CASE STUDY

5

TITLE

Diversifying assessment: project based learning in a module

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Dr John Healy

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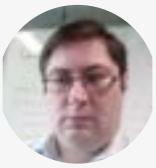


Dr John Healy was born in Co. Dublin, Ireland in 1983. He was awarded the B.E. and Ph.D. degrees in Electronic Engineering from University College Dublin in 2005 and 2010. He has worked as a postdoctoral fellow in Physics in UNAM, Mexico, and in Computer Science and Electronic Engineering in Maynooth University. In 2012, he was awarded the NUI Postdoctoral Fellowship in the Sciences. He has been a Lecturer in Electrical, Electronic and Communications Engineering in UCD since 2015. He is a member of the IEEE, the OSA and the SPIE.

Outline

Title	**Diversifying assessment: project based learning in a module**
Abstract	Modes of delivery were diversified from PowerPoint lectures to include a textbook, MATLAB code demonstrations including video, and video lectures. Accessibility of teaching material was enhanced. Assessment was changed dramatically to centre on a group project with a choice of topics. Other assessments were removed during the pandemic, but these will return in the steady state to provide a diversity of assessment methods.
Module Name	EEEN40620 Biomedical Imaging
Discipline	Electronic Engineering
Level	4, 5 credit module
Student numbers	18

Introduction and Context

Two mainstays of university teaching, lecturing and final exams, are perhaps overused (Friesen, 2011). Lecturing is a medieval solution to a medieval problem: in a time when a printed book might cost as much as a house, lecturing was the most cost-efficient method of transmitting information from a lecturer to a student. The role of the student in a traditional lecture is passive. The student's prior learning and experience are of little relevance. Teaching practices that focus on the student's construction of knowledge are seen to be more effective in the development of science literacy (National Research Council, 2003). The price of this fixation on lecturing is that the profile of students who achieve academically is narrower than it could be; we see examples of this in students who perform above expectations in the capstone project because the nature of project work is quite unlike the rest of their education. My goal in this pilot study has been primarily to broaden the range of teaching and assessment approaches I have experience using, resulting in a better learning environment for the students. I have read that even when faculty were aware and in favour of inclusive teaching, they often felt constrained from implementing them by factors such as time, and that felt a little too familiar! A more diverse palette of teaching modes should in turn allow a broader range of capable students to demonstrate they can and have learned the module material. I also wanted to improve student engagement. Of my modules, this one is the outlier with lower-than-average student feedback scores; there also existed an opportunity to revitalise the module in that regard.

I will detail the changes made to the module later on, but my motivation for the changes I proposed came from reading relating to a Teaching and Learning module. The very short version goes as follows. People used to think that learning was a passive activity. Strong students could synthesize ideas beyond what they read, and weaker students were limited to rote learning. These ideas are out of fashion among experts, though I have heard echoes of them in many a discussion around teaching. Piaget introduced the idea of learning as an active process, in which teachers don't merely deliver material, but are responsible for how students receive it. Stimulating learning activities then result in students learning better. Mutual support from other students is also relevant. Based on this kind of thinking, I planned to reduce the weighting of the final exam and subsume my existing assignments into a more open-ended project.

EEEN40620 currently explores topics in two broad categories: the physical principles of medical imaging from a signal processing and Fourier analysis perspective, and image processing for image enhancement or interpretation. In the first category, students learn about the compound microscope and optical imaging in general, medical x-ray images, and magnetic resonance imaging (MRI). They study mathematical models of image formation, reconstruction algorithms, and factors that limit resolution of those devices. In the second category, they learn how a digital camera works, how a digital image file represents and stores an image, wavelets for removing noise from images, and the fundamentals of neural networks for problems like segmentation and categorisation. The topics complement each other, forming a complete pipeline from patient to image. The topics and the links between them explicitly drawn in the module are depicted in Figure 1. Some additional links exist, e.g. neural networks are applied in all three imaging modalities, but are not emphasised for time reasons.

