns to address in the ethics form. To streamline the submission process, we worked together to draft one version of the form, to be submitted first, before implementing any requested changes and then adapting this submission for the other two sub-groups. Our University's Centre for Academic Development provided training and easily modifiable template consent forms, participant information sheets and data management plans, all of which made this process simpler than we first expected. The ethics form was sent to our Departmental ethics committee for approval. Due to our significant preparation and the relatively simple nature of the project, our ethics form was accepted without any suggested changes, but as the ethics team was unused to projects of this type, it did take them two months to get back to us.Two specific ethics related aspects merit particular comment. Firstly, we were lucky that we were able to pay our student participants (£15 in gift vouchers). This was a fair way of rewarding students for their participation in the project and encouraged a wider range of students to volunteer. This cost the Department about £250 in total, which is not completely insignificant for a new research group in the current financial climate, but we were able to argue successfully that this was good value and a low price compared to the costs of other groups' projects.

Secondly, we had to consider issues relating to positionality (Braun and Clarke, 2021). This primarily related to students' perceptions of us as lecturers. We could be thought of as being in a state of fluid identity (Thompson and Gunter, 2011) with respect to our students: our prior experience of being maths students may make students more comfortable with us, but students might be cautious of us given our position as authority figures. This might affect how honest they were in their answers, and particularly criticisms, especially as we were recording the focus group, which can be a concern even if we promise anonymity – the well known 'recorder phenomenon' (King, Horrocks, Brooks, 2018). Additionally, as the data we were analysing related directly to our own work, our own conscious and unconscious biases would affect how we would interpret what the students said. To mitigate both factors, we excluded students with whom we had a close educational relationship. This still did leave room for significant bias to creep into our results, but this could not be resolved while we were studying students in our own department and being aware of this in our analysis was important. Future work using other methodologies (such as questionnaires) or collaborations with other institutions, where we might interview each other's students, may reduce this bias further.

3. Reflections

3.1 Reflecting on our skills

This project has allowed us to develop our research skills, both individually and as a group. As an internal reflective measure, each group member completed "before and after" self-assessments of their confidence in each of the seven aspects of an "integrated academic" listed in Evans et al, 2021, shown in Figure 2.

Figure 2. A figure containing each group member's self-assessed confidence "before" and "after" the project, in each of the seven aspects of an integrated academic (Evans et al, 2021).

We were initially confident in Disciplinary knowledge, Pedagogical expertise, Academic practice, Contextual awareness, and Critical pedagogy, with average "before" self-assessments between 3 and 4 out of 7 for these factors. However, our collective confidence in our Data analytic competence and Research methodology expertise was much lower, with group average scores between 1 and 2. This reflects our position as budding DBER practitioners: we had experience and confidence in the practice of teaching, but were less assured in the research and scholarship aspects. The average "after" scores are higher in all categories, with the biggest increases in the two categories where we were previously least confident.

3.2 Using the group structure

A key factor in the success of this project was the group structure. Our Pedagogy Research Group, which had been meeting for some time to read and discuss pedagogical literature, had previously undertaken informal surveys of student attitudes. This structure was valuable in its own right: even before the project started, we were used to working together as a collegial, productive group. Running the project as a group endeavour on one hand, and independent research projects on the other, means that we have access to opportunities not only for individual development and ownership, but also the support and motivation of other group members. We recognise that not all Departments have such large groups of people interested in DBER. We note that there are increasingly active networks of pedagogy-focussed mathematicians in the UK and elsewhere and would encourage collaboration between smaller groups.

3.3 Leadership and sharing responsibility

Equally valuable was clear leadership. Each sub-project had a nominated “leader”, but so did the project as a whole. By making one person responsible for the continued progression of the project, it was always clear who would organise the next meeting, find new papers to read, or decide what to do next to move the project forward. As a large group with wide-ranging interests, the natural tendency was for us to move in different directions or find different projects to focus on. This is a strength of the group, but without this leadership the balance between allowing for individual circumstances and maintaining group momentum would have been difficult to strike.

3.4 Structural support from the department

Support from our department has also been vital. This has come in the form not only of a small budget to pay our participants, but also as protected “scholarship” time. In the current system, 20% of our time is assigned as scholarship. This is treated in a similar way to the 40% protected “research” time for our research-and-education colleagues. This structure has allowed us the space and freedom to dedicate the necessary time to reading literature and planning and undertaking projects such as these.

