Putting the education science into bioscience education

Introduction

I am an experienced academic with an established track record in learning enhancement, within the university and beyond. I teach bioscience within healthcare-related courses, including pharmacy. Early experiences revealed student 'learning' is an outcome of their total experience. I set an essay on diabetes, and noted top performers had personal experience of the condition. This was my first exposure to the 'hidden curriculum[1].' Enhancement requires understanding this hidden curriculum, so student partnership forms the cornerstone of my teaching philosophy.

This partnership model has evolved - my 'innovation' is not my individual enhancement interventions, but the *mechanism* whereby I identify necessary activity. Curricula are complex sociotechnical systems, outcomes of which include student achievement and satisfaction. Human Factors (or *ergonomics*; HFE) is the science of work systems. Knowledge gained is applied in practice, optimising system performance and improving wellbeing. What is unique about my practice is the application of HFE science to the bioscience curriculum. HFE uses a systems framework as a lens for understanding work (**Figure 1**)[2].

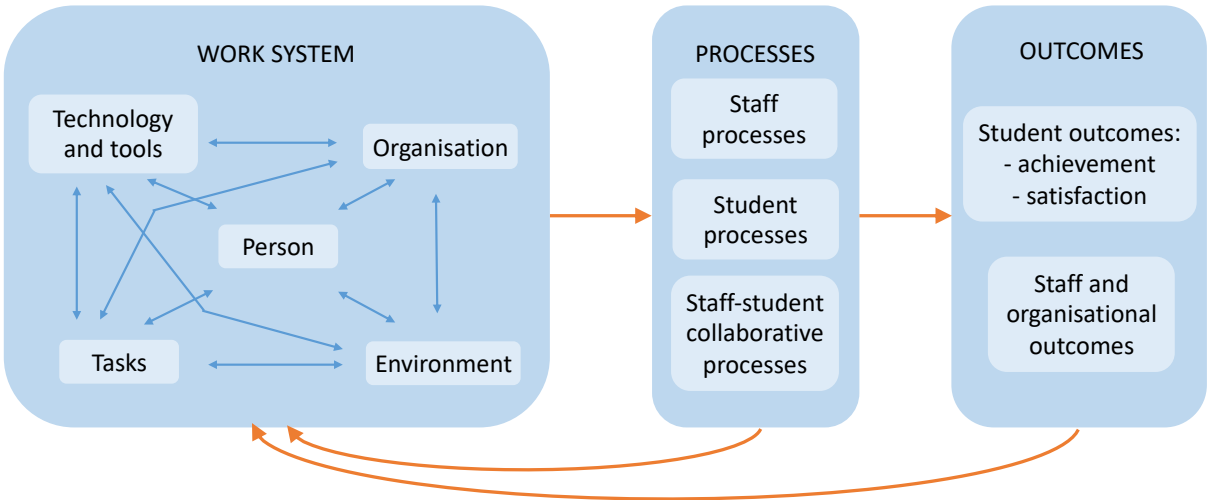

Figure 1: A system is a set of entities engaged in a common purpose. The entities may be physical artefacts (such as people and the equipment they use) or they may be less tangible, such as organisational culture. When work processes are undertaken, they force interactions between the entities. For example, when a student views an online lecture, there is an interaction between the student and the content of the lecture, but also with the technology interface that allows them to view the slides. It is the quality and number of these interactions that will determine if processes will deliver desirable outcomes. Considering our online lecture – poorly designed slides, or an unreliable internet connection can undermine excellent lecture content, and the student finds the process of learning more difficult.

