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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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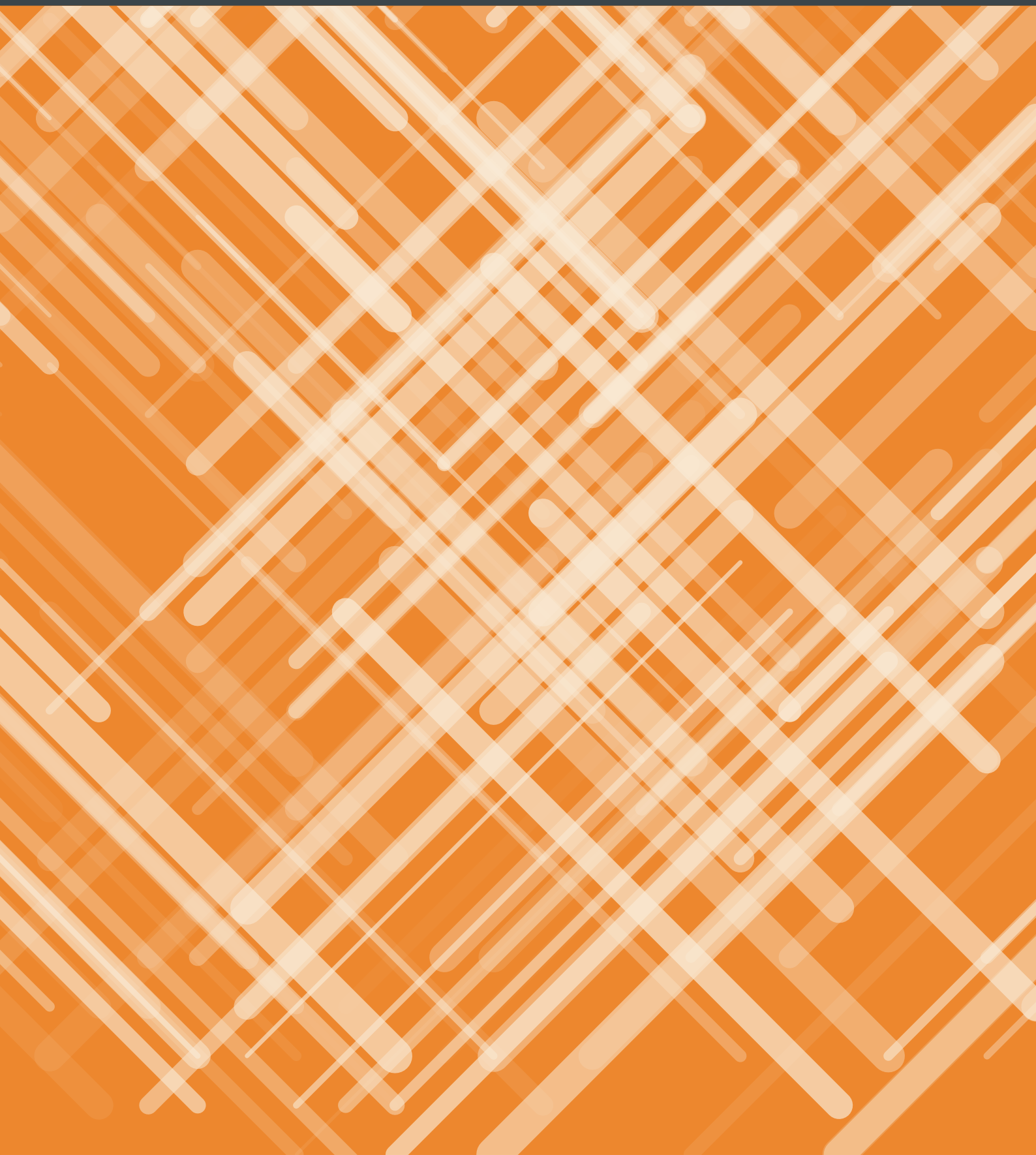

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EDITORIAL

Alun Owen, **sigma** Mathematics and Statistics Support Centre, Coventry University. Email aa5845@coventry.ac.uk

Welcome to the first edition of MSOR Connections for the academic year 2024/2025. We are delighted that MSOR Connections continues to attract contributions from across the globe, with this edition including some very valuable experiences and insights being shared from Australia, the USA, and the UK.

We start with two case studies which focus on learning and teaching technologies. The first by Haddley and Ardito examines the benefits of the use of Generative AI in assessment and reports on the student perception when asked to use these tools. The other by Evans and Williams, describes a tool to visualise and interact with probability density functions implemented entirely using Python code. As a statistics educator interested in Generative AI in HE, I found both of these of great interest.

These are followed by four very different articles that address, from different perspectives, the really important issue of students' transition to and subsequent engagement with their degree studies. Saha kicks this group of with a case study which provides an informative and interesting outline of a Welcome Day event for students, with a range of useful ideas provided which can be adapted and implemented by others. We then present a report by Shearman and Shaker on the latest meeting of the FYiMaths (First Year in Mathematics) New South Wales, Australia, held in December 2023. This report presents details of a wide range of talks given at that workshop that provide a real insight into what is happening in HE mathematics and statistics in Australia. This is followed by a research focused piece by Brown and Pawley, who report their findings of a study that investigates the importance and experience of student communities for those studying by distance learning. This provides some interesting insights into the student view and poses some interesting questions about how we can better facilitate a better sense of community for those students that require it. This group of four articles is then rounded of by a final case study by Richard and Brady-Van den Bos, that describes an investigation into how designing their own tutorial questions could help students negotiate the often-challenging transition to university mathematics. The focus here is on linear algebra, but the ideas presented can be translated into other topics.

This edition then closes with a very welcome piece by Stewart, which will be especially interesting to those who support nursing and other health care students with mathematics. The focus in this case study provides an insight into how the same issues are experienced in the USA, but also describes the positive impact of viewing "med math" as more than just a dosage calculation and very much part of the overall policy of medication administration, improving patient care and maintaining patient safety.

I would like to say thank you to all these authors for sharing their work. *MSOR Connections* can only function if the community it serves continues to provide content, so we strongly encourage you to consider writing case studies about your practice, accounts of your research into teaching, learning, assessment and support, and your opinions on issues you face in your work. However, just as important are the many reviewers who continue to contribute hugely to the sharing of this good practice and experience, but often go unacknowledged – thank you too for all your support for the journal. We can all help with the functioning of the journal by volunteering as a peer-reviewer. When you register with the journal website, there is an option to tick to register as a reviewer. It is very helpful if you write something in the 'reviewing interests' box, so that when we are selecting reviewers for a paper, we can know what sorts of articles you feel comfortable reviewing. To submit an article or register as a reviewer, just go to http://journals.gre.ac.uk/ and look for *MSOR Connections*.

CASE STUDY

Generative AI in Assessment: Towards Understanding the Student View

Joel Anthony Haddley, Department of Mathematical Sciences, The University of Liverpool, Liverpool, United Kingdom. Email: j.a.haddley@liverpool.ac.uk
Cesare Giulio Ardito, Department of Mathematics, The University of Manchester, Manchester, United Kingdom. Email: cesaregiulio.ardito@manchester.ac.uk

Abstract

This case study reports on an intervention that took place within a second-year mathematics module at a higher education institution in the United Kingdom. Prior to completing an essay, students were supported to understand the potential benefits and risks of using Generative AI to aid their process. Students were allowed unpenalised use of Generative AI to complete this assessment. They were interviewed to gain an understanding of how they used this technology, and their perceptions of it. A small sample (n=3) allowed for in-depth exploration. All participating students reported using Generative AI in ways which developed their critical awareness of the technology, and the authors believe that the overall value of the assessment to students was enhanced. The case study ends with recommendations for integrating Generative AI into assessment, and directions for further study in this rapidly developing field.

Keywords: Generative AI, Assessment, Higher Education.

1. Introduction

Generative AI is a disruptive technology whose mainstream awareness has recently come into sharp focus through rapidly increased availability and awareness of platforms. According to the best public statistics we could find, ChatGPT (for example) attracted its first million users just five days after it was launched in November 2022, and as of April 2024 boasted over 180 million users (Exploding Topics, 2024).

The main aim of this case study is to contribute to the understanding of student perceptions of Generative AI, and how and why they use Generative AI in assessment. Previous studies have demonstrated that students generally have a positive attitude towards Generative AI, citing its potential for personalised feedback (Baidoo-Anu and Owusu Ansah, 2023), and anonymous support; and that once students learn to trust the technology, they are likely to continue using it (Ka et al., 2023). The perception of students is rather more complicated when considering how other students might use, or misuse, this technology (Johnston et al., 2024).

The Russell Group published high-level principles to guide higher education institutions on how to adapt to the changing landscape (Russell Group, 2023). The fourth one states that, “Universities will ensure academic rigour and integrity is upheld”, and the impact on academic integrity has been among the first and main concerns about this new technology. Some education providers have responded to the challenge posed by forbidding student use of Generative AI for assessment (Lim et al., 2023), perhaps due to a generally different approach to avoiding or embracing new technology (Wozney et al., 2006), but opinion is very split: Dwivedi et al. report on the diversity of opinions in their paper, “So what if ChatGPT wrote it?” (Dwivedi et al., 2023). Some believe

emerging strategies will prevent plagiarism (Ahmad et al., 2023). Others argue that traditional assessment formats such as essays will stop being viable in the near future (Eke, 2023; Stokel-Walker, 2022), or at least will be integrated into an assessment strategy with alternative modes that mitigate the risks associated with Generative AI (Qadir, 2023). Academics cannot reliably identify whether a given text is written by a human or by Generative AI (A Matthews and Volpe, 2023). Novel approaches are emerging, such as asking students to critique artificially generated essays rather than to produce the essays themselves (Smolansky et al., 2023). Academics reported a high preference for this novel approach due to its restoration of academic integrity, but students reported only a slight preference, citing a loss of creativity. The very notions of creativity, academic integrity and plagiarism are up for debate as we enter this new age (De Silva et al., 2023).

The first three Russell Group principles (Russell Group, 2023) state:

1. Universities will support students and staff to become AI-literate.
2. Staff should be equipped to support students to use generative AI tools effectively and appropriately in their learning experience.
3. Universities will adapt teaching and assessment to incorporate the ethical use of generative AI and support equal access.

These lend themselves more to developing student capacity for lifelong learning (Mhlanga, 2023), and equipping students with adaptable, future-proof literacies (Bozkurt, 2023). It is more obvious in some disciplines than others how Generative AI is likely to play a role in the future (Yüzbaşıoğlu, 2021), yet the pedagogy to align with “critical use” encouraged by the Russell Group principles is still catching up (Sit et al., 2020). Some students believe that higher education institutions are not equipped to prepare students for work in sectors that use Generative AI (Abdelwahab et al., 2023), and it has been reported that the student voice is poorly represented when making decisions regarding learning, teaching and assessment provision related to Generative AI (Sullivan et al., 2023).

2. Intervention and Research Strategy

The intervention took place within a second-year mathematics module at a large UK university. The module is optional and enriches the degree programme by supporting students to develop transferrable skills that are otherwise not well-represented within the core modules. One of the main summative assessment activities is a 2000-word essay focusing on a topic related to education. Following an academic writing workshop, teaching takes the form of individual supervisory meetings. Students choose their own titles based on their interests and complete their own reading to inform the essay, all with support from the module leader. Academic integrity and poor academic practice are discussed in class, with more information signposted on the virtual learning environment.

The intervention was to allow students to use Generative AI when completing this assessment. In an initial phase, a seminar was delivered to raise awareness of Generative AI. This gave specific warnings about hallucinations, and that Generative AI is capable of plagiarism due to how it builds its response from input data. Students were warned that they would be responsible for ensuring their submission contained no elements of plagiarism but were advised how to use Turnitin’s similarity tools on draft submissions (Giray, 2023). Critically, students were made aware that the final mark would be based solely on the quality of the submitted essay, regardless of whether they

had used Generative AI. The seminar also raised awareness of constructive ways that Generative AI might be used:

- Brainstorming: Ideas for the content or structure of your writing.
- Review/Feedback: Critique and immediate advice on how to improve your writing.
- Summarise/Analyse: Your own work, or someone else's.
- Spellchecking/Phrasing: Practical tips to enhance your writing.

Following the seminar, students were invited to participate in two interviews. This was done on a volunteer basis, and participation in an interview would not impact results in any way. Three students expressed interest to be interviewed.