3.5 Clarity of purpose

It was also important to be clear about the goals of the project. Is the point to write and publish a first research paper, or is the focus more on the development of skills? How each of us answered this question naturally affected how we viewed our roles, aims, and level of participation in the project. This difference in perspective can be a benefit to the project, rather than a drawback: a key strength of the format is its flexibility. This has also allowed group members to participate in as many stages as they choose to, including several members who joined a year after the project began. Other members of the wider Education group in the department, who could not dedicate as much time to the project, very generously shared their expertise at relevant moments. On the other hand, our determination to involve as many people as possible in every stage of the project contributed to the timing issues noted above. Expectation-setting was key to navigating these issues.

3.6 Next steps

The analysis of the results of the focus groups is forthcoming, and we also plan to continue using this structure as a framework for future research projects. By changing the theoretical framework and research protocol, we will develop our expertise in other areas, with a particular focus on quantitative methods for our next project. Our confidence assessments suggest that gaining experience with quantitative data, to improve our “data analytic competence,” will be a fruitful next step for the group. We also plan to assign different roles to each group member, and in particular to choose a different leader, to ensure that more group members have the opportunity to develop project management and leadership skills.

Overall, this project has provided a fun, engaging, and supportive environment in which to undertake a first DBER project. It has improved the skills and confidence of the whole group, and several of us have moved on to individual DBER projects of our own. We would thoroughly recommend this approach to DBER, and welcome any contact or questions from other groups beginning similar projects.

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[i] Here we define education-track staff as academics whose primary focus is on pedagogy and/or scholarship. We are sited within our disciplines, rather than in Education departments. Different names for staff in these roles are used across the sector: they may be referred to as teaching-track, teaching-focussed, teaching and scholarship, or education-focussed staff.

WORKSHOP REPORT

History for Diversity in the Teaching and Learning of Mathematics

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Abstract

This paper reports on a workshop delivered at the CETL-MSOR Conference 2025 that explored the use of historical narratives to foster inclusivity, enhance student engagement, and support a stronger sense of belonging in university mathematics, particularly for under-represented groups. The workshop addressed several interconnected themes, including historically overlooked mathematicians, mathematics and statistics with problematic historical legacies, the role of historical perspectives in shaping student confidence and mathematical identity, and the use of historical mathematical methods to illuminate modern problems. Through a combination of discussion-based activities and illustrative case studies, participants considered how history can be incorporated into teaching in ways that encourage critical reflection on both the development and use of mathematical knowledge. The workshop also introduced the History for Inclusion & Diversity in Mathematics Network, which supports practitioners interested in using the history of mathematics to promote equality, diversity, and inclusion in higher education, and participants were invited to engage with the network and its resources.

Keywords: History of mathematics, inclusivity, diversity, mathematics education, higher education.

1. Introduction

There is a long-standing tradition of regarding mathematics as an abstract world which does not interact with wider society, that societal issues are not part of the discipline and not the business of those teaching it. Many draw inspiration on this theme from Hardy, who wrote in 1920: “The study of mathematics is, if an unprofitable, a perfectly harmless and innocent occupation” (Hardy, 1920).

This is quite complicated, because Hardy did not consider applied mathematics as a legitimate branch of mathematics, contrasting this with “the real mathematics of the real mathematicians” (Hardy, 1969) and thus significantly reducing the field to which his comment applied. We must also consider the time in which he was writing. In his famous *A Mathematician’s Apology* (1940) he wrote “No one has yet discovered any warlike purpose to be served by the theory of numbers or relativity, and it seems very unlikely that anyone will do so for many years. … So a real mathematician has his conscience clear” (Hardy, 1969, p. 140). He wrote about the uselessness of number theory, relativity, and quantum mechanics, writing about these before later applications were developed in cryptography, GPS, lasers, microelectronics, MRI scanners, and more.

Still, this historical baggage means it is worth saying very clearly that we believe mathematics and statistics are not neutral nor detached from society. Apart from the many uses of mathematics, there are issues to consider when mathematics interacts with society.

- Where did mathematics come from? How did we get where we are today?
- What areas of mathematics and statistics emerge from problematic origins?
- What legacy is left in modern mathematics and statistics?
- Creation of mathematical knowledge – who gets to participate, how are they funded?
- How outcomes from mathematical work are used – in policy-making, in other disciplines, etc.
- Ethics – who is impacted by the products of mathematical work, what biases are embedded?
- How mathematics and statistics are communicated to those in wider society.