	Compressive MRI		**Machine learning in medical imaging**
Image processing Computer programming	Compressive Sensing	Wavelet Transform	Neural networks
Physical principles Design considerations	Magnetic Resonance Imaging	Microscopy	X-ray imaging

Figure 1. Thematic links within the components of the module

Design and Implementation Description

The module I chose to modify, Biomedical Imaging, is one I have taught for several years. The majority of the class are Biomedical Engineering students from the 4th year of the BE or the 4th or 5th year of the ME programmes. The class size is intermediate, ranging from 15-35 from year to year. The class is typically roughly 50:50 men and women, as is typical in the Biomedical Engineering programmes. I have been asked to comment on disabilities in the class for this case study: there are typically 1-3 students with mild accommodations for, e.g., dyslexia. The students are quite capable, so I wanted to challenge them a little more and cultivate some skills they could carry into capstone projects and beyond. More specifically, this links in with a number of programme outcomes, viz:

— Demonstrate advanced knowledge and understanding of the mathematics, sciences, engineering sciences and technologies underpinning Biomedical Engineering;

— Identify, formulate, analyse and solve complex engineering problems, specifically problems related to physiological and medical/healthcare systems;

— Ability to work effectively as an individual, in teams and in multidisciplinary settings, together with the capacity to undertake lifelong learning; and

— Communicate effectively on complex engineering activities with the clinical and engineering communities and with society at large.

My existing approach to delivering the module was narrow in terms of teaching style. Lectures consisted of PowerPoint presentations supplemented with material delivered on the whiteboards that was usually driven by class questions and/or the kind of intangible class feedback during lectures – that feeling that you are losing them – that many of my colleagues have complained of missing since the pandemic denied us that style of class interaction. There are some UDL principles that can be applied to PowerPoint slides to good effect, and which are now captured well by the Ally tool in Brightspace. These include issues like awareness of the effects of font selection on dyslexic students, and of colour choices on colour-blind students. I was surprised to learn that colour-blindness is as prevalent as 1 in 12 men, meaning that this invisible issue was likely present in every class I have ever taught. Most of those modifications are quite painless once you know to look out for them. Another issue that comes up is making better allowance for screen reading tools. While I have not taught a student with severe visual impairment, there are more moderate visual impairments which may be less obvious, and those students may also be coping in silence. I found it interesting to consider this from a UDL perspective: many students are regular users of podcasts, and there are tools incorporated into Ally in Brightspace now to convert a document to an audio format. Small accommodations are all that are necessary to make documents friendlier to such tools, and so the student who wants to review notes on a treadmill or while jogging are accommodated in the same way as is a student with a visual impairment. There are two important – but again quite painless – changes that I am aware of that help here.

— Providing sections using the structures in PowerPoint and Word instead of simply having section divider slides makes the structure machine-readable.

— Alternative text for images eliminates gaps in the narrative in audio format. I'm still getting to grips with best practice on alternative text, especially with complex images and how they interact with captions, because alt text is one UDL element I put on the long finger when I was pivoting to deal with the pandemic.

The discussion above about screen readers is part of a broader principle in UDL of providing multiple modes of learning. To that end, I have attempted to diversify the module materials as follows:

— I have begun to add a textbook;
— I have added a number of MATLAB demos (video + code); and
— And an almost inevitable consequence of the pandemic is that I have recorded my lectures as videos.

In Figure 2, I show a side-by-side comparison of some material from the textbook and the slides. I teach primarily in our partner programme in Beijing, and a consequence of that has been that I have tended towards lecture slides which are a little verbose for my taste. The reasoning was that students who might struggle to follow every word of my lectures could at least find the slides relatively readable. That comes at a toll on slide design, to which the pandemic offers a bypass. The recording of video lectures, along with the provision of more narratively complete textbooks, allows me to pare back the text on slides and reduce the reading burden on students during lectures. I haven't looked into providing subtitles, which I would like to do at some point.