The first interview took place while completing the essay, and the second was after marks and feedback had been returned. To minimise bias, a co-researcher who had nothing to do with marking completed the interviews, and student anonymity was maintained from the module leader. Students were made explicitly aware of this. The first interview explored the student's prior experience of Generative AI, their own perceptions of it, what they believe the perceptions of others might be, and their initial thoughts on the appropriateness of such an assessment given the power of Generative AI. The second interview asked the student to reflect on their use of Generative AI having received marks and feedback, and to look forward and share whether they believe Generative AI should be permitted for such an assessment, or whether there should be restrictions. The specification and rubric for the assessment were purposefully left unmodified to explore and understand the baseline of how students use Generative AI when permitted to do so. Despite being enabled at the institutional level, the Turnitin AI score was not considered during marking; the essay was marked exactly as in previous years.

3. Results

3.1 Student A (ChatGPT 3.5, through online interface, October 2023 - January 2024)

Across both interviews, Student A shared an apprehension and distrust regarding Generative AI in the domain of education. Although they had heard of it, they had not used it before outside of a few sporadic experiments and were concerned that students with more experience using Generative AI might gain a technical advantage. Their distrust was underscored by experience using Generative AI for mathematics, where it often gave an incorrect answer. Moreover, stories about flatmates using Generative AI and losing marks, e.g. for mixed-up references, contributed to a feeling of unease about the technology. The student particularly appreciated the intervention highlighting how Generative AI might be used constructively. The student reported that both they and their peers felt that institutional guidelines are strongly against Generative AI, and their peers were shocked that the student was allowed to use Generative AI for this assessment. They said that people do not want to risk using it even if allowed, even if only for planning, in case they are caught out and penalised. The student remarked, "I worried that it might be considered cheating, especially when I used it to rephrase my own question. It did not feel entirely right," however the student later reflected that they believe they used Generative AI within acceptable guidelines.

When asked to consider what lecturers' perceptions of Generative AI might be, the student said that the few mathematics lecturers who have spoken about it seem intrigued and excited over its potential – adding that this is possibly due to technical aspects of it or the efficiencies it could bring. The student thinks most mathematics lecturers do not discuss Generative AI because it is not

particularly dependable for mathematics, and they therefore do not want students to become reliant on Generative AI.

The student used Generative AI when writing their essay. They particularly found it useful for summarising long sources into digestible chunks, and this aspect greatly sped up their work. They also used it for brainstorming, structuring thoughts, identifying pros and cons, or finding the right word for a sentence. There was however a learning curve, as the Generative AI platform often did not return answers in the format the student wanted – and further dialogue with the platform was required to obtain responses in a useful format. The student used Generative AI to create an essay plan and stuck to this plan for the write-up. The student reported this was helpful due to a lack of prior experience writing essays, and the suggested word counts simplified the process of structuring the essay. The student used Generative AI to suggest titles for the essay but was not happy with the output and ended up writing their own title instead. The one piece of writing that was used directly from the Generative AI output was a rephrasing of a question into a statement.

When asked about the role of Generative AI for assessment in the future, the student was not concerned about the impact on mathematics assessment as it would have to improve a lot to be helpful. The student said that essays as assessments continue to be appropriate, but students need to be trained to understand what Generative AI can and cannot do, and there needs to be clarity around what students are or are not allowed to do. The student proposed a compromise that Generative AI might be used for planning essays but not writing essays, acknowledging that no one can really monitor what a student might use it for. They said that "[if the university says] it's ok to use AI, it feels like giving free rein to do anything," and that the university needs clear guidelines, especially for essay-based disciplines, to prevent academic malpractice.

During the second interview, after some time to reflect, the student clarified their opinions on Generative AI and said that students, "should be advised not to rely on AI to write their essays entirely. It is common sense not to misuse it in that way. AI should be used as a tool, similar to how research sources are used. It is not cheating to use them effectively." The student would continue to allow Generative AI to be used in this module.

3.2 Student B (ChatGPT 3.5, through online interface, October 2023 - January 2024)

This student had greater prior awareness of Generative AI compared to Student A, having used it informally for brainstorming ideas and helping with mathematics problems. This student had used Generative AI for structuring essays before, even though they described themselves as someone who does not typically use a lot of technology. They are not afraid of Generative AI, though they recognise that others might be, and reported that they and their peers are distrustful of it and would not rely on it to answer mathematics problems. One lecturer had told them not to use it.

Student B used Generative AI for brainstorming and planning the essay, asking for pros and cons on different titles, generating ideas for different approaches, and experimenting with different inputs to compare different outputs as some were not useful. The student had both good prior and researched knowledge about the essay topic, and used Generative AI only to fine-tune their writing, stating "I used some of these phrasings in my essay as [Generative AI] articulated my thoughts better than I could have." The student found Generative AI very helpful and kept it open while working on the essay, regularly referring to its output.

When asked about the student's thoughts on whether other students might use Generative AI to cheat, they explained they believe the correct approach for the university to take is one of recommendation and guidance, rather than restrictions and limitations. They do not think that other students would not use Generative AI for doing anything more than what they used it for, stating that human-written essays are much better than anything Generative AI can produce. They pointed to the frequently inappropriate style that Generative AI adopts, writing in dramatic and overly flamboyant language. They said that maybe some students do use it to cheat, but their peers do not trust it to produce sufficient quality and do not use it to cheat. They reported that their work was their own, even if Generative AI helped. Given this, they believe that asynchronous, uninvigilated assessments such as take-home coursework remain valid.

Reflecting after the release of marks, the student realised that Generative AI had been more useful than they had initially thought, having used it to summarise sources – something they had not considered before the intervention within this module. They said they would definitely use it in the same way for another essay, even though they were not convinced it actually had a significant impact on the mark: it just sped up the entire process. They raised that there should be a level-playing field for students: since you can't really restrict students from using Generative AI to support essay writing, students should be advised on how to get the most out of it, avoid the associated risks, and encouraged to "play around" with it before attempting serious application to a task.

3.3 Student C (ChatGPT 4, through online interface, October 2023 - January 2024)

Student C has a subscription to a premium Generative AI service and has used it extensively before this assessment for a variety of purposes and reported experimenting with it too. Their use was rather different to Student A and Student B: they did not use it for brainstorming ideas, summarising sources, or structuring the essay; but rather used it to organise, summarise and critique their own ideas. This was especially useful after "talking" to Generative AI, using voice recognition features. They also used Generative AI for help with rephrasing but never copied anything directly into their own essay since they were never fully happy with the results. The student uploaded their entire essay to the platform to get an "external" perspective of its quality. They found it very useful for this purpose. They are satisfied with their mark and would use Generative AI for assessments again. Their perception of Generative AI changed during this assessment, and the student reported being "surprised" and that they had underestimated how useful Generative AI would be.

This student is unsure whether they would have used Generative for this essay without explicit permission but believes its use should not be prohibited for assessment in the future: "It's going to be everywhere," so it would in any case be impossible to forbid it. Moreover, the student is confident that they would be able to bypass Generative AI detection. The student said that assessments need to change, and that, "if a question is so easy that a student with [access to Generative AI] can reach the same performance as one that has revised a lot, then the question needs to be changed." Their advice for other students would be to experiment a lot, not to trust its output, and to generate a variety of answers to pick the best.

4. Discussion

4.1 Academic Integrity and Assessment Validity

Although the nature of the intervention allowed for unpenalised use of Generative AI, participants were prompted to share their perceptions of what “cheating” could mean within the context of using Generative AI to support essay writing. Participants stated that they or their peers would not trust the accuracy or quality of the produced output enough to submit it as their own work. This is a form of self-policing of academic integrity based on distrust of the platform. This may also be due to a risk aversion towards being caught, despite Generative AI detectors being unreliable (Ardito, 2023; Odri and Ji Yun Yoon, 2023), and Student C reporting a belief that they could easily be bypassed. Student A indicated this anxiety could be based on the perceived institutional position against the use of Generative AI, but such a culture could make it challenging to deliver the critical use advocated by the Russell Group principles. Notably, Student A presented the view that mathematics lecturers’ opinions differ from the university's position.

Student A and Student B both reported direct copying of Generative AI output into their essays. Student A reported feeling uneasy about this, despite understanding that it was permitted by the assessment guidelines. Indicators for academic integrity include bravery, honesty and empathy (Staats et al., 2009), and future interventions should clarify boundaries more clearly to avoid students unnecessarily experiencing feelings of apprehension or guilt.

Student B’s use of Generative AI output is presented differently, and they directly used the output in their essay on several occasions. This use of Generative AI fell within the permitted guidelines of this assessment but raises questions about authorship. Authorship is discussed in (Yeo, 2023), which presents arguments for and against categorising such a use as plagiarism. On the one hand, the student inputted the text into the Generative AI platform, and so can claim authorship of the output; on the other hand, the words are used directly from an external source without acknowledgement. Student B’s claim to authorship is explicit. They reported that Generative AI did not lead to a significantly improved mark but saved time: implying that they were personally capable of arriving at suitable paraphrasing, and used Generative AI only to streamline their process. Even while using Generative AI, all (?) students reported repeatedly making judgement calls over the suitability of output to be included in the essay, evidencing their ability to use the platform in a critical way. As Student C pointed out, assessment needs to adapt to recognise the role of Generative AI. Given the potential grey area regarding direct copying of paraphrased material, it is essential that assessment specifications directly address whether or not this would be considered plagiarism to submit in the final product. But, as Student C points out, it may be impossible to detect it anyway. Provided an examiner considers the interplay between learning outcomes and Generative AI, and provided there is a mutual understanding between examiners and students regarding what consists of appropriate use of Generative AI, the authors believe this assessment format continues to be valid.

4.2 Generative AI Equity: Access and Competence

Student B advocated for a level playing field for Generative AI. Factors beyond the control of higher education institutions may have longer-term impacts on equitable access to Generative AI (Sætra, 2023) but, at the time of writing, OpenAI provides free access to GPT3.5. However, Student C had access to GPT4.0, which offers various improvements in reliability (Koubaa, 2023); thereby un-levelling the playing field. The availability of a multitude of models, and thousands of “wrappers” which change their capabilities with hidden prompts, and finally the speed at which the

sector moves, with several daily changes in each of the tools, further contribute to a fundamentally un-levelled playing field.

Possibly the most equity-creating aspect of Generative AI is that effective interactions can be based on natural language, not requiring particular technical expertise. However, this does not fully address all the layers of digital fluency required to interact proficiently with Generative AI systems: indeed, techniques such as prompt engineering can unlock several features of models that a "basic" user would not be able to access. Furthermore, both prior knowledge and integration in digital networks can make a stark difference – as mentioned, there are thousands of diverse ways to interact with the same model, each different, and knowledge of a particularly one, appropriate to the task being undertaken, can significantly enhance output.

Student participants had diverse levels of prior experiences with Generative AI, reflected in their confidence using the platform. All student participants, even Student C with the greatest prior experience, reported improved ability to use Generative AI following this essay; including recognition that Generative AI cannot be trusted.

4.3 Reported Benefits

This intervention aimed towards achieving some equity by highlighting possible constructive uses and possible risks. Students reported using Generative AI to support their essay writing in several ways, which we propose to classify in five macro-areas:

- Creation: Generative AI was used for brainstorming ideas, including topics and essay titles. This use requires the least prior authorship before creating the prompt but has the highest dependency on Generative AI for creation of content. Students reported using it as a starting point or inspiration but did not report further usage to write larger chunks of their essay.
- Enhancement: Students used Generative AI for improving their own work, in the form of paraphrasing or rewording. Compared to creation, students have greater initial authorship as they write their own starting point which they want to improve, and the dependence on Generative AI for creation of content is lower.
- Feedback: Students used Generative AI to solicit feedback on content entered into the platform. The prior authorship here is the greatest, and dependency on Generative AI for creation of content is the lowest. This use of Generative AI mirrors the personalised formative feedback provided by teachers, but feedback is immediate.
- Structuring: This theme covers use of Generative AI to suggest essay plans or organise material entered into the platform. Students reported using Generative AI in this way, which could be considered a scaffolded approach to essay writing.
- Summarising: Use of Generative AI to summarise text could be applied to one's own work, or to someone else's. Students reported using Generative AI to summarise the work of others, as a means to speed up the essay-writing task.

While is it difficult to completely decouple "product" from "process," the first three themes are more related to product, and the final two are more related to process, so each may be more or less relevant depending on the intended learning outcomes of the assessment activity.

4.4 The Mathematical Context

Student participants reported that they, their peers, and their lecturers distrust the ability of Generative AI to solve problems in mathematics. Student B reported a lecturer had said not to use it due to its perceived inaccuracy. Student A believes the validity of mathematics assessment will not be undermined by the current capability of Generative AI in this domain.

It is true that current versions of this type of AI model perform badly at mathematical tasks (Davis, 2024), with a study evidencing significantly worse performance than the average student in university physics exams (Yeadon, 2023). Generative AI may be more suitable as an educational aid in other domains (Giannos and Delardas, 2023).