For example, on the question of who gets to be a mathematician, Francis Su's excellent *Mathematics for Human Flourishing* (2020) considers the case of Sofia Kovalevskaya (1850-91). She attended university classes unofficially in Russia, before moving to Berlin to work with Karl Weierstrass. His university refused to let her attend his class despite him petitioning for this, so he tutored her privately. When she had done enough work to earn a doctorate, they worked to find a university that would give her a degree. The University of Göttingen awarded her a PhD in 1874, the first in the world to be awarded to a woman for mathematics.

Still, she could not get a job, either in Germany or Russia. She left mathematics and wrote fiction and theatre reviews instead. Su writes "we might not have benefited from her subsequent outstanding contributions in mathematics if she hadn't returned to it six years later, and tried again" (p. 141).

This raises natural questions, about how many others did not have the opportunity to have their mathematical ability recognised and nurtured, and how many did not push this hard in the face of adversity. This historical example speaks to problems that cause barriers today. One justification given for systems and structures is 'this is how it has always been'. Well, women didn't get PhDs in mathematics – until they did. Su writes beautifully (p. 143):

> *In a broken world, we must also recognise that power is often unearned, and it doesn't just come to those who would use it well. So, you and I have a responsibility, as we grow in power, to use it for good.*

Nevertheless, this example teaches us something else about diversity. Notice Su's comment about Kovalevskaya, this time with emphasis added: "**we** might not have **benefited** from her subsequent outstanding contributions in mathematics if she hadn't returned to it six years later, and tried again". This is reminiscent of the way some companies justify inclusive policies on the grounds that it benefits the bottom line. For example, Georgeac and Rattan (2022) cite this from AstraZeneca "innovation requires breakthrough ideas that only come from a diverse workforce". Must we think of 'we', the majority, and how 'we' benefit? Might we not think about Kovalevskaya, and how she benefitted from and enjoyed her work in mathematics? Georgeac and Rattan contrast AstraZeneca with this from Tenet Healthcare: "we embrace diversity because it is our culture, and it is the right thing to do".

If we wish to embrace diversity, because it is the right thing to do, we must guard against bias. Biases are natural short cuts to decision making, positive and negative. Perhaps a bias to always visit the same cafe simplifies lunch breaks on busy days, a good outcome. But we must be aware of negative biases, especially unconscious ones. Su says "It's not enough to say, 'I don't think about that stuff— I treat everyone the same,' … Those in marginalised groups don't have the luxury of saying, 'I don't think about that stuff,' because that stuff affects us on a daily basis" (p. 152).

We seek to explore opportunities to develop more inclusive curricula, fostering inclusivity and a greater sense of belonging, because it is the right thing to do, and because included students are more engaged.

Understanding where mathematics came from and the sometimes-problematic stories behind this development can help us to acknowledge or avoid presenting this in a way that excludes people. For example, Bradshaw and Mann (2021) give the example of Karl Pearson, asking "how does a student who is aware of Pearson's racism feel about using 'Pearson's correlation coefficient'?"

Also, understanding where methods came from and learning about the people who struggled to bring them into the world can help students appreciate and contextualise their own struggles.

Our workshop at the CETL-MSOR conference addressed these themes in particular, aiming to explore how using historical narratives can support inclusivity, belonging, and engagement in teaching university mathematics.

2. Mathematics and statistics with problematic stories

Although it is important and highly relevant to discuss underrepresented mathematicians and statisticians as role models for our students, it is equally crucial to address the ethical dimensions of mathematics and statistics. In the case of pure mathematics – though applied mathematics and statistics are not exempt – there is a common belief that mathematics is neutral, value-free, and therefore devoid of social responsibilities. However, recent works have started challenging this view (Chiodo and Muller, 2024; Ernest, 2021). Indeed, mathematics and statistics are deeply embedded within society: they are influenced by cultural factors, and the economic and historical context directly shapes the types of mathematical research funded by governments and institutions. Consequently, the perception of mathematics as detached from ethical and social considerations should be questioned and also challenged in the classroom, with the underlying aim to develop and nurture a critical and ethical approach in the students to mathematics and statistics.