HFE explores 'work-as-done', not 'work-as-imagined' by triangulating data from multiple sources and will always, where possible, include direct observation (**Table 1).**

Source	Type of data
Assessment performance	Quantitative; some qualitative data can be drawn from eg appeals and mitigation processes
NSS (and institutional surveys)	Quantitative; some qualitative data from free-text responses
Minutes from staff-student liaison groups	Qualitative
Reports (including from accreditation events, institution-led subject review, internal QA events)	Qualitative and quantitative
Audits	Mixed
Minutes and outputs from Student Learning Enhancement teams	Mixed; largely qualitative
Direct observation of staff and student activity	Mixed
Simulation	Mixed

Table 1: Sources (and type) of data gathered to model 'work as done.' Qualitative data is thematically analysed, with data extraction and synthesis mapped onto the systems framework shown in **Figure 1**.

HFE ideally works with *all* stakeholders. 'Work-as-done' is modelled, allowing intelligent redesign to support good outcomes. In effect, HFE is risk management, but it considers risks to all outcomes, not just safety. In HFE terms, design is *inclusive,*[3] aiming for environments that can be accessed and used by as many people as possible, regardless of age, gender, race, socio-economic status etc. HFE approaches mean needs of all users are proactively accounted for, rather than reactively responded to. I have published a book chapter on its academic application[4].

Figure 1 shows processes are undertaken by staff or students, while some processes are collaborative. Understanding the system can optimise outcomes through this same structure:

- Staff can re-design activities (staff working *for* students);
- Through partnership, *co-creation* is possible (staff working *with* students);
- Students can find their own learning solutions (students working *for themselves*)

Empowering students to find their own learning solutions

I established Student Learning Enhancement Teams (SLETs) as a partnership mechanism, before moving to an HFE model.[5-9] Key features include:

- Engagement is open to all, but staff actively seek participation from traditionally under-represented groups
- Students prefer short-term projects to fit around their study
- Students don't like 'individual excellence' in staff enhancement activities – it raises expectations not met elsewhere
- Students, unlike staff, experience their course in its entirety and are well-placed to identify gaps

SLETs became a primary mechanism for exploring the curriculum system and to date, 350+ students have directly engaged as members. SLETs were singled out by Stephanie Marshall (then HEA CEO) as a 'wonderful example of partnership benefitting students.' This is reflected in comments from students and staff:

"To be honest, I was struggling with the course before this – I felt as if I didn't really belong, and I found the science stuff really difficult. I'm not even sure what my reasons were [for joining SLET], probably to put something on my CV! Being on the team made me feel valued, especially when I saw our work being used in the curriculum. But beyond that, my marks got better – having to think about how to design learning activities helped me understand why those G-protein coupled receptors mattered to patients! 😊" [AL; student]

"Crucial to our forward momentum has been establishment [under Helen's leadership] of strong collaborative staff-student partnership based on mutual respect and recognition of shared values and goals. The underlying principle is "continuous improvement" - there is no absolute finishing point. Staff and students now continually question and reflect on how to achieve excellence in teaching, learning and assessment." [IR; Staff]

The move to HFE followed SLET identification of patient safety as a curriculum gap. Public recognition of 'healthcare harm' is longstanding, but interventions have been largely ineffective[10]. We concluded that the difference between healthcare and other high-risk industries is the lack of Human Factors specialists. Lack of HFE expertise also afflicts educational provision - most patient safety learning comes from what students observe in practice. For pharmacy students, who have very little formal placement, this 'hidden curriculum' comes often from their own employment, beyond the oversight of the university. I recognised parallels between patient safety, student achievement and satisfaction: all depend critically on context and all are outcomes of complex sociotechnical systems. The logical step was that HFE should not just be *content*, but also underpin curriculum development, and I proposed the model in **Figure 2**[11].