An interesting contrast can be observed in students' perceptions of staff views on Generative AI, with the university perceived to be strongly against the use of AI, but lecturers in mathematics being more excited or curious. While this may well be confirmation bias due to this intervention running within a mathematics module, Student A mentioned that "a few" mathematics lecturers expressed positive views about Generative AI.

5. Conclusion and Recommendations

5.1 The Student View

Student participants were of the opinion that when it comes to Generative AI, higher education institutions should focus more on guidance and support, than restrictions and penalties. Student C said it is going to be everywhere anyway: this could be interpreted that students should be trained to engage with this emerging technology or could simply be a pragmatic response as policing its use may well be futile. Student A initially advocated for guidance on what was or was not permissible, but their opinion evolved while completing the essay and settled on a similar viewpoint that students should be supported to engage critically with Generative AI. All (?) Student participants suggested that the intervention to raise awareness of the pros and cons of Generative AI would, in the future, benefit from encouraging students to develop their familiarity with the technology further in advance of a summative assessment to make sure they use it as effectively as possible. It should be highlighted to students that it is wise to compare several different outputs to prompts to get more ideas, and to select the best one; and students should understand that the output may not actually be very good at all, and Generative AI output should never be trusted for quality or accuracy.

5.2 The Authors' View

This particular intervention allowed for unpenalised use of Generative AI and so, by definition, no student breached academic integrity policies due to whether or how they used Generative AI in this assessment. But, more importantly, it is clear from the interviews that these students engaged with the assessment in a way that developed, not only their knowledge of the essay topic, but critical awareness and practical knowledge of Generative AI. The authors support the students' recommendations and plan to integrate them into this assessment in future years.

There is nevertheless a subtlety regarding what is actually being assessed, and the authors acknowledge that being able to author text directly is not exactly equivalent to authoring text using Generative AI to help phrasing. Along similar lines as (Bozkurt, 2024), more work should be done to unpack these differences, considering different perspectives on them. The authors additionally

recognise that this intervention ran in an upskilling module designed to enrich a mathematics degree, so it might be more appropriate to follow recommendations in similar contexts as opposed to contexts which depend more heavily on essays as a mode of assessment.

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CASE STUDY

A Tool to Visualise and Interact with Probability Density Functions – Development and Case Study

Kristian Evans, Department of Mathematics, Swansea University, Swansea, UK. Email: K.Evans@Swansea.ac.uk
Arron Williams, Department of Computer Science, Swansea University, Swansea, UK. Email: 709719@swansea.ac.uk

Abstract

This article is an overview of the design, implementation and testing of a tool to visualise and interact with probability density functions. The tool is a desktop application implemented entirely in Python using the tkinter library for the graphical user interface. The project was undertaken as part of a collaboration between Mathematics and Computer Science. The goal of the application is to provide a simple user interface for teaching staff and students to visualise and interact with probability density functions, and we investigate whether such a simple visualisation tool can improve staff and student engagement. The application should help improve students' understanding of the concepts involved and its simple design should reduce the complexity barrier that often faces users when using technology in the classroom. Following initial testing, a variety of teaching staff were involved with trialling the tool, together with student volunteers from a first-year and second-year statistics module at Swansea University. Feedback was obtained and evaluated from all participants. For the teaching staff group, we found that all four participants strongly agreed that the application is easy to use and that the user interface was not distracting. Furthermore, all teaching staff stated that they would consider using the application in their own teaching and all would recommend using the application to a colleague/friend. For the student volunteer group, all twelve participants either agreed or strongly agreed with the statements that the application is easy to use, useful and not distracting. Similar to the teaching staff group, all the student participants stated that they would consider using the application in their own learning and all would recommend the application to a friend. A full analysis of the survey results is provided in the Feedback section.

Keywords: Teaching application, visual learning, statistics, probability density functions, python.

1. Introduction

This application was developed as part of a multi-disciplinary project between Mathematics and Computer Science, which was undertaken as part of an MSc dissertation in Computer Science. In particular, the first-named author, who is based in the Mathematics Department at Swansea University, supervised the MSc dissertation of the second-named author, who was studying MSc Computer Science at Swansea University. This was part of a wider initiative to promote collaboration between Mathematics and Computer Science at Swansea University. The main aim of this project was to create a user-friendly application which helped visualise and perform simple functions on continuous probability density functions. Due to time limitations of the project, we focussed on three distributions, namely the normal, gamma and student's t distributions.

Using visualisation in mathematics contributes to the development of abstract thinking (Yilmaz and Argun, 2018), with some research indicating that using visualisations is a vital component of teaching mathematics (Boaler et al., 2016). Visualisation in mathematics involves the creation and formation of models that reflect mathematical information (Van Garderen and Montague, 2003). There are many examples of using visualisation in mathematics, e.g., graphical representation of functions and

histograms to spot patterns in a data set. Using technology to aid in the visualisation process can provide additional opportunities for students to explore and interact with mathematical concepts, which in turn leads to better student outcomes (Scharaldi, 2020). The potential of the use of technology to aid the visualization process has been noticed from as far back as the 1990s e.g., (Thomas et al., 1996). Despite recognition of the potential of digital tools for visualisation, specific research into effective design choices which influence adoption and usage for such applications is limited.

Next, we consider research that has been conducted on the use of software packages in mathematics to justify the need for digital visualization tools from a pedagogical perspective. Geogebra is one example of such a software package that is available as a web application and desktop application, which is an interactive application for learning and teaching mathematics. Students using the Geogebra software had a better understanding of geometry concepts than those who did not use the software (Jelatu et al., 2018) and also had improved reasoning skills (Bhagat and Chang, 2015). These findings were also confirmed by (Liburd and Jen, 2021), who also found that using technology in the classroom improved students' attitudes to learning. In another study (Fraij and Al-Mahadeen, 2012) which focused on the whether a digital tool assisted students in understanding one-to-one functions, two groups of students were asked to identify one-to-one functions, one group only had the definition whilst the other had the definition and access to a digital visualisation tool. The group with access to the visualisation tool outperformed the group that did not have access to the visualization tool, indicating that the visualisation tool had a positive impact on their learning (Fraij and Al-Mahadeen, 2012). While these results provide an argument in favour of incorporating digital tools in the classroom, they are based on small-case studies and there is a lack of variety of different applications being investigated.

Despite the numerous digital tools that have been developed in the past, teacher adoption of technology has been limited (Niu, 2018). Numerous factors have been suggested as to why teachers are reluctant to adopt the use of technology in the classroom, some of these include lack of training, the time commitment to learn how to use the tool and confidence in their own and their students' ability level in using technology (Ertmer et al., 2012). Perceived ease of use plays an important role in the adoption of digital tools in the mathematics classroom (Arthur, 2022), therefore one of the key focuses of this application is making it easy to use. It is worth noting that wider issues such as lack of resources are also limiting factors, which cannot be addressed by this project.

In (Bansilal, 2015), student teachers' perception of use of technology in the classroom was investigated from the perspective of their own learning and their own teaching. The study focuses on a broad range of technologies, however some reference is made to tools for mathematics teaching. There were some contrasting views on the use of technology in the context of sketching functions. Some students highlighted how technology is beneficial to sketch complex functions rather than sketching by hand, yet others found this to be a negative point and that learners should be taught how to sketch by hand. These skills are expected to be developed in secondary education, see (Gov, 2016) and (Department for Education, 2013), and whilst we do not dispute that students need to develop skills in sketching by hand, it is important to consider the practicalities of taking this approach all the time. Mainly, it is the time element; a fairly accurate hand drawn graph of a function requires several calculations at different points. Using a computer for this purpose is a much faster process, allowing the efficient use of time, and it enables learners to focus on investigating properties of the functions rather than on several calculations (Forster, 2006). In such cases, an important consideration for teachers to consider is the appropriateness of using such tools within the context of the lesson. (Ochkov and Bogomolova, 2015) goes further to suggest that some teachers only hold this negative perception of digital tools because they do not know how to use them. While this is a bold claim, it does raise the question whether those who did have negative perception towards the

use of digital tools in the classroom would change their viewpoint if the tools have a minimal learning curve and are relevant to the curriculum.

In section 2, an overview of various existing tools will be provided. This section informed the development of the application, in particular with respect to the user interface design and features. This theme will continue into section 3, where the application will be discussed in more detail. In this section, the requirements of the application will be set out, and the design and main features of the application will also be discussed. Section 4 will focus on the feedback we received from both teaching staff and students. Details of the questionnaires used will be provided, together with a thorough evaluation of the results. Section 5 is dedicated to concluding remarks. This section will include the main points highlighted from the feedback questionnaires and remarks about future improvements to the application.

2. Existing Tools

Desmos and the Normal Distribution applet are examples of tools which exist for visualising probability density functions and performing an evaluation of these tools aided the design of this application. This was particularly the case when looking at some design choices which we may have over-looked in the initial design phase of the proposed application. For the purpose of these evaluations, the focus was based on visualising the normal distribution. Please note that the existing tools considered are not necessarily designed for probability density functions alone, but do offer the capability of performing the visualisations.

Desmos

Desmos graphing calculator is an advanced graphing calculator that is available as a web application and a mobile application that was launched in 2011 (Empson, 2011). At the time of writing, Desmos does not have full support of all Greek letters without installing additional plug-ins. Desmos is very responsive and provides a smooth experience for the user, which includes a feature to display easy-to-use sliders. Due to the potential need to manually impose restrictions on the parameters (for example, the standard deviation) and manually inputting the formula (if the built-in function is missed), there is a steep learning curve to using Desmos to fully utilise all of its features and it could be unsuitable for users with limited technological background. Due to the vast capability of Desmos, it can be used in other areas such as geometry, making the time investment in learning about its capabilities worthwhile. Finally, it is important to note that Desmos has some excellent accessibility features, in particular, sonification of graphs that provide visually impaired users with the ability to explore visualisation through sound.

The Normal Distribution Applet

The second tool that was considered was the Normal Distribution applet (Bognar, 2021a). The applet is free to use and has been specifically designed for the normal distribution. The applet allows the user to enter values for the mean “μ” and standard deviation “σ” and it also can be used for calculating probabilities. The colour scheme used in the applet is visually pleasing and there are no distracting features. The help button is visible and provides easy to follow instructions on how to use the applet and it also provides some information about the distribution and the constraints on the parameters. Overall, the applet is very easy to use. It is important to note that Bognar has also created similar applets for other distributions, see (Bognar, 2021b).

One of the main issues found with this applet was the lack of immediate response to the user when parameters are changed. There are no sliders and all of the inputs must be manually typed.

Additionally, it is difficult to determine the visual effect that changing the parameter has on the distribution. Another identified issue is the small size of the applet.

There is no option to vary its size and when viewed on a screen with resolution of 1920x1080 pixels, it is small (in fact, the visible plot section only measures 620x200 pixels). In a teaching environment, using the applet while projecting to a screen could be problematic as it could be difficult for the audience to see.

Other Tools

Further tools are available for probability density functions, for example Matlab and R. With both of these tools there is a steep learning curve involved since programming is required to create visualisations. On one hand, the steep learning curve involved in learning the required programming skills just for the purpose of creating simple visualisations of probability density functions would not seem to be a viable option, and it could be very discouraging to beginner users. However, on the other hand, as they are both very powerful languages with advanced capability, it could be beneficial as an introduction to using the tools for future work.

From trialling the existing tools highlighted above, it was decided that it is important for this application to be user-friendly, featuring sliders and for it not to have too many distracting features. In particular, when the sliders are adjusted, the plot should automatically be updated to reflect the changes. Furthermore, it should be visually pleasing, of a suitable size and it should contain a useful help function.

3. The Application

The application considers three continuous distributions, namely the normal distribution, the Student's t distribution and the gamma distribution. The application was created using Python (version 3.10) and there is a Windows-compatible version and a Mac-compatible version. There were initial concerns regarding performance as Python is slower than other high-level languages such as Java and C (Brihadiswaran, 2020). The suitability of Python was assessed during the build of the prototype by building a working visualizer for the normal distribution with sliders for the parameters, and it appeared to be a suitable choice as there was no noticeable delay when the parameters were changed. Numerous principles have been written in the past to guide the development of user interfaces. Examples of these include the usability heuristics, see (Nielsen, 2005), and the golden rules of interface design, see (Shneiderman et al., 2016). This is very important for a successful application since a well-designed user interface provides the user with ease of use of the application which in turn allows the user to naturally and intuitively interact with the application (Christensson, 2009). The Graphical User Interface (GUI) is built using Python's standard GUI library, tkinter, which is cross-platform (Amos, 2022). For plotting the probability density functions, the matplotlib library is used which is a "comprehensive library for creating static, animated, and interactive visualizations in python" (matplotlib, 2022). For calculations of the cumulative distribution function, the stats module from Scipy is used which covers a large number of probability distributions and other topics of statistics (Scipy, 2022). The documentation for Scipy were very clear and easy to navigate and understand, making it a convenient module to use for development.

