Case Study 1: How you have used a range of methods, approaches and digital skills in your teaching, learning or assessment

1. Context

In this case study I will examine my pedagogical practices as a Lecturer in the Department of Mathematics. I joined Hull in the current academic year 2023/24 and led the following modules:

(1) *Numbers Sequences and Series* (Module 400297 T1 2023/24)

(2) *Differential Geometry, Topology and Applications* (Module 661955 T1 2023/24)

(3) *Statistical Models* (Module 551305 T2 2023/24)

This was an intense and challenging journey, which gave me the opportunity to reflect and greatly improve on my teaching. In particular I will focus on the use of technology in developing teaching materials, see Section 2, as well as the inclusion of formative assessment in tutorials and classes, see Section 3. Conclusions and future plans are discussed in Section 4.

2. Designing and delivering interactive teaching using technology

When I joined the University of Hull in 2023/24 I took over leading the 3 modules in (1)-(2)-(3) above. For these, I inherited some teaching material in the form of PDF format lecture notes, slides, and weekly tutorials. I felt that the material needed updating, to be brought in line with my theoretical mathematical expertise. Acknowledging the pivotal role of technology in modern education and its capacity for pedagogical transformation [Holley et al., 2021], I looked into ways to incorporate digital tools into the teaching material [A4, K4, K6, V3]. The standard way of writing mathematics is by using a computer language called LaTeX [K4]. The latter outputs nicely formatted PDFs documents or slides that can be uploaded on Canvas. I wanted to use something more accessible than PDFs for my lecture notes. While I was aware of digital publishing frameworks such as Jupyter Notebook, I found them to be more oriented towards Python coding and data science, and not really suitable for mathematics, slides, or long pieces of work, such as lecture notes. After some research [V3, A5] I discovered Quarto [Scheidegger et al., 2020], which is an open-source scientific publishing system. In particular it allows to write mathematics alongside plain text and code, such as Python. Quarto is at the bleeding edge of scientific publishing technology, and it allows to share documents digitally on the web, as well as producing a traditional Word or PDF files which replicate exactly the digital content.

I employed Quarto to write lecture notes and slides for my three modules, and designed sessions around this material [A1]. The teaching material I produced is available online, see links in supporting evidence (F)-(G)-(H). I also uploaded the PDF version of the lecture notes and slides on Canvas, ensuring all students could easily access the materials [V2]. While learning Quarto required an investment of time, the outcome was rewarding, as it allowed for more interactive and accessible materials. This aligns with my commitment to continuous improvement and innovation in teaching practice [V3]. Feedback from students, as indicated in question Q8 in the MEQ in Evidence (C), affirmed the value of this approach, indicating its positive impact on their learning experience.

Digital notes offer several advantages, aligning with key points of the UKPSF 2011. First, they are highly accessible, as the content can adapt to any screen size, allowing for easy viewing on various devices, including smartphones. This facilitates the use of accessibility features on smart devices, such as text magnification or contrast enhancement, improving the learning experience for students with different needs [A4, V2]. Additionally, the digital format allows for compatibility with text-to-speech software, overcoming the limitations often encountered with PDFs. This feature is particularly beneficial for students who prefer auditory learning [Weinstein et al., 2019], or who have visual impairments, promoting inclusivity and equal access to learning materials for all students [K3, K4, V1, V2]. Such practice ensures access and inclusion for all, rather than expecting individual students to adapt [McKee and Scandrett, 2021].

In addition to accessibility, digital lecture notes and slides allow to introduce a level of interactivity and visualization which would not be possible with traditional PDFs, Word, or PowerPoint documents [A4]. I wanted to train students to develop mathematical intuition, and I thought this could be achieved more easily through interactivity and visualisation [V3]. While over-reliance on intuition can be risky in certain contexts [Weinstein et al., 2019, Page 28], mathematics stands as an exception.

Here, intuition is indispensable for navigating through the intricate technicalities essential for formulating concepts and statements. In mathematical education, comprehension should span both intuitive understanding (the "why") and technical proficiency (the "how"), as emphasised in [Feferman, 2000]. However, traditional teaching in mathematics often prioritises technical mastery at the expense of intuition [K1]. Consequently, students often resort to memorisation, leading to swift forgetting once the course concludes [Weinstein et al., 2019]. By incorporating visualisation and interactive elements, students were better able to cultivate their mathematical intuition [A4]. This approach garnered positive feedback from both students, as indicated in the MEQ responses, see Q8 in Evidence (C), and observers, see Evidence (A)-(B).

3. Tutorials and Formative Assessment

In my view mathematics needs to be experienced to be fully understood. As a seasoned researcher, it is easy to forget how daunting the mathematical language can appear to those unaccustomed to it, particularly to first-year students. This challenge is common in any highly technical discipline [K3], as noted in [Neuhaus, 2019]. It is crucial for students to recognise this and actively engage with their understanding and intuition through practical exercises [K2].