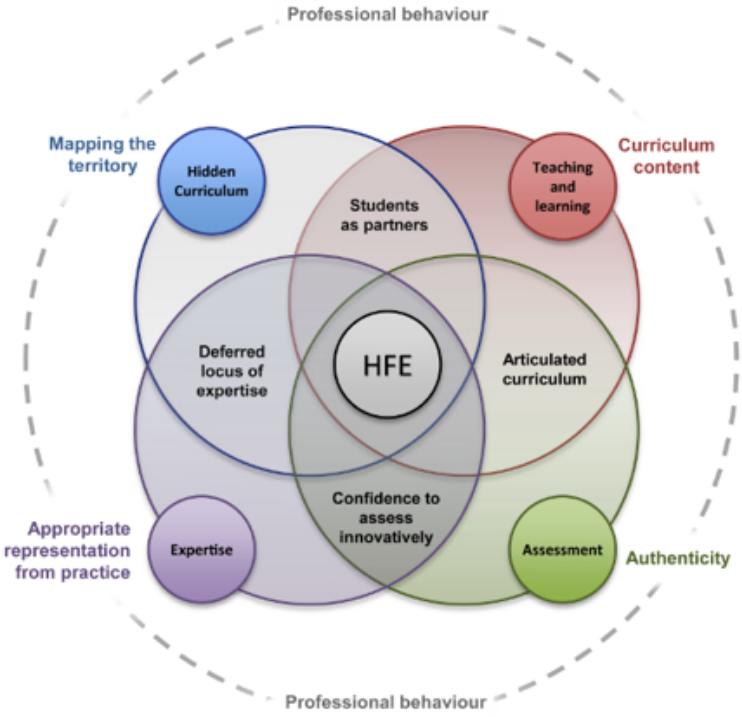

Figure 2: A model for embedding patient safety teaching
A traditionally constructively aligned healthcare curriculum reflects professional behaviour, articulated in the programme outcomes. Assessment is designed to capture these outcomes, and appropriate learning activities support student success in assessment. Appropriate staff expertise is required to deliver the course. The model proposed above develops this further by:
(a) recognising the importance of the 'hidden curriculum' in driving student learning and behaviour. This hidden curriculum must be mapped by working in partnership with students who are the 'experts' in this. Space must be provided within the curriculum to allow student-led exploration of all the experiences that contribute to their professional development.
(b) recognising that curriculum content must be driven by the needs of the practice role and assessment must be authentic, effectively measuring professional competencies. This may require a move away from traditional assessment formats, requiring staff to challenge their existing practice.
(c) proposing that HF provides the tools to deliver on all of these aspects, and should be central to the curriculum, in both delivery and design.

Debriefing the hidden curriculum identified 'safety competencies' as not just an education gap, but a practice one (**Figure 3**). I introduced students to basic HFE principles and they were keen to co-design related learning activities, but recognised it would take time. To address the immediate need, they established a student-led Institute for Healthcare Improvement Patient Safety Chapter, now involved in inter/national activities, bringing this learning back to RGU, delivering education events for peers. The Chapter is recognised as a learning resource, with staff reporting positive impact on academic performance. There are ~200 members with ~400 students (from different courses) attending events annually.

Figure 3: Word cloud illustrating themes arising frequently from sessions debriefing the hidden curriculum. These included fear of making errors, feeling untrained in error recovery strategies and recognition that sometimes staff got blamed for things beyond their control, like software design.

Co-creation: The NHS Health Check

In recent years, I have led the development of guidance to support HFE embedding in educational curricula[12-15]. One resource was described by reviewers as "a masterful digest that dispels myth, clarifies points of misappropriation and at the same time very clearly sets out what Human Factors education can be." This guidance[12] has been officially adopted by NHS Education for Scotland (NES), and it identifies that HFE should be added to existing activities. The NHS Health Check (**Figure 4**) is a suitable activity.