In order for end users to use the application, PyInstaller is used to bundle the application and its dependencies into a single package. The benefit of using PyInstaller is that there is no requirement for the end user to install a Python interpreter or any of the modules (Cortesi, 2022), making this a suitable option for the beginner user. Unfortunately, PyInstaller is not a cross-compiler and does not support backward compatibility. Building the application on a Windows OS will not be compatible

with Mac, and vice-versa, however the same code can be used for both applications.

Full details of the coding and the steps taken to finalise the functioning of the application are too detailed to be considered here, but further details can be provided on request.

The application needs to be downloaded for use. In order to make this accessible to Swansea University students, the application was made available on the University computer system (in the same way that other applications are made available). The user interface maintains a consistent appearance across all distributions, and it is straightforward for the user to switch between these distributions, see Figure 1 below.

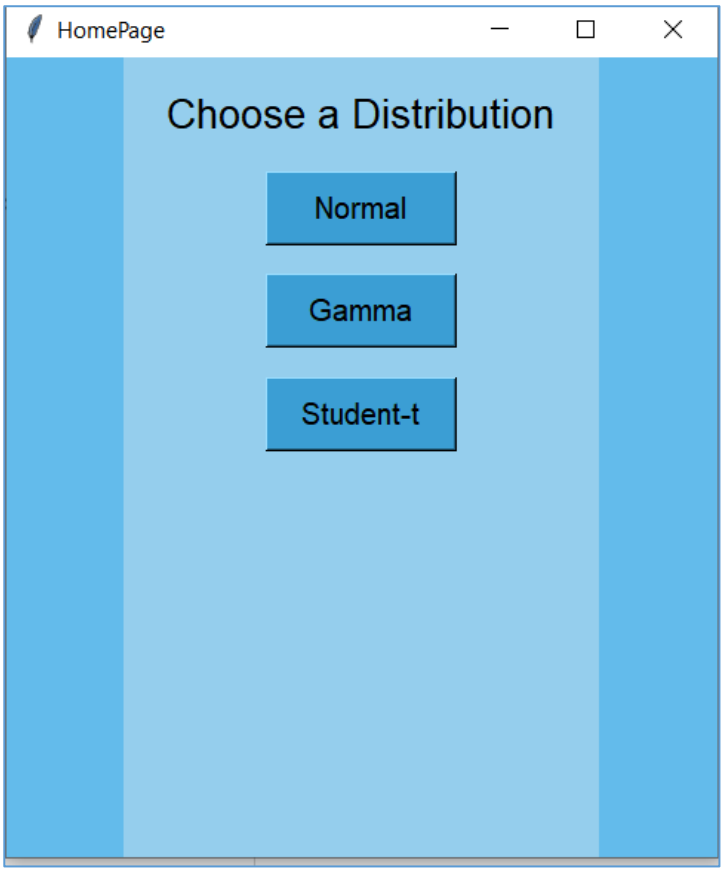

Figure 1. Application home page indicating the choice of distributions.

If users want to return to the home page after selecting a distribution in order to select a different distribution, this can be simply done by using the **Back** button. For all three distributions, the application displays a plot of the distribution according to the parameter(s) input by the user. The parameters can be adjusted by the use of sliders or they can be manually inputted by using a text box. When the user changes the parameter(s) the application updates the plot automatically so that the user can immediately see the impact of any changes on the properties of the plot. Further features can be found under the **Show** option on the application. In particular, there is a zoom option for the plots to help with visualisations and the user may choose to add gridlines to the plot. It is also possible to calculate probabilities for the chosen distribution and the area under the curve that represents the probability is automatically highlighted on the corresponding plot. For example, see Figure 2 below for the probability $P(-1 \leq X \leq 3)$ for $X \sim N(1.54, 1.64^2)$.

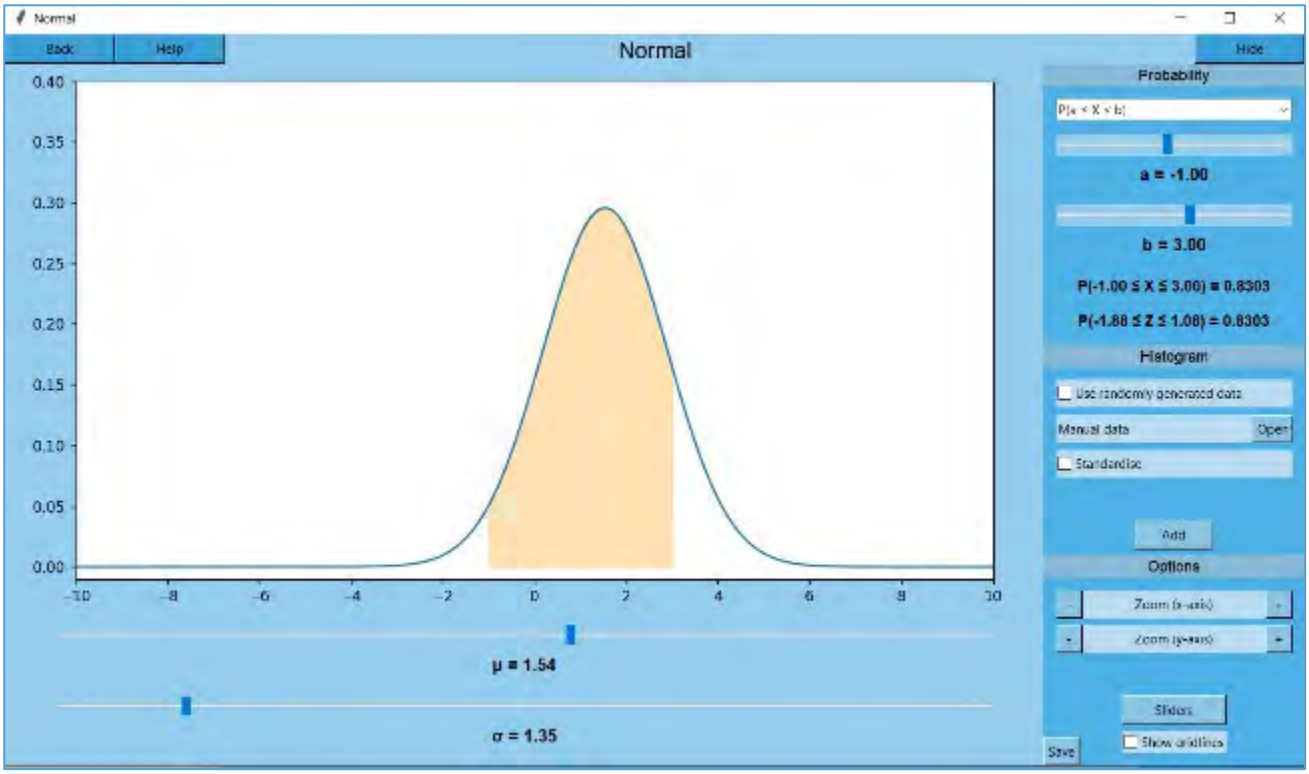

Figure 2. An illustration of an example using the normal distribution option of the application.

For the normal and gamma distributions, histograms can be produced from randomly generated data or from a data set – either manually entered or by uploading a csv or txt file. The Student's t-distribution also has a confidence interval calculator. Users have a number of options for producing these – they can enter the required parameters to produce the interval, or they can enter the data directly (either manually or by uploading a csv or txt file). See Figure 3 below for an illustration. The **Raw data** option is used for entering data.

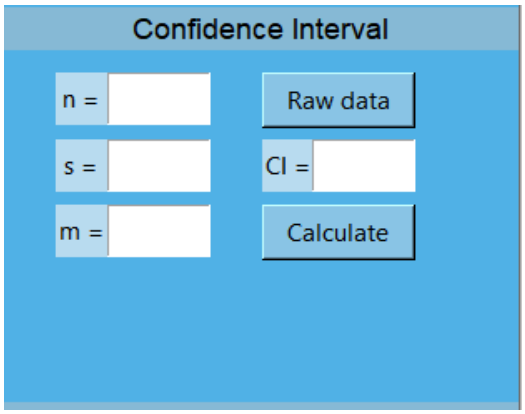

Figure 3. An illustration of the application's confidence interval calculator.

Another feature of the student's t-distribution case is the **Show Normal** option. This allows the user to see how the Student's t-distribution compares with the standard normal distribution, in particular as the degrees of freedom become larger. See Figure 4 below for an illustration of this feature where we have the Student's t-distribution with 4 degrees of freedom (in blue) and the standard normal distribution (in orange).

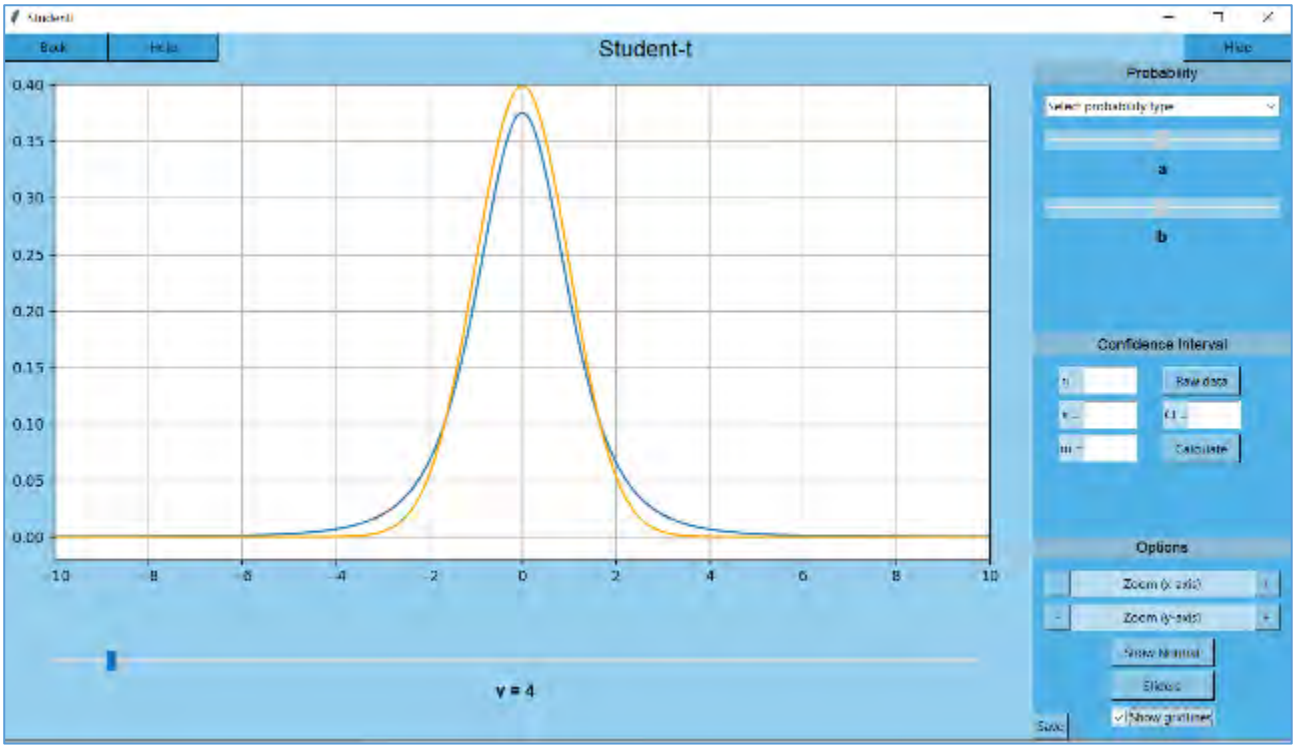

Figure 4. An illustration of the application's Student's t-distribution option.

Finally, all three distributions feature a **Help** function. The help function contains a description of all of the options along with worked examples. Users can try to perform the examples themselves and check their answers within the help function. For example, Figure 5 below is an illustration of a practice question from within the help function for the normal distribution:

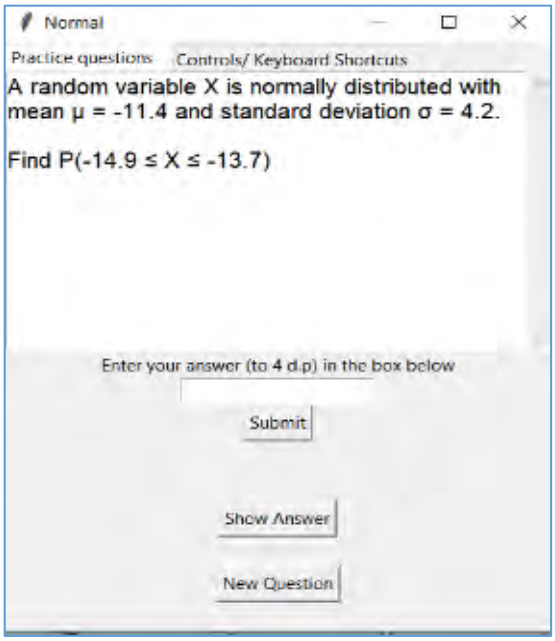

Figure 5. An illustration of the help function for the normal distribution.