2.1.Some examples

We discussed three examples where mathematics was not exempt from ethical consequences:

- John von Neumann (1903-1957) was an important applied mathematician whose work influenced quantum theory, game theory, and modern computer science. In 1943, he joined the Manhattan Project, a research and development program undertaken during World War II by the USA, UK and Canada to produce the first nuclear weapons. He actively worked on the calculations needed to build the atomic bomb, as well as overseeing the computations related to the expected size of the bomb blasts in Hiroshima and Nagasaki. He estimated death tolls and the distance above the ground at which the bombs should be detonated for maximum effect (that is, maximum deaths) (American History Foundation, n.d.).
- Francis Galton (1822-1911) was a polymath, anthropologist and statistician who pioneered the use of questionnaires and surveys to collect social data, as well as developing the concepts of correlation and "regression towards the mean". He is also known as the father of eugenics, a set of beliefs and practices that aim to "improve" the genetic quality of a human population by discouraging reproduction by people presumed to have inheritable undesirable traits (usually by mass forced sterilisation of non-white non-Western people, and in particular of African descendance) and encouraging reproduction by people presumed to have inheritable desirable traits (in particular, the British). In his work "*Hereditary Genius: An Inquiry into its Laws and Consequences*" (1869), he links race to intelligence and genetics: that is, he argues that intelligence is hereditary and different races, by nature, have higher/lower intelligence status. These ideas were developed further in the 19th century, culminating in the "racial improvement/breeding" carried out by the Nazist regime in Germany between 1933 and 1945 (where racial improvement implied the extermination of people with disabilities, or those who were Jewish, or Roma, or non-heterosexual) (Theories of Race, n.d.).

- The Sally Clark case is one of the most famous legal cases of miscarriage of justice in the UK, where witnesses and jury wrongly applying conditional probabilities and Bayes' theorem convicted the innocent Sally Clark. In December 1996, Sally Clark's first son died within a few weeks of his birth of unexplained causes (first piece evidence), and her second son died in similar circumstances in January 1998 (second piece of evidence). A month later, Clark was arrested and tried for both deaths. Her defence said that both children died of sudden infant death syndrome (SIDS). A paediatrician, as expert witness, testified that the chance of one child from an affluent family suffering SIDS was 1 in 8,500, concluding that the chance of two children from an affluent family suffering SIDS was 1 in 73 million (calculated as $1/8{,}500 \times 1/8{,}500$) – this was later disputed, as medical literature showed that susceptibility to SIDS is inherited, and therefore the probability of a second child dying for SIDS is higher and depends on the likelihood of the first child to die of SIDS. Moreover, the jury mistook the probability of both Sally Clark's children dying of SIDS conditional to her being not guilty (1 in 73 million) with the probability of her being not guilty given that both her children died of SIDS, wrongly concluding that she was guilty beyond reasonable doubt (Wikipedia contributors, n.d.).

2.2. How to incorporate ethical aspects of mathematics in the classroom

We discussed possible challenges when adapting such historical sources in a classroom, identifying four major ones that change the type of resource one can produce.

1. The **class size** shapes the level of engagement and discussion that we can have with students; we discussed that, with classes up to 50 students, it is possible to discuss in groups and monitor and guide some of the points of discussion. With classes with over 50 students, these resources can be used to introduce a theoretical concept (e.g., Bayes' theorem), or can be a point of reflection later developed in tutorials (which comprise around 30 students).
2. The **type of classes** shapes the interaction we have with students too: in a lecture scenario, resources can be shared as examples between theorems or definitions, or provided in lecture notes for further reading. In problem classes, these resources seem working better when redirected to students in the form of questions to discuss in groups. Tutorials and seminars help in managing group discussions and sharing opinions, although guidance and expectations to tutors should be given. There is also the option of giving students extra material to read in their own time if interested, with the help of questions to prompt reflection.
3. The **time** we have to develop new resources is tight. There are, however, resources that can be adapted relatively quickly depending on the educator's needs. For example, MacTutor for biographies (O'Connor & Robertson, 2003), YouTube videos like "What Happens When Maths Goes Wrong?" by Matt Parker (The Royal Institution, 2019), articles on slave insurance models on Wikipedia (Wikipedia contributors, n.d.). Other resources available are materials from the "Ethics in Mathematics" Project (Chiodo, Müller and Shah, 2023), the monthly readings and discussions in the History for Inclusion and Diversity in Mathematics Network (more about it later), and, with expected publishing date in 2026, the resource "*A Global History of Mathematics*" on OpenLearn (please, contact Dr Brigitte Stenhouse, The Open University, for more information).
4. The **cohort** of students itself shapes the resources provided. Education has many goals, and we may be trying to encourage within students an appreciation of mathematics and its applications. Starting with a rogue's gallery of problematic individuals and topics might not fit with this aim, whereas students might appreciate more philosophical approaches later in the degree. Also we must consider the purpose for learning mathematics and approaches may differ whether the students are studying mathematics to become mathematicians, or are students of other disciplines coming to use mathematics as a tool.