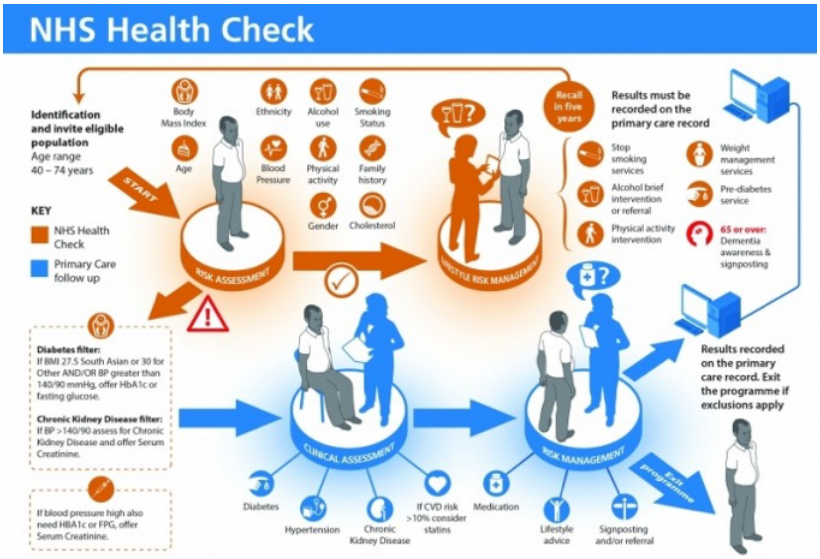

Figure 4: The NHS Health Check
The NHS Health Check is a cardiovascular risk management programme. Through research, hazards to cardiovascular health (such as high blood pressure) have been recognised. High-quality longitudinal studies have allowed mathematical modelling that allows the risk posed by these hazards to be quantified. A detailed patient history is taken, alongside some point of care testing (including blood pressure and lipid/glucose levels), data is entered into a risk engine which calculates a 10-year risk of a cardiovascular event. The pharmacist works with the patient to – in effect – formulate a risk management programme. The normal hierarchy of controls is observed (eliminate risks where possible, mitigate if not), paperwork is completed and the patient is recalled for review 5 years later.

The Health Check (i) is a relevant practice-based activity; (ii) provides the opportunity to develop clinical skills and (iii) risk factors for cardiovascular disease are tightly linked with the vascular pathology of atherosclerosis. The 'Modernising Pharmacy Careers Review[16] revealed placement is concentrated towards the end of programmes and is therefore spatiotemporally separated from the science teaching which happens earlier. This undermines student application of science knowledge in practice, which is considered a risk to patient safety. Learning activities based round the Health Check specifically require students to repeatedly make links between the data they collect and the underlying pathology, which was commended by the General Pharmaceutical Council.

It is a prolonged activity – cardiovascular content spans the entire semester, with weekly courseworks where students learn the practical skills. This made it an ideal fit for learning about HFE: students were exploring 'pharmacist work.' Furthermore, the Health Check is a risk management programme, so it supports students in developing risk management skills. We then take a step back... and consider the risks of not running the risk assessment properly! Poor outcomes are a real possibility – if the pharmacist misses a high-risk patient, they may experience a preventable cardiovascular event. Students apply HFE knowledge to the Health Check system, identifying interactions which particularly influence outcomes. They then re-design their work system to eliminate poor interactions, while retaining good interactions. Finally, students run the Health Check for real on academic staff. Assessment is through written examination.

These activities were developed with SLET members through a funded summer placement. Real-life Health Checks were observed, using standard HFE data collection tools. These data informed a series of simulations reflecting vulnerabilities of the real-life work. These were user-tested with a different student group to test if applying a systems framework to the simulations was realistically achievable. Students analysed the system and planned design interventions. The full details of this work have been published[14,17], but results indicate students engaged well with the systems framework, identifying many of the problems found by more experienced staff. The activities were embedded in the module.