4. Feedback

As mentioned in the abstract, feedback was received from both a teaching perspective and from a student perspective. The participants from the teaching perspective were two school teachers who taught A-level mathematics and two members of staff involved with university-level teaching. The students who provided feedback were volunteers from first-year and second-year statistics modules at Swansea University. In particular, four first-year students volunteered to provide feedback, while eight second-year students volunteered to provide feedback. All participants provided suitable consent to take part in the case study.

Teacher Feedback

The questionnaire provided to the teachers was as follows:

The application is easy to use. (1 = Strongly disagree, 5 = Strongly agree)	1	2	3	4	5
The user interface is not distracting. (1 = Strongly disagree, 5 = Strongly agree)	1	2	3	4	5
The application is responsive. (1 = Strongly disagree, 5 = Strongly agree)	1	2	3	4	5
I would consider using this application in my own teaching/ learning.	No			Yes	
Would you recommend this application to a colleague/ friend?	No			Yes	

Figure 6 – The questionnaire provided to the teaching staff participants.

The following open-ended questions were also asked to try to determine if any design choices/considerations had been missed (and which would not have been picked up in the questionnaire):

- *What did you like the most about the application?*
- *What did you dislike the most about the application?*
- *Additional comments:*

Figure 7 below contains the results from the questions in Figure 6 for the teaching staff group. The entries in the cells in Figure 7 denote the number of participants who provided that particular answer for each question.

In summary, all four participants from this group strongly agreed that the application is easy to use and that the user interface was not distracting, indicating that the design choices made for the application have been successful. Whether the application was responsive was positively rated with three participants strongly agreeing and the other agreeing. In addition, all four participants stated that they would consider using the application in their own teaching and all would recommend using the application to a colleague/friend.

The application is easy to use. (1 = Strongly disagree, 5 = Strongly agree)	0	0	0	0	4
The user interface is not distracting. (1 = Strongly disagree, 5 = Strongly agree)	0	0	0	0	4
The application is responsive. (1 = Strongly disagree, 5 = Strongly agree)	0	0	0	1	3
I would consider using this application in my own teaching/ learning.	0			4	
Would you recommend this application to a colleague/ friend?	0			4	

Figure 7 – Results of the teaching staff questionnaire.

With respect to the open-ended questions, three out of the four participants commented that they liked the simple functionality of the application. Furthermore, two out of the four participants commented that they liked the practice questions. One participant did comment that they would use the application on the condition that it was free, and further commented that the application would be particularly beneficial for new teachers because of its ease of use. Finally, one participant liked most the links to histograms and the visualisations.

The participants were also asked to include what they did not like about the application – this was to gather an idea of any oversights in the design or features of the application. The ability to manually configure parameter values was not clear for one user, and they were unsure whether this was possible when using the application. Another participant commented that the normal distribution did not link to z-values, but in fact the application does include z-values when the probability is selected. This indicates that this feature is not immediately obvious to the user. A further comment was that not being able to input a probability value to calculate the corresponding z-value was something they did not like about the application, therefore this is a potential feature implementation for a future release. A further comment made by one participant was that the application looked outdated because everything was too square/rectangular. Unfortunately, this is a limitation of using tkinter, and while efforts were made to give the application a more modern look, it does not match up to modern applications. Finally, one participant mentioned that locating the questions in the help section does not make it immediately obvious that there is a question generator. This comment is understandable, and perhaps a better option would be to have a button specifically for the question generator.

Student Feedback

Feedback was obtained from student volunteers during designated lab sessions, which took place in-person during the second semester of the 2022/23 academic year. During these sessions, student participation and consent information was provided to all students both verbally and in writing.

The teaching staff questionnaires took place before the student ones, and in light of the feedback received from the teaching staff group, we decided to include additional questions in the student questionnaire in order to try to obtain more feedback on the usefulness of the application and on the help function. In addition, we asked the student participants for feedback specifically about potential changes or additional features of the application – these comments will be taken into account in any future work in this area.

The questionnaire provided to students was as follows:

The application is easy to use. (1 = Strongly disagree, 5 = Strongly agree)	1	2	3	4	5
The application is useful. (1 = Strongly disagree, 5 = Strongly agree)	1	2	3	4	5
The user interface is not distracting. (1 = Strongly disagree, 5 = Strongly agree)	1	2	3	4	5
The application is responsive. (1 = Strongly disagree, 5 = Strongly agree)	1	2	3	4	5
The in-built help function is useful. (1 = Strongly disagree, 5 = Strongly agree)	1	2	3	4	5
I would consider using this application in my own teaching/ learning.	No			Yes	
Would you recommend this application to a colleague/ friend?	No			Yes	

Figure 8 - The questionnaire provided to the student participants.

The following open-ended questions were also asked:

- *What did you like the most about the application?*
- *What did you dislike the most about the application?*
- *Would you like to see any changes or additional features to the application?*
- *Additional comments:*

Figure 9 below contains the results from the questions in Figure 8 for first-year students, and Figure 10 provides the results for second-year students. The entries in the cells in Figure 9 and Figure 10 denote the number of participants who provided that particular answer for each question.

The application is easy to use. (1 = Strongly disagree, 5 = Strongly agree)	0	0	0	3	1
The application is useful. (1 = Strongly disagree, 5 = Strongly agree)	0	0	0	2	2
The user interface is not distracting. (1 = Strongly disagree, 5 = Strongly agree)	0	0	0	1	3
The application is responsive. (1 = Strongly disagree, 5 = Strongly agree)	0	0	1	1	2
The in-built help function is useful. (1 = Strongly disagree, 5 = Strongly agree)	0	1	0	0	3
I would consider using this application in my own teaching/ learning.	0			4	
Would you recommend this application to a colleague/ friend?	0			4	

Figure 9 – Results of the first-year student questionnaire.

The application is easy to use. (1 = Strongly disagree, 5 = Strongly agree)	0	0	0	3	5
The application is useful. (1 = Strongly disagree, 5 = Strongly agree)	0	0	0	0	8
The user interface is not distracting. (1 = Strongly disagree, 5 = Strongly agree)	0	0	0	2	6
The application is responsive. (1 = Strongly disagree, 5 = Strongly agree)	0	0	1	2	5
The in-built help function is useful. (1 = Strongly disagree, 5 = Strongly agree)	0	0	1	2	5
I would consider using this application in my own teaching/ learning.	0		8		
Would you recommend this application to a colleague/ friend?	0		8		

Figure 10 – Results of the second-year student questionnaire.

In summary, all students either agreed or strongly agreed with the statements that the application is easy to use, useful and not distracting. Ten out of the twelve student participants either agreed or strongly agreed with the statements that the application is responsive and that the in-built help function is useful. All the student participants would consider using the application in their own learning and all would recommend the application to a friend.

With respect to the open-ended questions, three students commented on the simplicity of the application as being what they liked most, while five students stated that it was the ease of use of the application that they liked most. Two students commented that they liked most the fact that the application provides good visualisations and one student stated that they liked the examples within the help function most.

With respect to what students disliked most about the application, three students commented about the use of the sliders being difficult to choose specific values – as mentioned above, it is possible for specific values to be inputted without using the slides, therefore this feature could be made clearer. One student also commented that they would like to see all features accessible in one window and another student stated the location of the practice questions as being what they disliked most.

With respect to changes or additional features to the application, many of the comments reflected the comments from the previous question. In particular, five students stated that they would like to be able to input specific values instead of using the sliders – this clearly relates to the remarks provided in the previous question above, therefore this needs to be made clearer to users. One student explained that they would like to see all functions of the application available in one window, while another student stated that they would like to see the practice questions more clearly labelled. These remarks will be taken into account in any future developments of the application.

5. Conclusion

Having identified the need for simplifying applications for use in education through background work, an application for the purpose of visualising and interacting with probability density functions was created. The application works as expected and have met the requirements initially set out.

Future work on the application would involve acting on the feedback gathered from the test participants. Implementations to make features more apparent would improve the application, such as question generator, manually entering parameter values etc. These are minor implementations but making these features more apparent to the user would be beneficial in further simplifying the application and providing a better user experience.

One of the non-functional requirements that could have been improved is the communication of errors to users. At the moment, when users enter invalid values when manually setting slider ranges, for invalid values the submit button is disabled but does not offer much guidance to the user in what constitutes a valid range. In this respect, improvements could be made to communicate to the user what errors they have made when entering values.

In addition, using the application and seeing if student understanding of probability density functions is improved in comparison to not using any technological aids could be the basis of future research that could contribute to research in the effectiveness of digital visualisation tools in the mathematics classroom.

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CASE STUDY

Towards a Better Transition to University: A Student-Centric Welcome Day for the New Undergraduate Students in a Mathematics Department

Subhrajyoti Saha
School of Engineering and Computing, University of Central Lancashire, Preston, United Kingdom.
Department of Mathematical Sciences, University of Liverpool, Liverpool, United Kingdom.
Email: ssaha2@uclan.ac.uk, subhrajyoti.saha@liverpool.ac.uk

Abstract

This case study delves into a Welcome Day event organised by the Department of Mathematical Sciences at a UK university for the incoming first year students in the department. This report reflects some of the practicalities and the evaluation of the event. The event, primarily focused on student engagement activities along with reduced amount of traditional presentations, was aimed at facilitating peer networking and smoothing the transition from school to university, hence nurturing a sense of belonging within the student community. The structure of the event was crafted to align with the department's unique ethos, with an emphasis on activities that resonate with the field of mathematics. Evaluation of the event is done based on the responses from the students during the event via an online questionnaire. The event not only demonstrated high levels of student satisfaction but also served as a good example of department-specific orientation programs. These localized events can complement university-wide initiatives, offering a more tailored setting for new students to acclimate to their specific academic environment. This paper has the prospect to guide others and to reinforce the notion of seeking to tailor welcome days to match the needs of new cohorts.

Keywords: Transition to university, student community, welcome event, orientation event, first year students.

1. Introduction

Learning communities create an environment and framework for individuals (students) to unite under a common objective. Within the university setting, the student community plays a pivotal role in linking students together, fostering collective learning, and nurturing a sense of belonging, which is closely associated with academic success (Thomas, 2012). It's crucial, therefore, to establish a robust student community from the very beginning of a student's journey in the university. This is even more important because the transition from school or college to university marks a significant milestone in a student's academic journey. During this period students navigate new academic challenges, social dynamics, and personal growth opportunities. The first-year experience is crucial in setting the tone for a student's entire university life, impacting their academic success, social integration, and overall well-being. In this context, welcome or orientation events play a pivotal role. In addition to being just ceremonial introductions, these events can be carefully designed to ease the transition, providing first-year students with essential information, resources, and leading them towards an enriching student community. These events, in particular, can be utilised to offer a platform for students to connect with peers, familiarize themselves with the university environment, and understand the expectations and opportunities of their new academic community. Moreover, as discussed in (Gill et. Al, 2011), a carefully planned and good quality welcome or orientation program

along with sufficient peer involvement in programs can improve student retention (Davig and Spain, 2004; Ramsburg, 2007).

Globally, various approaches (Cooper, 2021; Zachary et al, 2012, 2014) have been adopted to improve first year orientation or welcome events, aiming to make it more student-centred in nature which can cultivate a sense of community and friendship among students. Most of the time these approaches were typically implemented across entire universities. However, as discussed in (Saha, 2023), it's essential to cultivate a feeling of community within individual academic departments, as students mainly encounter university life in these specific settings. Starting from the academic year 2022-23, a significant stride in enhancing the student community within the Department of Mathematical Sciences at this UK university was made and it is reported in (Saha, 2023). This paper, however, reports the practical aspect and evaluation of the welcome event which took place for the first-year new students in the academic year 2023-24 which is a more organised version of the last iteration with an outlook to measure its impact.

2. Overview of the event

In 2023-24 academic year, total number of year 1 enrolments (at the Department of Mathematical Sciences) was 194 and a total of 125 students attended the welcome event. Rather than centering the welcome day around lectures, the department shifted its approach to emphasize student engagement, peer interaction, and building relationships within the campus community, while still delivering key information to students.