After the excursus of examples and points of discussions on how to incorporate historical resources in our day-to-day teaching, we ran a 15-minute session on reflection on what has been discussed, where participants were asked either to think of a resource on some challenging topic from the history of mathematics and statistics, that they could include in their teaching, or to think on how to use historical sources in different teaching contexts, how it might be assessed, or what support might be given to students and tutors in having challenging conversation.

3. Underrepresented Mathematicians and Historical Methods in Modern Context

3.1. Showcasing overlooked mathematicians

In this session, we introduced an internship project titled *Using History and Biography to Increase Awareness of Diversity in Mathematics and Statistics* at Maynooth University (2025). Over the summer, four undergraduate students taking modules in service mathematics were recruited and developed a collection of eighteen posters celebrating the lives and achievements of historically overlooked mathematicians and statisticians that the students themselves selected. These resources, in addition to illustrating the diversity of mathematical and scientific contributors, provide links to further materials, such as podcasts and videos. As part of the department's broader commitment to promoting equality, diversity, and inclusion, the posters are displayed on campus, featured on its website, and are currently being incorporated into teaching where possible.

3.2. Historical methods: "algebraic" techniques

Alongside the stories of individual mathematicians, we aimed to show that mathematics is not only a product of the present, but is deeply rooted in human history, diverse cultures, and ingenious solutions that predate modern notation. By exploring a series of classical "algebraic" methods, participants were invited to view mathematics as a shared human endeavour—a tapestry woven from many civilisations.

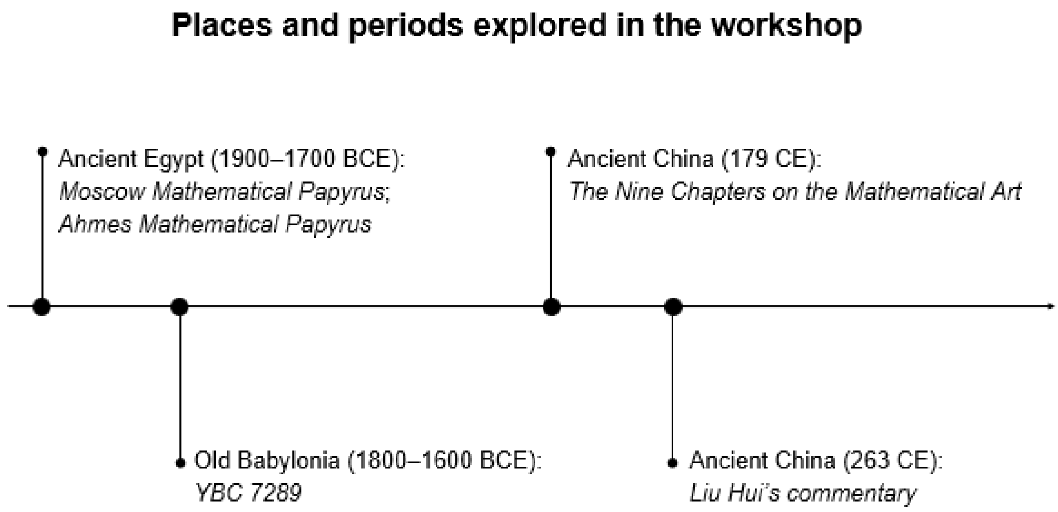

Figure 1. Timeline of the places and historical periods explored in the workshop, from ancient Egyptian and Babylonian sources to classical Chinese mathematical texts and commentaries.

We began in ancient Egypt with *regula falsi* for solving simple linear equations, drawing on Problem 26 from the Ahmes (often called the Rhind) Mathematical Papyrus (Chace, Manning and Archibald, 1927, pp. 68–69) and Problem 19 from the Moscow Mathematical Papyrus (Katz, 2008, pp. 7–9). From there, we travelled to China's *Nine Chapters on the Mathematical Art* (《九章算術》), exploring the Method of Excess and Deficit for solving simultaneous linear equations in Chapter 7, together with Liu Hui's commentary. A ratio table was used to illustrate how excess and deficit balance, and a parallel was drawn with the modern secant method, highlighting the similarity of the underlying concepts despite centuries of changes in notation.