The module *Numbers Sequences and Series* comprises weekly tutorial sessions lasting one hour each. I would upload an Exercise Sheet on Canvas, assigning the students to complete the exercises at home. The following week, I would solve the exercises on the board, and subsequently upload detailed solutions to Canvas after the tutorial session [A2, A3], see Evidence (E). While this traditional approach is common in mathematics tutorials, I soon realised that it resulted in low student engagement and minimal completion of homework exercises [A4]. Low engagement was exacerbated by the fact that tutorials were scheduled for 9 AM, and many students were commuters. Seeking a solution, I consulted a colleague, who suggested a more interactive approach: having students solve exercises at the board and discuss solutions collaboratively. Later, through participation in PCAP, I learned that this approach aligns with the *flipped classroom* paradigm, where students engage with course material before class, and class time is dedicated to active learning activities [A5, V3], see [Ashwin et al., 2015]. I implemented this approach in my tutorials, instructing students to contemplate the exercises at home, and then collectively solving them in class the following week. The response was overwhelmingly positive, resulting in increased engagement. To foster discussion, I designed the exercises to allow for multiple alternative solutions [A1, V1], encouraging debate among students, see Evidence (E)). This approach also led to students proposing solutions that I had not considered, promoting a sense of active participation and contribution to the module.

I experienced the occasional low student engagement during some of the more technical lectures in the module *Statistical Models*. To address this, I attempted to foster engagement and assess understanding with direct questions [A3]. This approach had mixed results, as also noted by Catherine in her peer observation. In the observation, see Evidence (A), she encouraged collaborative work among students. Following her advice, I explored the PCAP resources available on Canvas and discovered the concept of *informal group work*, which is an instance of *formative assessment* [Pokorny, 2021]. To ensure the effectiveness of informal group work, I needed to provide clear tasks and objectives, as well as the necessary resources for students to complete them [A1], see [Brame and Biel, 2015]. Since I had already included numerous worked examples in the slides (see Evidence (H)), I decided to transform these into 15–minute tasks for students to solve in pairs. To further stimulate student interest, I included tasks grounded in real-world applications [A1, V4], as illustrated in Evidence (D). After presenting the task, I made it clear that I was available to answer any questions and that we would review the task together at the board after the allotted time. This approach was really well received and produced a spike in engagement. Most tasks were solved to a satisfactory level, often sparking lively discussions among students regarding the best strategies. I would gently guide these discussions, to get to a common solution in a time effective manner [A2, K6]. However, a drawback emerged when some students lacked access to laptops, particularly for tasks requiring coding in R, leading to instances of digital exclusion [Holley et al., 2021]. To address this issue, I have requested that certain classes be moved to a computer lab in the future. Overall, the integration of interactive formative assessments proved to be highly successful, and I am grateful to Catherine and my colleague for suggesting it.

4. **Conclusions**

In the upcoming academic year, I aim to solidify the teaching strategies outlined previously [A4]. I intend to initiate flipped class tutorials from the outset and incorporate more Group Exercises during lectures, promoting collaborative learning [A1, A2]. I will revise the digital lecture notes and slides to align with these changes [A5, K4, K6]. Furthermore, I plan to integrate Mentimeter for interactive questions and feedback, along with quizzes designed for pair participation. These enhancements align with my commitment to continuous improvement and innovation in teaching practice [K4, A5].

I found the module *Reflective Teaching in Higher Education* to be incredibly enriching, providing ample opportunities for me to enhance my understanding of teaching practices and engage in reflective practice. One particular reading, [Neuhaus, 2019], resonated strongly with me. It prompted me to consider that a teacher's effectiveness extends beyond just pedagogical methods and subject knowledge; it also hinges on the quality of relationships they cultivate with their students. As such, my goal for the upcoming year is to begin fostering relationships with students from the very first session. I plan to share selected feedback from previous years' MEQs, illustrating how I have incorporated student feedback to improve the module [A4]. For example, in the MEQ for *Differential Geometry*, students expressed enthusiasm for surfaces (Q18 in Evidence (C)), prompting me to include more surface-related topics and real-world applications. By doing so, I aim to demonstrate to students that they have an active role in shaping their learning experience and foster a sense of belonging within the learning community [V2, V4]. Additionally, I will strive to arrive to class 15 minutes early to engage in informal conversations with students before the session begins. I am eager to implement these changes and enhance the overall student experience in the coming year.

Supporting Evidence

(A) Peer observation from member of PCAP team
File name: `Evidence - Catherine Lille Observation.docx`

(B) Peer observation from colleague on PCAP programme
File name: `Evidence - Daniel Farrow Observation.docx`

(C) MEQ for *Differential Geometry, Topology and Applications* (Module 661955 T1 2023/24)
File name: `Evidence - MEQ Differential Geometry Topology and Applications.pdf`

(D) Excerpt from Week 7 Slides for *Statistical Models* (Module 551305 T2 2023/24)
File name: `Evidence - Sample statistical models slides.pdf`

(E) Week 8 Tutorial and solutions for *Numbers Sequences and Series* (Module 400297 T1 2023/24)
File name: `Evidence - Tutorial 08 solutions.pdf`

(F) Fanzon, S. *Lecture Notes on Numbers Sequences and Series.* (Module 400297 T1 2023/24)
Available online at: `https://www.silviofanzon.com/2023-NSS-Notes`

(G) Fanzon, S. *Lecture Notes on Differential Geometry.* (Module 661955 T1 2023/24)
Available online at: `https://www.silviofanzon.com/2023-Differential-Geometry-Notes`

(H) Fanzon, S. *Lecture Slides on Statistical Models.* (Module 551305 T2 2023/24)
Available online at: `https://www.silviofanzon.com/2024-Statistical-Models-Slides`

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