The traditional informative part of the event was redesigned to make it appropriate for the students so that they are not overwhelmed. The essential program and degree information was concisely conveyed by the Head of Teaching in a one-hour session. Mindful of the diminished efficacy often associated with prolonged presentations, this was strategically segmented into two thirty-minute talks, interspersed with a lunch break. Live (and anonymous) questions/feedback was also incorporated in each of the 30-minute presentations. Apart from this there were only two other “talks” in the whole event: one by an existing student on the importance of Equality, Diversity, and Inclusion and the other one by the career team of the university. Both talks were brief (10-15 minutes each). Hence a major part of the event was completely student-centric, and the three such key activities were “campus-hunt”, “group quiz”, and “discussion with senior students”.

The "campus hunt" was a dynamic group activity, engaging students in teams of three or four. This interactive exercise involved visiting strategically chosen campus locations, such as lecture theatres and the library, to enhance familiarity with key university facilities. Participants were tasked with decrypting a set of clues that guided them to various spots across the campus. Upon reaching these destinations, they had to find hints and answer questions related to each location, turning the campus into an engaging and educational landscape for exploration and discovery. There are different ways one can organise this activity. In our case we created a set of 5 questions each having two clues to decrypt. Upon decrypting first clue they would know the specific location of the campus where they should go. Then when they are at that specific location, they can find the answer hidden in the second clue for the question. So, for example in one of the questions first clue was “This building is positioned in row 6 of the campus map grid. The building number is divisible by 13.” This referred a building number 221 in the campus map (provided separately). They second clue for the question was “Your integer A will be the total number of lockers present on the whole of the first floor.”

So, they need to physically go the building 221 in order to find out that there is total 96 lockers (numbers are marked, so no need to count separately!) and thus they record that A=96. Similar way from other questions they find integers B, C, D and E. Once they have found all five integers they can answer online questions involving these, for example “Find the value of $f'(\frac{A}{E})$ where $f(x) = x^2 + 3x - 2$. There was total 4 questions like the above which they had to submit online. These were auto marked online using Microsoft Forms which also records when the answer was submitted.

Similarly, the "group quiz" was another engaging group activity, typically involving the same teams of three or four members. This fast-paced challenge required the groups to answer 20 questions within a 30-minute timeframe, with responses submitted online. To encourage collaborative problem-solving and resourcefulness, students were allowed to use any available resources to assist in finding the answers, or parts thereof. All these questions were multiple-choice question with possibility of having more than one correct answer. These questions were created with the idea of making each of them a fun mix of general/searchable knowledge with mathematics. For example, one of the questions was “As in The Hitchhiker's Guide to the Galaxy by Douglas Adams, the "Answer to the Ultimate Question of Life, the Universe, and Everything" is an integer n. Which of the following polynomials has a root which is an odd prime divisor of n?” There were four options for this question and out of them two were correct. The important thing to note that either someone can know the integer n for the question, or they were allowed to use any means (like internet) to search for it and then they need to do some simple mathematics to finalise the answer. The whole quiz administered and then was auto marked online using Microsoft Forms which also records time taken to complete. Adding a competitive edge to the event, the winning groups from both the campus hunt and the group quiz were awarded prizes, fostering a spirit of enthusiasm and achievement among the participants.

The "discussion with senior students" activity was a thoughtfully designed interactive session. Prior to the discussion, new students were encouraged to submit their questions anonymously using an online platform called Padlet. This submission window closed 30 minutes before the session began, allowing the next half-hour for senior students (year 2 and above), with the assistance of staff members if needed, to review these questions and prepare their responses. During the discussion, senior students addressed these queries, providing insights and sharing their experiences. The session's primary goal was to foster a comfortable atmosphere where new students could freely ask questions on a range of topics. By enabling anonymous online submissions, the activity aimed to reduce any hesitation new students might feel in posing questions directly, thus promoting a more open and honest exchange of information. The whole event was organised with the help of student helpers who were undergraduate students of year 2 and above. Some of these students also participated in the “discussion with senior students” activity.

It is important to note that while we were inspired by some previous works, like (Ronan, 2019), Cooper (2021) and Zachary et al. (2012, 2014), in developing activities, these were not directly duplicated. Instead, they were adapted to reflect the unique characteristics of the Department of Mathematical Sciences. The core elements of the activities, such as the clues in the campus hunt and the questions in the group quiz, were thoughtfully designed to relate to the field of mathematics. For instance, participants were required to apply basic mathematical principles to arrive at the final answers for each activity. However, we ensured that the complexity was kept to a minimum to maintain student engagement.

3. Goal and rationale

The aim of the event was to complement the conventional "lecture"-oriented welcome event with activities centered around the students. There were two major goals for this event.

Reduced Information:

It is discussed in (Gill et. al, 2011) that despite of the fact that participation at the welcome or orientation programs is important in helping students' transition and adaption to university life (Dilekmen, 2007), these programs are often overloaded with information for the students (Singer, 2003). Gill et. al (2011) showed the effectiveness of "just-in-time" information contextualised to the cohort. In this departmental level orientation event, we also focused on contextualised information for the year 1 students.

Peer networking:

The student-centric activities were aimed to provide opportunity for peer networking and meeting new people. For example, the campus hunt activity was designed as a group-based task and the design of the activity itself was intended to promote peer discussion among students. Students also had the chance to network during a complimentary lunch.

4. Evaluation Method

The data collection was aimed at evaluating the impact of the activities conducted during the event. An online questionnaire was administered to students who participated in the event and responses were collected during the event. The participation was entirely voluntary, and all responses were anonymized. A total of 103 responses were collected. An ethics was approved by the University Ethics Committee for this study.

5. Impact: evaluation of results and students' perception

To start with, this event could be considered to have a positive effect as more than 83 percent respondent said, overall, they were satisfied with the welcome event, see Figure 1.

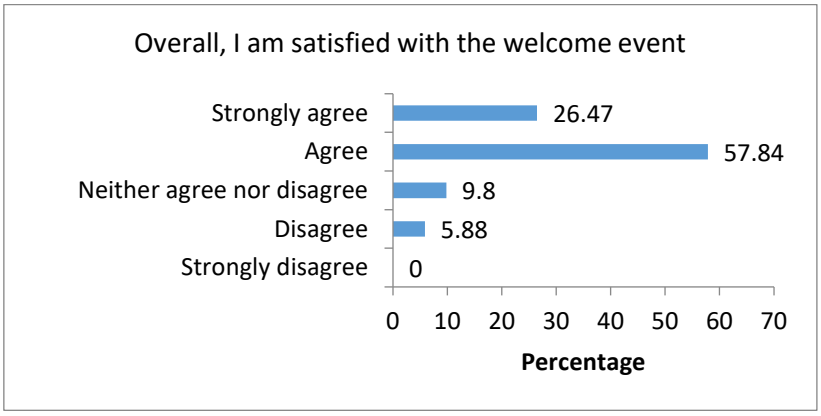

Figure 1. Summary of Responses to the Question "Overall, I am satisfied with the welcome event"

We further asked specific questions to the participants to measure the success and effectiveness of different goals for the event.

Reduced and contextualised information:

The essential program and degree information was concisely conveyed by the Head of Teaching. Feedback from the students indicated that the presentation was highly informative. This was substantiated by the survey results, where over 95% of respondents agreed that "The presentation given by the Head of Teaching was informative" as illustrated in Figure 2.

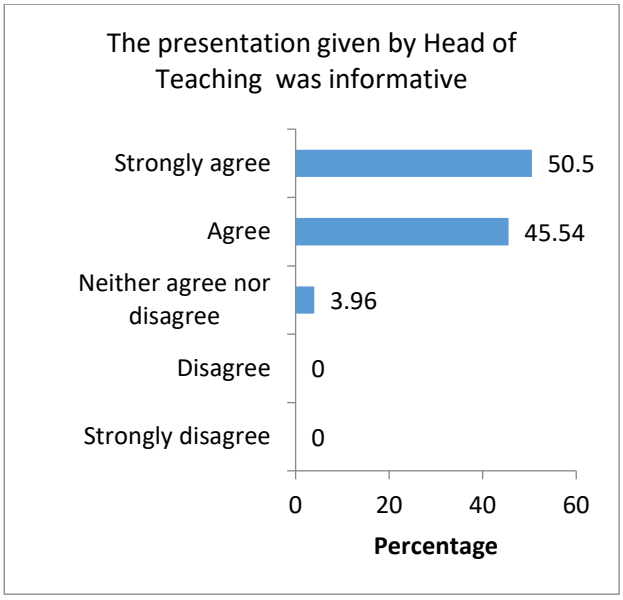

Figure 2. Summary of Responses to the Question "The presentation given by Head of Teaching was informative"

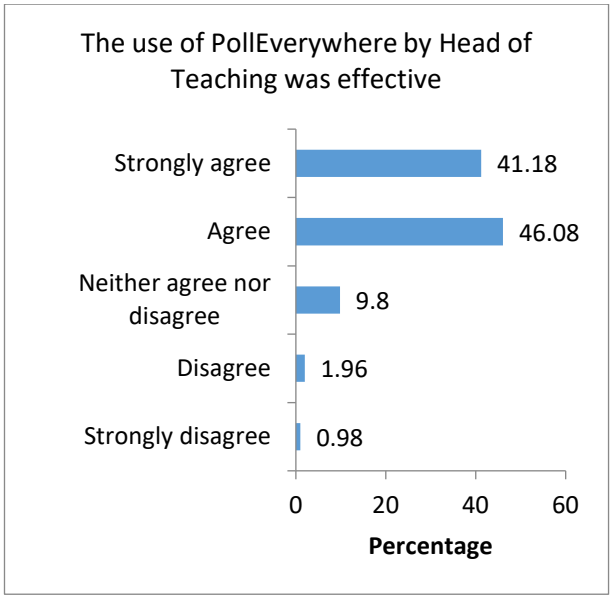

Figure 3. Summary of Responses to the Question "The use of PollEverywhere by Head of Teaching was effective"

Some of the comments from the students also reflected the same.

"The head of teachings presentation was informative of how university would differ from previous education, and how best to deal with that change."

We deliberately made these presentations more student friendly by incorporating live (anonymous) questions/feedback and polls via online platform. Over 87% of respondents agreed that "The use of PollEverywhere during the presentation given by Head of Teaching was effective in encouraging students to ask questions" as illustrated in Figure 3. PollEverywhere is a licensed software which was be used to organise the in-event anonymous polls.

Peer networking:

The event featured student-focused activities such as "campus hunt," "discussion with senior students," and "group quiz," designed to facilitate peer networking and social engagement among new students. The campus hunt and group quiz were well-received, as evidenced by student feedback. A significant majority of the participants, approximately 87%, reported that these activities

effectively promoted interactions between individual students and their peers, as detailed in Figure 4.

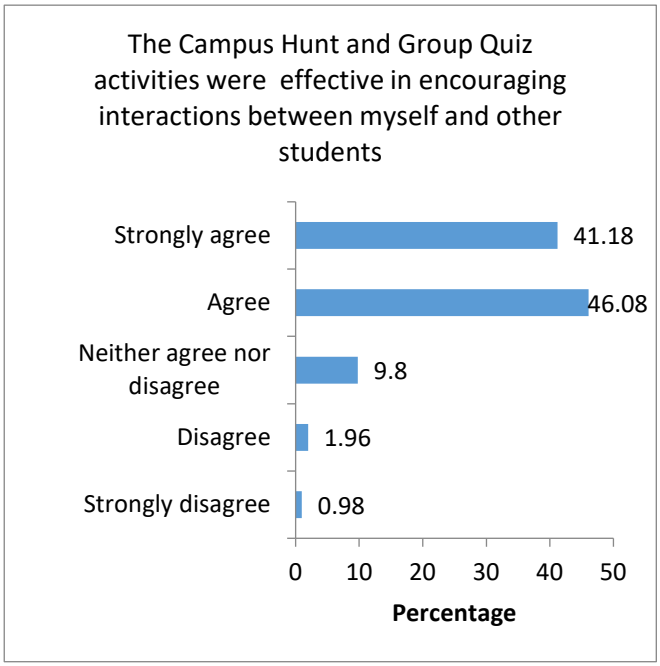

Figure 4. Summary of Responses to the Question "The Campus Hunt and Group Quiz activities were effective in encouraging interactions between myself and other students"

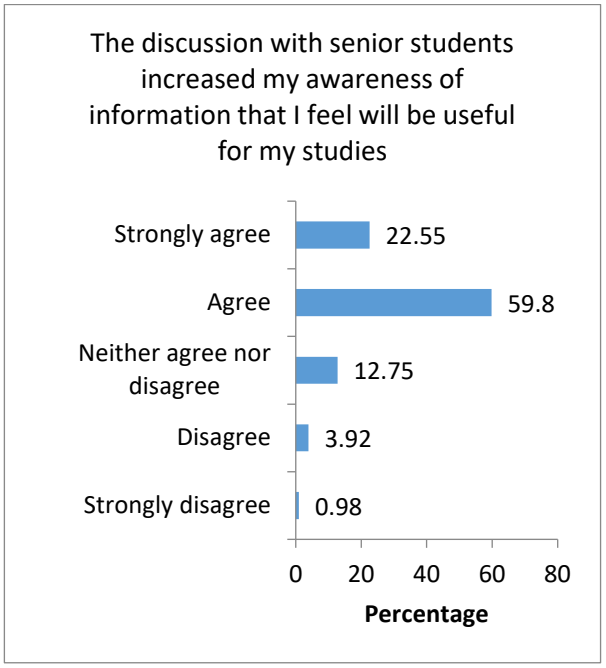

Figure 5. Summary of Responses to the Question "The discussion with senior students increased my awareness of information that I feel will be useful for my studies"

The students' feedback similarly mirrored these observations.