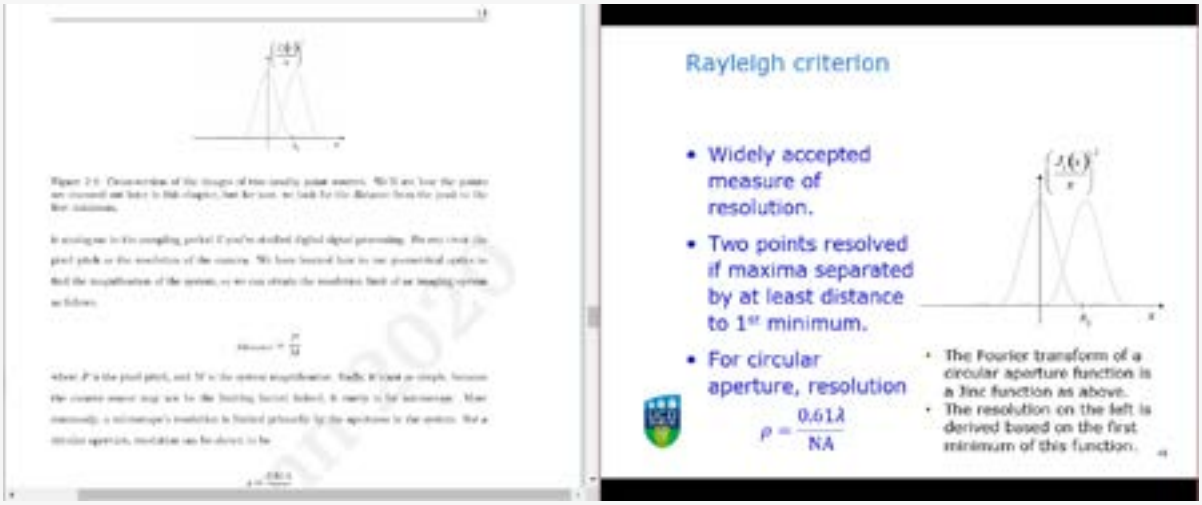


Figure 2. Comparable material is provided in book form (left) and PowerPoint slides (right). The book provides a more coherent narrative to students who prefer to learn in that way.

I was conscious that the changes to the assessment which I will discuss later denied the students certain opportunities to explore basic concepts further through experimentation with code. I introduced a number of MATLAB demos to compensate. I supplied the students with the code and a video in which I executed the code section by section, explaining the meaning of each figure. An alternative I have recently begun to investigate is the MATLAB livescript, which allows me to embed sliders and other interactive elements into the demos. In Figure 3, I show an example from one of the demos.