Impact:

- 1000+ students so far have engaged with these activities
- Module performance significantly improved (1st attempt failure rate moved from 50% to 2% in 2012) and has been maintained.
- Student experience questionnaire data is almost universally extremely positive.
- Student contribution is discussed during teaching, stimulating SLET recruitment, promoting sustainability
- This model could be applied to any healthcare service and has been adopted by NHS Education for Scotland as part of their national healthcare HFE programme.
- Highlighted as 'excellent' during multiple quality assurance events, including reaccreditation and Institution-Led Subject Review.
- Students regularly receive awards in recognition of partnership-related activity, including Scottish Pharmacy's 'Future Pharmacist' and Royal Pharmaceutical Society Student of the Year awards. SLET was shortlisted for a Student Participation in Quality Scotland award. Students contribute nationally, through appointments to

professional/regulatory working groups, evidencing longitudinal benefit of partnership.
- Outputs include student publications.
- Graduates report impact on professional performance:

"Helen's second year learning materials were particularly valuable during later years of study… and when I qualified as a pharmacist. [These subjects] weren't taught again and her resources formed the foundation of my work performance... she is critical to my professional practice." [AA; Graduate]

In 2020, the first-time pass rate was 100%, although this will be skewed by the different assessment modality due to the pandemic. However, student partnership gave me insight into the impact of the pandemic on students. Students were differentially affected – some lived in crowded homes with extended families, some were isolated. A few were managing bereavement alongside their studies. Online discussions about work systems allowed students to safely disclose and discuss issues affecting their personal study systems. Students clearly valued this – I received many emails, but my 'exceptional contribution to student support during the pandemic' was recognised through our student-led awards. This also triggered my student nomination for Bioscience Teacher of the Year award!

"Just... to thank you for everything that you have done during this pandemic, as well as the rest of the year. How you, and the rest of the module team, have handled this situation is a way in which other modules should aim for."

An unanswered challenge: Working for students

I was increasingly aware that ethnic minorities were over-represented during re-sits. This was also commented on by the regulator during their last accreditation visit. A systems approach revealed several students didn't have English as a first language. Considering the system from their perspective (though focus groups), a common theme was 'language of instruction.' We often talk about 'constructively aligned curricula' but what does this mean for bioscience students? Learning requires relating new content to previous understanding, which may not have been developed using English. While most students are learning a new 'science language', some are doing this via a different language, which may require 'translanguaging' to access course content and participate in assessment[18]. Students rarely articulate this – much of it happens unconsciously anyway. In systems terms, I could see that the interactions between these students and written assessment tasks – especially multiple choice - were particularly challenging. There are many questions, rapid changes of focus, with every word critical to understanding. This is recognised for students with *visual* processing impairments, but not for students whose processing speeds are affected by language proficiency.

I modelled student engagement with simulated MCQ assessment tasks using an HFE tool called Hierarchical Task Analysis (HTA)[19]. HTA provides a visual output – the hierarchies represent 'redescription' where each step required to complete the goal is further broken down. To understand cognitive elements, HTA is supported by verbal protocol analysis, where subjects tell you what they're doing. A simulated MCQ assessment was given to

students who were asked to verbalise their activity, which was recorded. One group (n=9) were native English speakers, the others (n=11) were not. **Figure 5** shows the time taken for each of the two groups to complete the assessment.