"Exploring campus with a new group of people made it easier to make friends"

Reflective feedback from students regarding the session featuring discussions with senior students mirrored the same positive sentiment. Such an interaction was possibly a new experience for the first-year students, but overall, they showed good enthusiasm and participated actively. Almost 82% students agreed that the discussion with senior students increased their awareness of information that they feel will be useful for their studies, see Figure 5. This perspective was also evident in several remarks made by the students.

"The Q&A with senior students also opened my eyes to new things to try whilst at the university."

"Q&A with students to get the students perspective on what uni life will be like"

To render the session more approachable, we provided the chance to the new students to submit their queries anonymously via a digital platform. More than 79% participants appreciated this effort in their response, as detailed in Figure 6.

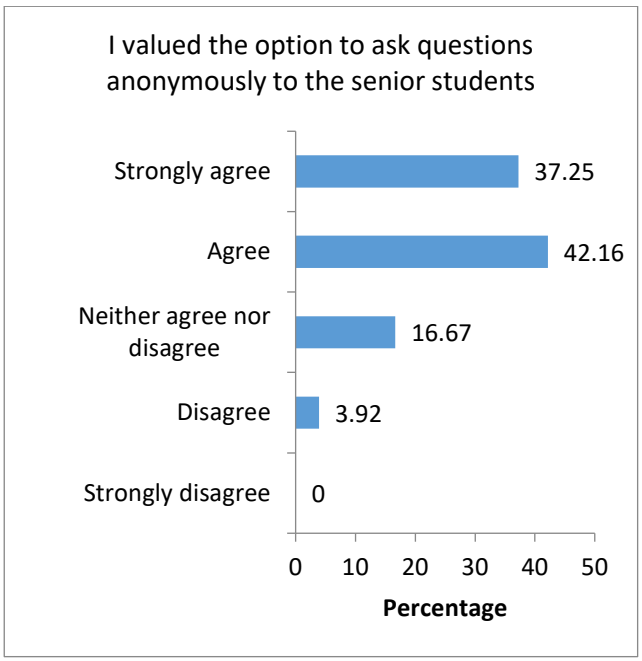

Figure 6. Summary of Responses to the Question "I valued the option to ask questions anonymously to the senior students"

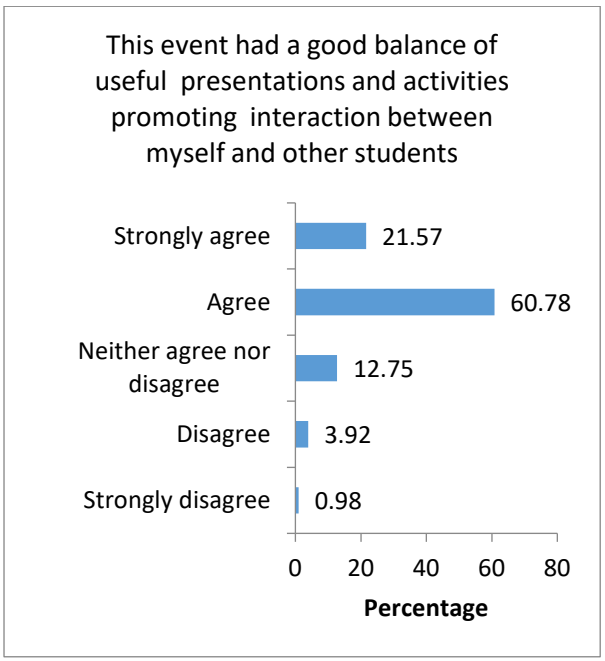

Figure 7. Summary of Responses to the Question "This event had a good balance of useful presentations and activities promoting interaction between myself and other students"

As previously mentioned, a significant portion of the event, constituting over 55 percent of the total duration, was dedicated to student engagement. At the same time, we were careful to impart only the most pertinent information necessary for students to commence their university journey without overwhelming them. This approach was validated by our survey results, where more than 81% of respondents (as detailed in Figure 7) concurred that the event struck an effective balance between informative presentations and activities that fostered interaction among students. Similar reflections were also echoed in some of the students' comments.

"Information about support, hearing from senior students, getting to know the people will be studying with"

"Meeting people on my course Better understanding of the campus lay out Less anxious about starting lectures from information provided and the representation of staff"

"Meeting new people, gathered a lot of information about the course, and spoke to senior students with great information about the future of my education"

6. Conclusion

This paper concludes by highlighting two key aspects. Firstly, the project's adaptability, as noted in (Saha, 2023), demonstrates its applicability across various departments. The informational lecture segment can be easily replicated by any department, with adjustments to include relevant program details, but keeping it concise. The student-focused activities are also adaptable but can incur additional workload. For example, the senior student discussion session is always challenging to conduct due to the hesitancy of new students to engage; but this can be effectively managed through

prior planning and using suitable methods like question submission. This event, though tailored to the spirit of a mathematics department, should be noted for its adaptability to various departmental themes, necessitating inventive input and extra effort from the educational staff. One other important thing to consider while planning is that the date should not coincide with any other major welcome event of the university as it might affect the attendance.

In concluding this paper, the second aspect to consider is the potential for enhancement. The activities were generally well-received by the students, but this does not preclude the possibility of further improvements. As we plan to continue similar welcome day activities in upcoming academic years, we will also explore areas for refinement. Feedback indicated that many students found the event lengthy. A viable solution could be to shift a portion of the informational sessions and talks to an asynchronous format. Additionally, the suggestion of splitting the event over two days merits consideration, provided that each day offers enough engaging activities to maintain student interest. Along the same line and in response to requests for more outdoor activities, incorporating more in-campus experiences like a library tour or meeting academic advisors could enrich the event's appeal.

7. Acknowledgements

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WORKSHOP REPORT

FYiMaths (First Year in Mathematics) New South Wales December 2023

Don Shearman, School of Mathematics and Statistics, UNSW, Sydney, Australia.
d.shearman@unsw.edu.au
Amanda J. Shaker, Department of Mathematical and Physical Sciences, La Trobe University, Melbourne, Australia. Email: a.shaker@latrobe.edu.au

Abstract

In this article, a summary is provided of the recent First Year In Mathematics (FYiMaths) New South Wales meeting held at the University of Wollongong, Australia, and online. The theme of the meeting was “Technology and Mathematics/Statistics” and the day comprised a total of 12 talks. We provide a brief background of FYiMaths, followed by a summary of the talks, and concluding remarks.

Keywords: FYiMaths, mathematics education, statistics education.

1. Introduction

The First Year in Mathematics (FYiMaths) group is an Australian group of academics, teachers and support staff with an interest in the teaching of mathematics at the undergraduate level. It began through a project funded by the Australian government to develop a handbook for coordinators of large first year mathematics subjects (Office for Teaching and Learning, 2015). Since then, the group has developed to become a community of practice for undergraduate mathematics and statistics education and the transition from secondary education.

FYiMaths NSW is the New South Wales branch of FYiMaths. The annual meeting of FYiMaths NSW was held as a hybrid event at the University of Wollongong and online on 13 December 2023, with about 50 people attending either in person or online. The theme of the meeting was “Technology and Mathematics/Statistics”, although the meeting also included talks from a wider range of topics.

The day comprised 12 talks (summaries below) and much lively discussion from all in attendance. Recordings of most of the talks can be found at the FYiMaths YouTube channel at https://www.youtube.com/playlist?list=PL-MI0q0vuCRXOm38W2HvcjqeuYZ-cBxO . A new innovation was introduced at this meeting, which was adapted from the CETL-MSOR lightning talks (e.g. CETL-MSOR, 2022). At the CETL-MSOR lightning talks, as a friendly incentive for speakers to remain within time limits, toy ducks were lined up, ready to be launched at a speaker with a toy projectile if their talk went over the specified time-limit. This light-hearted practice was adapted for the Australian context, whereby rather than toy ducks, it was the sacrifice of a number of toy koalas for speakers who exceeded their time limit. This proved to be a popular addition to the day.

2. Talks

2.1 Routes to First Year Mathematics (Ian Whiteway)

Where do the students who come to first year mathematics subjects come from and, more importantly, what do they know when they get here? The first speaker, a secondary teacher at a large private school, discussed the various routes that students could take at the end of their

secondary education including the Higher School Certificate (NSW education department exams), the International Baccalaureate, and the Cambridge A Levels, all of which are available to students in NSW. Similarities and differences in content and approach to learning were covered for the different levels of each qualification.

The ensuing discussion suggested that the information from this talk should be developed into a page on the FYiMaths website, and that it be expanded to include information about the larger groups of international students who study in Australia.

2.2 The Golden Gate Bridge is 1.479 km high and 2.15×10^6 m long, some thoughts on word problems in mathematics (Merryn Horrocks)

The answers quoted in the title of this talk were examples of answers given by students to questions in an engineering maths test. After dismissing the suggestion that such answers come from "stupid" students, the speaker discussed the difficulties inherent in word problems and outlined some strategies for overcoming them. This included unspoken assumptions in word problems and a model to teach students how to solve word problems.

2.3 When will I use this? Relating Mathematics to real life applications and its impact on student engagement and academic performance (Shatha Aziz)

This talk focussed on the concept of relevance in the context of a second-year linear algebra subject (module). The speaker began with a question that is commonly asked by students: *When will I use this?,* explaining that mathematics is often perceived as an abstract subject. For this reason, a case is made regarding the role of educators in connecting mathematics to the real world in order to positively impact student engagement.

As the speaker's cohort was predominantly comprised of future teachers, she developed an activity that would be relevant to their profession. The activity was optional, and involved creating a group video presentation explaining a simple application of linear algebra, followed by a reflection on the benefit of the activity to students' learning. Students could choose to explain one of four applications discussed in a research article provided by the speaker, or any other relevant application of their choosing. Student feedback on the activity was positive, with participating students commenting that they enjoyed the activity and that it was beneficial to their learning, helping them to appreciate the application of mathematics in the real world.

The speaker then facilitated a discussion on the activity, asking workshop participants for their ideas and insights. The discussion included acknowledgement of the benefit of implementing activities that provide concrete relevance, as was done by the speaker, as well as considerations around whether or not the activity should be mandatory and/or assessed.

2.4 CARMA/MATRIX poster/art competition awards (Judy-Anne Osborn)

The speaker, CARMA Director, discussed the CARMA/MATRIX Poster/Art Competition and announced the 2023 award winners. An overview of the CARMA-MATRIX awards history was provided. This was followed by a presentation of the 2023 artwork entries (e.g., Figure 1) and a description of their respective artist statements. Finally, the 2023 winners were announced as follows.

Art Prizes:

- 1st Prize: *Involution curve,* by Peter van der Kamp
- 2nd Prize: *Apollonian Sunset,* by Travis Stenborg
- 3rd Prize: *The beautiful patterns of Blaschke products,* by Juan Carlos Ponce Campuzano

Outreach Prizes:

- 1st Prize: *Turing Patterns,* by Travis Stenborg
- 2nd Prize: *Fractals, understanding the geometry of nature,* by Rahil Valani

All winners were congratulated, and workshop participants encouraged to consider submitting entries in 2024. Entries for the 2024 competition are now open on the CARMA webpage.