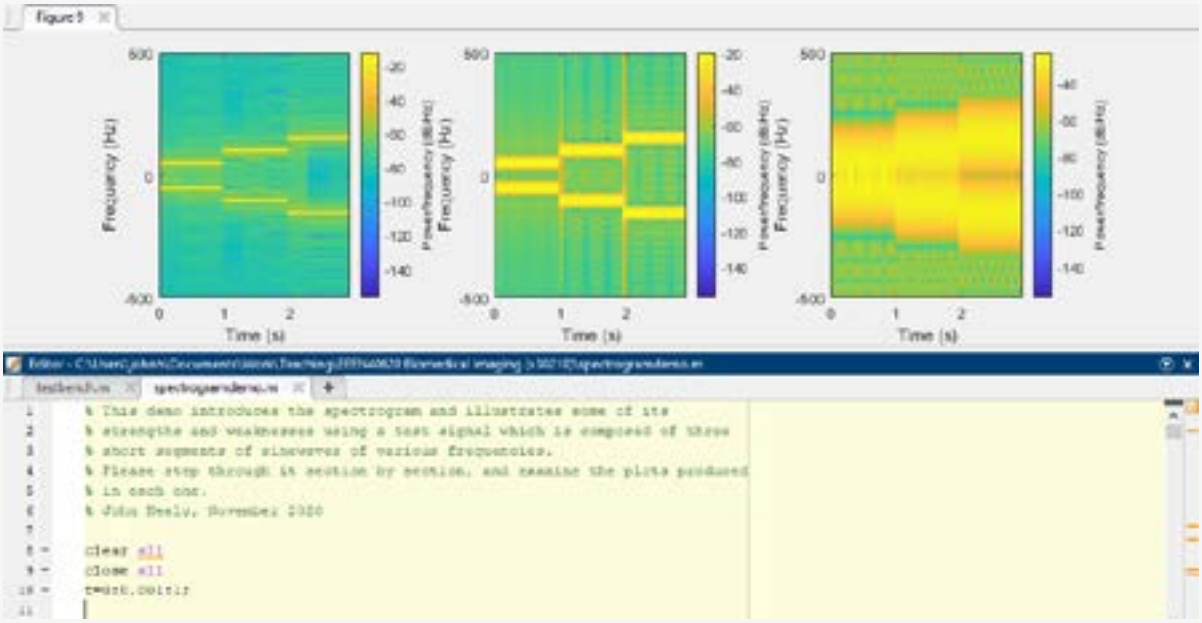


Figure 3. Example of a MATLAB demo. I provided short videos in which I stepped through the code, explaining the function of each section.

A final element of the diversification of modes of learning I introduced this year was the video lecture. I will discuss this in detail as it is something that has been extensively investigated by most teaching staff over the past year. One important lesson I took from my first implementation was to break the lectures into much shorter thematic pieces [14]. This encourages students to watch them and seems to better suit normal attention spans with video. More modular video is also a little easier to maintain.

The discussion above has focussed on the module's teaching materials. The other broad stroke of UDL which I will now discuss is assessment.

In the past, the module assessment consisted of a final exam and three in-class assignments. The assignments were intended to be quite formative, and I typically assigned 15% of the class grade each one to encourage good student engagement.

As I mentioned, my motivation for the changes I proposed came from reading about learning styles. Some authors have talked about learning styles, distinguishing between students who approach problem-solving in a relatively formal planning stage and those who tend towards trial and error from the off. I have also read that learning styles are not universally accepted, but this is a case study and not a formal essay on this material, so let's roll with it for now. My reading terminated in the modern theory of constructivism, the core principles of which are as follows.

— Learning is an active process.
— All new learning builds on earlier knowledge.
— There is no one way to learn. Teaching and assessment should reflect this.
— Learners should be conscious of their learning, and teachers of their teaching.

Based on this kind of thinking, I planned to reduce the weighting of the final exam and subsume my existing assignments into a more open-ended project. I read about problem-based learning and discussed it with my former colleague Bob Lawlor in Maynooth University who is a great champion of that approach. The following are the features of the project as run in late 2020.

— The project has components of a focussed literature review, mathematical modelling, and simulation.

— The students selected preferred topics from a list and noted any preferred partners.

— Multiple groups could work on the same topic if there was demand, though they were expected not to cooperate. Providing an opportunity to select their own topic is aligned with the UDL principle of providing a choice of assessment.

— Students would be free to work in a fairly uniform (i.e. unstructured) team or to play to their strengths in the project by taking charge of some parts of the work.

— Weekly meetings would be conducted with the module coordinator, and each student was to maintain a reflective journal online (shared only with the module coordinator). Engagement is worth 10%, based on the weekly meetings and the journal.

— The final report is in three parts: literature review, modelling and methods, and results and conclusions. Each of those parts is worth 30%.