Method of Excess and Deficit and its modern graphical interpretation

(a) Table representation

Trail payment	8	7
Excess / deficit	3	4
Cross product	8 × 4 = 32	7 × 3 = 21
Numerator	32 + 21 = 53	
Denominator	3 + 4 = 7	
Each person pays	53/7	

(b) Graphical representation

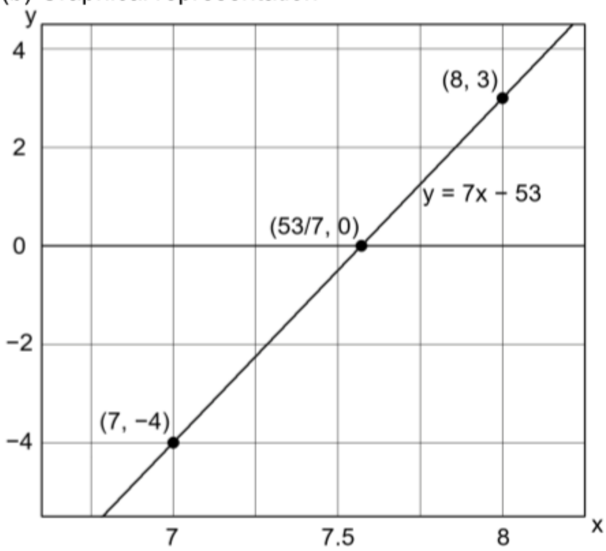

Figure 2. Comparison between (a) the table for Method of Excess and Deficit and (b) its modern graphical interpretation. In (a), two trial payments for each person produce one excess and one deficiency. In (b), the same trial values correspond to the points (7, −4) and (8, 3), whose x-intercept gives the common payment 53/7.

We then moved to Babylonia, examining algorithms for approximating square roots. In particular, we discussed the well-known YBC 7289 tablet, which records the value of $\sqrt{2}$ to six decimal places, demonstrating the remarkable accuracy of ancient numerical schemes (Fowler and Robson, 1998). Participants were guided to rediscover the associated iterative formula by squaring a binomial expression, using only junior secondary level mathematics.

Finally, in a counting-board activity, we simulated a Chinese counting board using animations and paper grids, as the physical board was not available. Quadratic equations were "solved" through the movement of counters (Lam, 1982). To deepen understanding, a geometric justification was provided by partitioning a large square into smaller squares and rectangular strips, allowing the algebraic formula to emerge visually.

Counting-board movement for $x^2 + 35x = 1334$

R_5			2	2	2	2
R_4	1 3 3 4	1 3 3 4	1 3 3 4	1 3 3 4	1 3 3 4	2 3 4
R_3			2		1 1 0	
R_2	3 5	3 5	3 5	5 5	5 5	5 5
R_1	1	1	1	1	1	1
		If x = 20	R_3: R_1×2	R_2:R_2+R_3	R_3:R_1×2	R_4:R_4−R_3

R_5	2	2	2 3	2 3	2 3	2 3
R_4	2 3 4	2 3 4	2 3 4	2 3 4	2 3 4	2 3 4
R_3	2			3		2 3 4
R_2	5 5	7 5	7 5	7 5	7 8	7 8
R_1	1	1	1	1	1	1
	R_3: R_1×2	R_2:R_2+R_3	If x = 23	R_3:R_1×3	R_2:R_2+R_3	R_3:R_2×3

Figure 3. Table-based visualisation of the counting-board activity used in the workshop. From left to right, the successive stages show how movement and rearrangement on each row support the solution of $x^2 + 35x = 1334$ until $x = 23$ is reached.

The purpose of this tour was not merely historical. Rather, it was to illustrate how revisiting older methods can enrich contemporary teaching practice: mathematics becomes more inclusive when contributions from different civilisations are made visible; students could develop a deeper understanding when they see how methods have evolved over time and recognise structure beneath symbolic form; and, perhaps most importantly, such approaches challenge the myth that mathematics is a purely Eurocentric or ahistorical discipline.

4. Further work

Readers interested in this topic are strongly encouraged to join the History for Inclusion & Diversity in Mathematics Network. This project, supported by the Isaac Newton Institute and others, aims to build a network around using history of mathematics to promote equality, diversity and inclusion in the mathematics curriculum in UK higher education. The Network hopes to tackle the following research questions:

- In what ways are current HE maths curricula experienced as exclusive?
- What examples are there of using history to make the curriculum more inclusive?
- What support do practitioners need in using history to diversify the curriculum?
- How is the effectiveness of such initiatives best evaluated?

Members are not experts in these topics, but people who are interested to explore these ideas and learn. The network is led by Prof Isobel Falconer and further details can be found on the website https://mathshist4edi.wp.st-andrews.ac.uk/

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