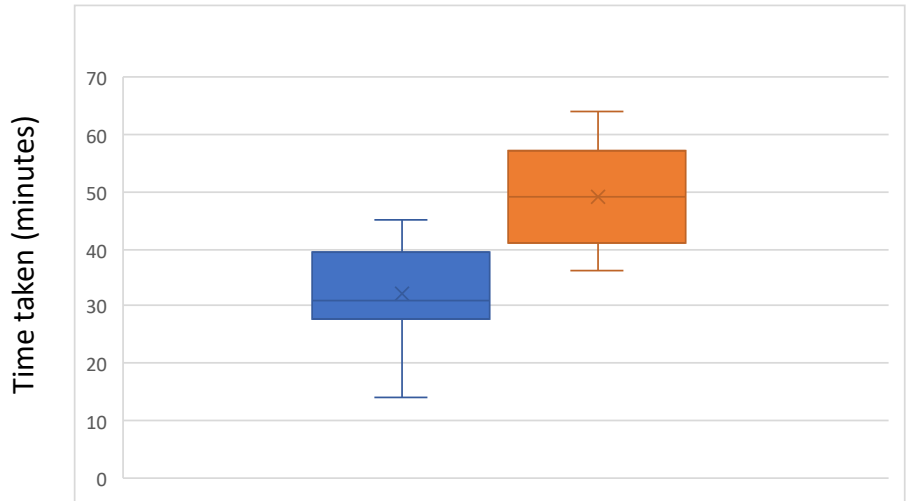

Figure 5: Students with English as a first language are quicker at answering multiple choice questions
In a simulated MCQ assessment, students with English as a second language (n=11; orange) took longer to answer the paper than those for whom English was their native language (n=9; blue). Median time taken was 49 minutes compared with 31.

Figures 6 shows a high-level task analysis for all students.

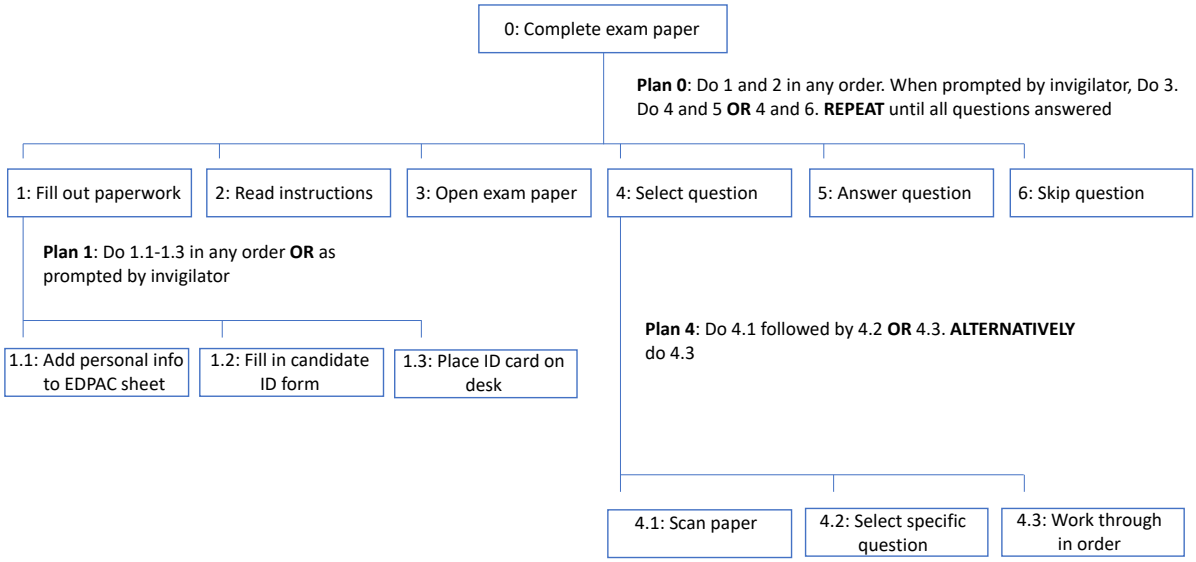

Figure 6: High level task analysis for student completion of multiple choice question paper

Figures 7 and 8 show composite HTAs for each group, with a more detailed look at the way they answer questions.