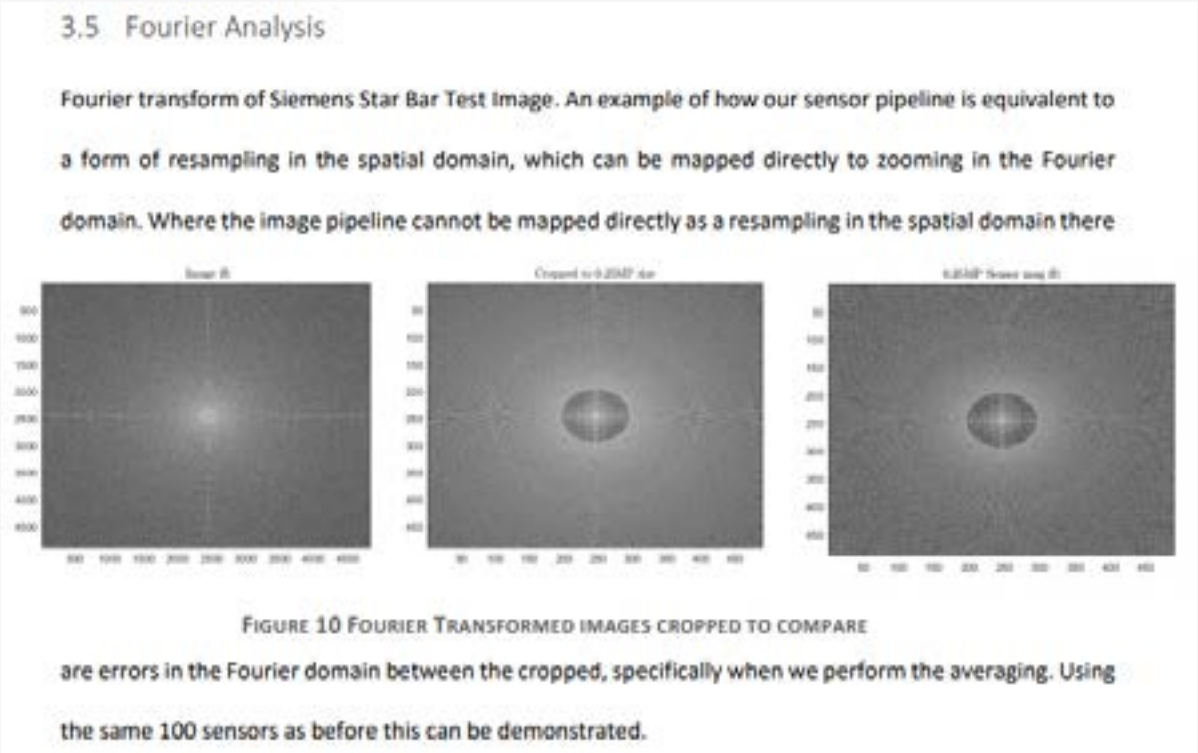
— Each student is permitted to finally nominate one of the components for a double weighting. E.g. double weighting the lit review would make it worth 60 marks out of a new total of 130. This was optional. The intention was to allow students more flexibility of choice in how they were assessed, which is again aligned with UDL principles.

Results and Impact

Any discussion of results has to begin with an acknowledgement of the effects of covid on the implementation. Time was diverted from writing the textbook and revising the slides to developing more video resources. The assessment was changed radically, removing the final exam and in-class exercises completely. As such, the group project (with expected time commitments suitably beefed up) became the whole of the grade, severely curtailing the intended diversity of assessment. While I received little direct feedback about this, the students on various programmes that semester made representations about the quantity of continuous assessment, which was necessarily crammed into a shorter-than-usual teaching term of just 11 weeks.

The class size was 18, which I broke into 6 project groups. The six weekly meetings certainly added a considerable time cost to me, though I was saved from the need to grade any exams. The time-consuming nature aside, I enjoyed the meetings, and felt I had a much better sense of who the individual students were than I would normally have. Assessment of the individual journals was also time-consuming.