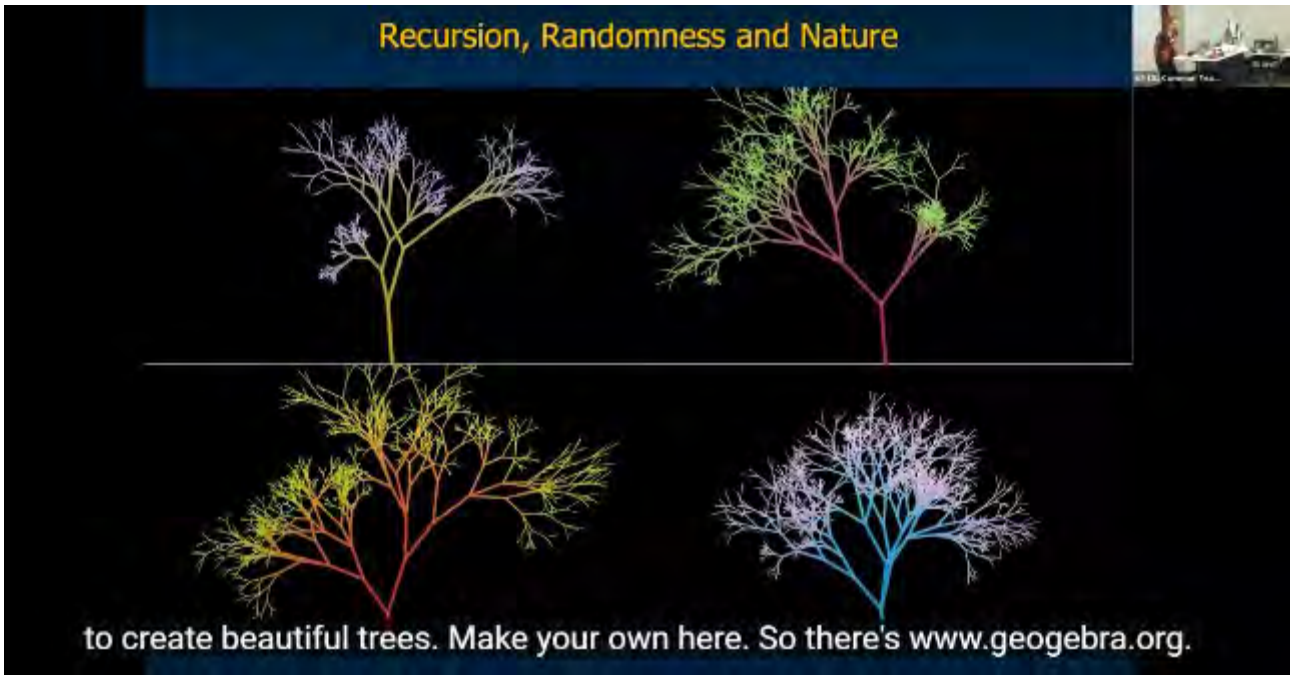

Figure 1. *Recursion, Randomness and Nature* by Juan Carlos Ponce Campuzano. The image can be directly accessed at this link.

2.5 Supporting self-efficacy beliefs through undergraduate tutorials (Sang Hyun Kim)

Given the fundamental nature of tutorials on student learning in mathematics, this talk summarised the results of a study comparing the effect of face-to-face tutorials with remote delivery in an undergraduate second-year service mathematics course at the University of Auckland. Effects compared included performance and self-efficacy. The study was a quasi-experimental design, with groups constructed such that students attending more than 50% of face-to-face tutorials were considered 'In-person students', and students attending less than 50% of face-to-face tutorials (i.e. completing their tutorial work online) were considered 'Online students'.

In terms of student performance, on average, the Online students' exam and final grade marks were higher than face-to-face students' marks, and this difference was significant in both cases. However,

in terms of self-efficacy, on average, there was a negative change in the Online group, compared with a positive change in the face-to-face group.

The speaker concluded by summarising some of the conclusions from the study so far, as well as describing possible future directions of the research. These include exploring possible reasons for the somewhat surprising results seen so far, and broadening the scope of the study.

2.6 Three online systems for organising teaching and learning resources (Jim Pettigrew/Laure Helme-Guizon)

In this talk, the speakers provided an overview of three online systems that have been developed for the organisation of teaching and learning resources.

The first system is a database website that allows for efficient management and easy look-up of previous exam questions (Figure 2). This system uses a MySQL database and a combination of PHP, JavaScript, CSS and HTML.

The second system contains an organised repository of responses to frequently asked student questions so that responses can be adapted and re-used as necessary. This system uses the Sphinx documentation-building tool.

The third system is a documentation website for comprehensive ‘how-to’ notes for the use of the Möbius online learning and assessment system. This system uses the Sphinx documentation-building tool.

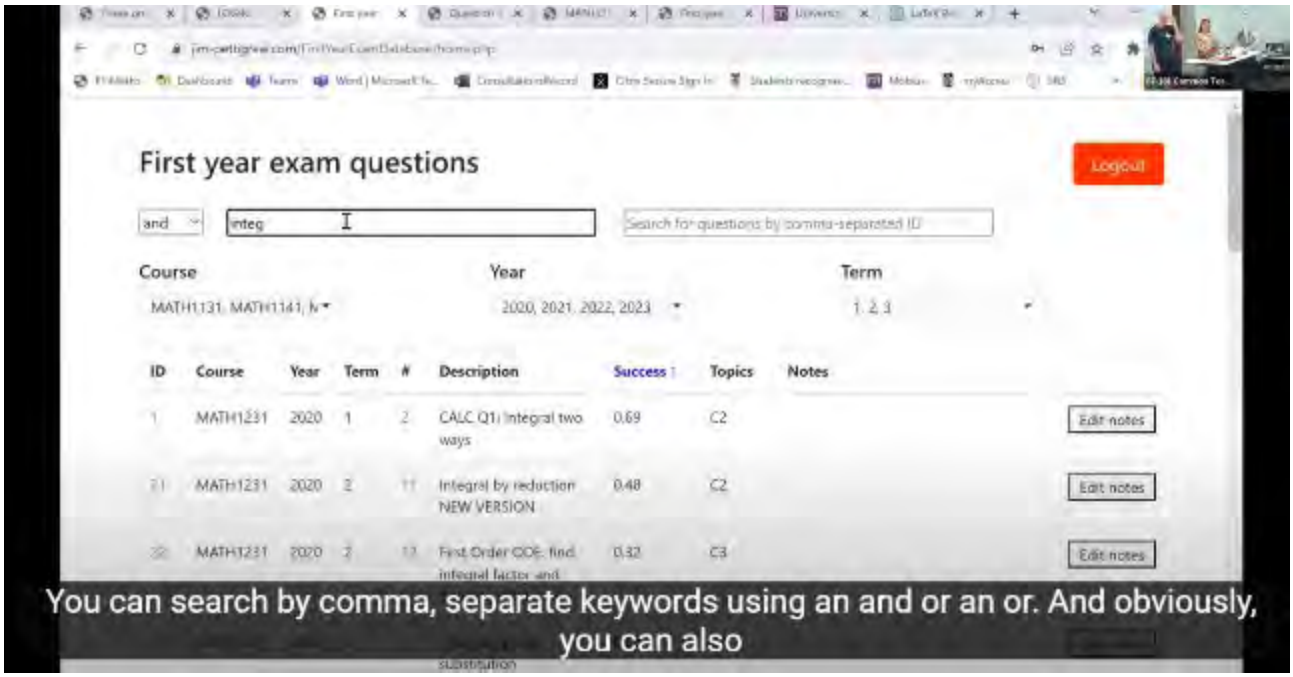

Figure 2. Database website that allows for efficient management of previous exam questions, including search functionality.

2.7 Maple use in first year exams (Jonathan Kress)

This talk describes the implementation of Maple, and other software, into large first-year exams. The speaker began by providing motivation for consideration of using Maple or other software in mathematics exams, including the availability and wide-use of sophisticated technology that is available in this day and age. The speaker then gave an overview of the use of Maple in first-year mathematics at the University of New South Wales beginning in the early 1990's.

The speaker explained that traditional exam delivery was disrupted due to the COVID-19 pandemic, and during that time, exams needed to be carried out as unsupervised, open-book assessments. This included the potential for students to use Maple during exams. For this reason, question design needed to be considered, with new questions focussing on understanding rather than calculation, and designed such that answers could not be obtained from an internet search or using a calculator.

Following this experience and with a return to invigilated exams, a decision was made to run the exams in computer labs with randomised questions, and thus, it was decided that the use of Maple would be allowed in exams. The speaker ended by reflecting on the types of mathematical skills students need in this day and age, which may now go beyond tasks that software and AI can perform.

2.8 Designing an introductory statistics subject for students with diverse educational backgrounds and chosen qualifications (Amanda Shaker/Rupert Kuveke)

In this talk, the speakers discussed the design of a large, first-year undergraduate statistics service subject at La Trobe University, which has been designed to cater for a diverse range of educational backgrounds and chosen qualifications. The subject is comprised of two parts: a core component containing foundational statistics concepts which all students complete, and a stream-specific component which contains differing content and assessment depending on students' chosen degree. Currently, the subject offers two streams: Science/Health, and Data Science, although additional streams can be added as need arises.

The speakers provided an overview of other design elements included in the subject, which include less emphasis on mathematical calculations and more emphasis on understanding and use of software, and various statistics anxiety considerations. After an initial evaluation, among other changes, a decision was made to use jamovi instead of R in the Science/Health stream, while Data Science students use R.

Over time and as a result of the iterative changes being made, both pass rates and overall student satisfaction have increased. A full paper on this project has been accepted for publication in *MSOR Connections* and appeared in a recent issue (Kuveke et al., 2024).

2.9 Users vs Developers (Usha Shridar)

The speaker in this talk used an analogy from computing of users vs developers to identify two groups of students of mathematics: the users who are essentially surface learners, and developers who want to understand concepts more deeply. Discussion within the talk focused on methods for accommodating these two groups within the traditional class structure.

2.10 A collaborative model for learning AI in the context of LANTITE content creation (George Papadopoulos)

The development of generative AI has caused consternation throughout academia due to many potentially negative outcomes which may arise from its use. This talk took an alternative view and discussed how AI has been used as a helper to write sample questions designed to help students to prepare for a compulsory literacy exam for pre-service teachers. The speaker had involvement with the beta development of Microsoft's Co-Pilot AI and used this in his role with a team of literacy educators to develop new questions from existing exemplars. Discussion centred around the possibilities that this approach offers for the development of questions in a mathematical context.

2.11 Technology challenges in AEI (Pranati Balijepalli/Visali Kadiyala/Radha Somanchi/Usha Shridar)

The speakers in this talk discussed the use of technology in a new subject, Arguments, Evidence and Intuition (AEI), which deals with data literacy and quantitative numeracy at a basic level. The talk included discussion around the issues created by the use of "big data", including data privacy, the use of language as technology and the use of Excel as a tool for generating statistics from data sets.

2.12 Higher Education Provider Amendment (Support for Students Policy) Guidelines - discussion (Don Shearman)

The Australian government has introduced new legislation which changes how students receiving government support for their studies are treated. Previously if a student failed more than four of their first eight subjects they would lose their government support. The new legislation moves the responsibility for students to pass their subjects more onto the tertiary institution by requiring them to assess a student's capability to succeed in their chosen program of study and to provide adequate academic and non-academic support to help students to succeed in their studies. This discussion session generated a lively discussion around the topic of how the new legislation will affect mathematics and statistics support in Australian universities with the consensus being that it will lead to improved services.

3. Concluding Remarks

The workshop included talks from a wide range of areas related to Higher Education mathematics and statistics in Australia and New Zealand. Topics discussed included pathways into first-year university maths, using maths word problems, student engagement and how students learn, e-assessment, and implications of forthcoming changes to government guidelines related to student support.

A recurring theme at the workshop was the diversity of academic backgrounds in service teaching of mathematics and statistics. This can lead to challenges with relevance, as students may not immediately see how these subjects apply to their chosen degree. Strategies discussed for addressing this included incorporating video assessments where students discuss real-life applications of mathematics in their discipline. Additionally, modularizing a statistics module to accommodate different disciplines was suggested for a large first-year statistics unit. The workshop also provided an update on various routes into first-year mathematics in the NSW context, acknowledging the role of FYiMaths in promoting awareness.

The meeting also discussed the new Support for Students Policy, emphasizing its implications for mathematics and statistics support services at universities. Another key topic was student engagement in a post-COVID world, comparing self-efficacy and performance between online and face-to-face cohorts.

The workshop highlighted several key lessons learned. One notable point was the use of mathematical software like Maple in mathematics exams, a practice adopted during the COVID-19 pandemic and recognized as beneficial. Another lesson stressed the importance of preparing students to tackle mathematical word problems, given the additional skills required for their solution.

Technology emerged as a recurring theme, with discussions on video assessments, software in exams, statistical software program comparisons in a first-year statistics unit, and systems developed for managing mathematics teaching resources. Another prominent theme was the interpretation of mathematics, encompassing mathematical word problems, real-world perspectives, and mathematical art.

The workshop was a welcome opportunity for attendees to share teaching ideas, connect, and collaborate. The FYiMaths NSW meeting is run annually in NSW towards the end of the calendar year. There is also a national FYiMaths meeting that is held annually in the middle of the year, with the next national meeting to be held in hybrid format in the middle of 2024.

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