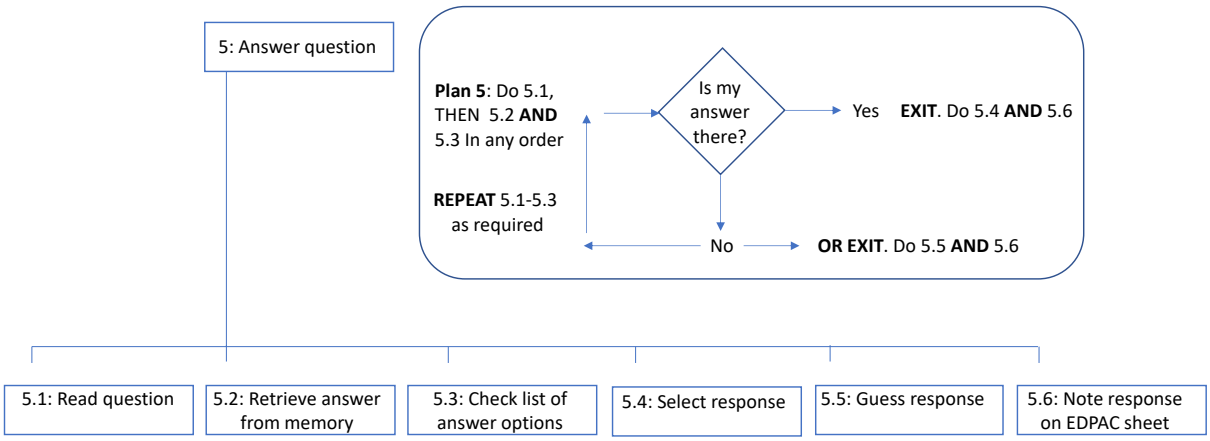

Figure 7: Partial task analysis for students with English as a first language

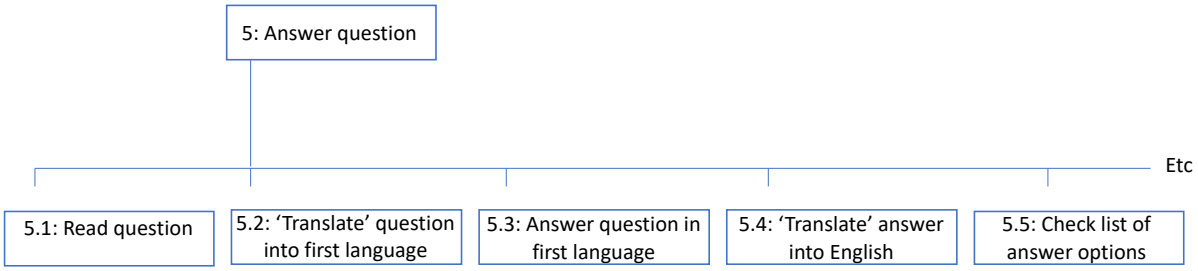

Figure 8: Extra steps are necessary for students whose first language is not English

This work is in its early stages and has limitations, but it is apparent that students with English as a second language have additional steps in their assessment tasks. The universal design approach would lengthen examination times for all students (which would also reduce the invigilation burden associated with 'rooming' exams for students with extra time), but this idea is meeting with resistance from academic staff. I plan to use HFE to explore these barriers.

Reflections

This is not a conventional case study: I am attempting to convey that it's 'the how', not 'the what' that's important – focussing on a single intervention would not have captured this. Adding an 'incomplete' piece of work also illustrates that enhancement is an ongoing part of my practice. The impact of my work is evidenced through publications, awards and professional recognition. However, nothing is as important as the feedback from students. I am leaving RGU to take up a post at Aberdeen University. At my Zoom leaving 'do', my head of school read out a message from our School Student Officer, and I finish with a quote from that:

"As S[tudent] S[chool] O[fficer], and on behalf of stage 3 MPharm, I would like to let you how amazing we all think Dr Vosper has been and how sad we all feel about her leaving. There are many great lecturers within [the School of Pharmacy and Life Sciences] but Helen goes the extra mile. The knowledge she has is breathtaking and she is fantastic at passing on that knowledge to us. She is clearly passionate about teaching, but more than anything, she genuinely cares about her students. When it became common knowledge that Helen was leaving, all of our group chats were filled with sad emojis. And while we very much look forward to coming back onto campus, it just won't be the same without Helen."

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