The final reports were written to an acceptable standard. I felt however that the reports didn't completely reflect the work I had seen week-to-week in the meetings, and whether I can blame my rubric or some other factor, the gap between best and weakest projects was a good deal wider than the gap between the best and weakest reports. There's something to figure out here, and I don't yet have answers. Pivoting to changes demanded by covid meant that I was on the back foot in terms of implementation, and rubrics were designed late in the day without any student input. Figure 4 shows an extract from one of the reports.



3.5 Fourier Analysis

Fourier transform of Siemens Star Bar Test Image. An example of how our sensor pipeline is equivalent to a form of resampling in the spatial domain, which can be mapped directly to zooming in the Fourier domain. Where the image pipeline cannot be mapped directly as a resampling in the spatial domain there

FIGURE 10 FOURIER TRANSFORMED IMAGES CROPPED TO COMPARE

are errors in the Fourier domain between the cropped, specifically when we perform the averaging. Using the same 100 sensors as before this can be demonstrated.

Figure 4. Extract from one of the submitted final reports.

There were two formal sources of feedback. Lisa Padden surveyed the students, with three replies that were quite positive. The normal UCD feedback was also responded to by three students, though apparently not the same three, as they were quite negative. One of the more concrete criticisms was that the nature of the assessment meant that there was little incentive to engage with the lectures; a fair criticism, though a transient problem created by the pandemic.

One student took the time to write to me to acknowledge the value of the literature review component of the group project in their final year project.

Hi Professor,

I thought you might be interested to know that during the gathering of the data for the conference paper I have heavily applied the things I learned from the biomedical imaging project that we did!

Figure 5. Student feedback email.

I have already mentioned some issues that arose, including some dissatisfaction with the mismatch between the projects I observed week-to-week and the final reporting. Some groups with a very unsatisfactory process were able to gloss over that in the final report, while students who had shown far more independent problem-solving capacity were obtaining similar or not much better grades. I haven't solved this yet. Another issue is the time cost for the students and for the module coordinator. Finally, I felt that some of the groups were excessively passive, turning up to meetings and expecting me to tell them what to do. I have never been taught by means of this kind of group project, and perhaps I didn't structure those meetings and clarify my role sufficiently.

Recommendations and Advice for Implementation

The module as I ran it last year was not what I wanted, not least because of the impact of the covid-19 pandemic. However, I believe it was a valuable step towards integrating a more engaging, flexible, and realistic style of assessment into a module. This kind of approach is suitable for modules later in the degree programme, where students already have a good foundation of knowledge and skill to synthesise in a project. It is relatively intensive, but I found the workload manageable for around half a dozen teams, which could be ~36 students with the larger teams I plan to use in future. Early indications as I write this are that the class is very popular this year, as we have just had to raise the capacity during registration, so I will have practical experience of how it scales shortly!

I have a few concrete recommendations regarding the group projects. Based on conversations with Bob Lawlor, I set the teams too small. In future, I'll be setting teams of 5-6 students, which provides some futureproofing as last year's class was smaller than usual. Another lesson from Bob was to make these team projects instead of merely groups, creating defined roles within the teams. The students may still self-organise but based on a predefined structure. To deal with the passivity I observed in the students, I was recommended to have the students set the agenda of meetings in advance. This forces them to think about what they want from the meeting. One means of reducing assessment workload is to require a summary of the learning journal, and to spend most of my attention for the journals on the summaries. Finally, I intend to revisit my rubrics and carefully re-design them to better tease out the strengths and weaknesses of the projects.

For anyone considering adopting the kind of approach I have discussed in this case study, I have a few recommendations:

— Start by considering the resourcing implications: how much time do you have to devote to the module? How much time per week can you allocate to each team? If you have access to capable Teaching Assistants, this may alter the equation;
— Design the assessment well in advance. I was devising grading rubrics late in the trimester, which compromised both the effectiveness of my grading and the clarity of the goals communicated to the students;

— Larger teams (5-6 students) with specified roles for the students were recommended to me; and

— Ask the students to bring an agenda to meetings. This avoids meetings where they arrive in a passive mindset, expecting the facilitator to tell them what to do.

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