Citation for Outstanding Early Career Contribution to Engineering Education 2021

Applicant:

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For innovatively using technology in large electrical engineering classes to improve learner engagement, enhance feedback and develop understanding of challenging concepts

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Overview

A childhood curiosity for all things electrical led me to pursue an engineering degree. As an undergraduate, I was fortunate to secure a tutoring role where I began to encounter firsthand the frustrations of students who struggled with complex and abstract concepts synonymous with the field, such as using imaginary numbers to represent currents or applying Fourier transforms to analyse electrical signals. Compounding this was the size of the cohorts[1], which reached up to 1000 within a single course. Consequently, individual students' issues often went unspoken or unheard, resulting in students' problems remaining unresolved as their course bowled on, leaving them disconnected and their progress impeded. Later, as a lecturer teaching a range of large electrical engineering courses, I continued to encounter this same scenario. I found that without a clear means for students to assess their understanding and receive tailored feedback – formatively in class, through their self-directed studies, and as part of summative assessment – they were unlikely to succeed.

To tackle these challenges in a scalable manner, I began to develop a range of pedagogically driven technological tools to develop students' understanding. These tools aimed to **motivate and inspire** students to engage with electrical engineering in a manner that was supportive and responsive to individual needs. The innovations included creation of scaffolded video content with associated prompts to enhance engagement through self-paced learning aligned to self-identified needs; design of a form-based marking scheme to improve the quality of feedback students received on their assignments; and development of an automated system for assessing students' conceptual understanding, enabling immediate and meaningful feedback. Implementation of these strategies has greatly improved student understanding of electrical engineering concepts as measured through grade performance and student experience scores. My work's impact has been recognised through teaching awards including Senior Fellowship and Associate Fellowship (Indigenous) of the Higher Education Academy, and a Vice-Chancellor's Performance Award for teaching. I have also disseminated outcomes of my practice through conference presentations and high-quality journal articles.

Approaches to teaching and support of learning that influence, motivate and inspire students to learn

Engagement and feedback are critical when designing mechanisms to **inspire and motivate students to learn**. Particularly when teaching large first year cohorts, where learners have diverse backgrounds and needs. In these enormous courses, time constraints result in limited opportunities for individual support and feedback. Evidence tells us feedback is a vital part of the learning process and needs to be timely and targeted for maximum impact[2]. Collection of feedback by the teacher is also crucial in evaluating the quality of educational practices, enabling teaching adjustments in response to students' needs. Ensuring effective feedback by exploiting technology, underpins my approach to teaching and supporting electrical engineering students.

Engaging students in large first-year cohorts through video content*:* In 2014 I tutored EGB120 *Foundations of Electrical Engineering*, a core first-year course with yearly enrolments of 1000. Lack of time in tutorials denied students the opportunity to properly engage with math-focussed problem-style questions. Students at a wide range of levels often needed to learn at different paces, but this was challenging to accommodate with large student to tutor ratios. To fill this gap, I created a range of supplementary videos consisting of a weekly overview and several longer problem-solving questions. I narrated the handwriting to support students in understanding the reasoning behind steps, while addressing common challenges. These high-quality resources allowed me to spend additional time breaking down complex problems, while giving students more **independence** over their learning journey. They could engage with the videos on their terms, skip through parts that they already understand, or rewatch components they found challenging. Consequently, students who lacked prerequisite knowledge could focus on easier examples in detail, while students with more developed knowledge could just watch specific parts that extended their knowledge and understanding. The videos attracted 17,000 student views in their first year of implementation and were positively received by students: "The tutors are also good; however the video tutes by Sam are a standout. Super informative, super helpful." (student survey comment, 2016). This resulted in an increase in student satisfaction as measured by QUT's institutional surveys – average student satisfaction before the videos were introduced was 3.9/5, but this increased to 4.1/5 afterwards. Additionally, the progression rate for the subject increased by 4%. As a result of the success of the supplementary videos in *EGB120*, I subsequently created a range of similar videos for two other subjects, *EGB242 Signal Analysis* and *EGB342 Telecommunications and Signal Processing*.

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[1] Gannaway, D., Green, T., & Mertova, P. (2018). So how big is big? Investigating the impact of class size on ratings in student evaluation. *Assessment & Evaluation in Higher Education, 43*(2), 175-184. https://doi.org/10.1080/02602938.2017.1317327

[2] Carless, D. (2020). From teacher transmission of information to student feedback literacy: Activating the learner role in feedback processes. Active Learning in Higher Education, 1469787420945845.

These also received positive feedback from students as a long-term resource, demonstrated by the following comment made 2 years after the video's implementation "Sam's videos are an excellent resource because of the accessibility but also his calm and well-paced teaching style" (student survey comment, 2018).

After completing my PhD in 2019, I was appointed as a lecturer and subject coordinator for *EGB120*. Over the first semester, I focused on **evaluating the quality of learning activities**. Through analysis of engagement and feedback data, I found most students were not accessing recorded lectures, meaning they were missing key concepts. Based on best-practice pedagogy[3], I decided to address this by creating short lecture recordings to make the ideas more accessible. Each week consisted of one timely video with important announcements followed by four topic-based videos. The topic-based video recordings had eight times as many views per student than the previous long 2-hour recordings, evidencing their success.

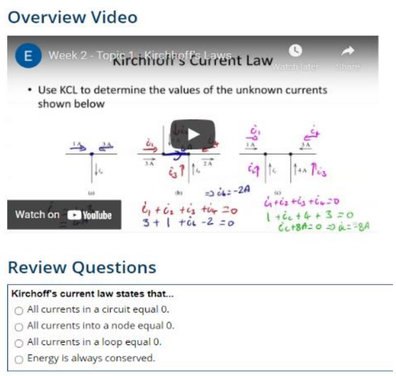

Figure 1 - Video with reflective question

Through further systematic evaluation of student data, I recognised an opportunity to improve student engagement with the videos by supporting students to identify and reflect on their learnings. I added short questions after each video for students to test their knowledge with feedback. I also added reflective questions at the end of each week's content to encourage active learning and foster improved outcomes (Fig 1). This approach motivated student learning: "The online layout of the weekly lecture content. Very easy to understand and work through. Much better than a 2 hour lecture recording each week. Highly recommend you keep doing this." (student survey comment, 2019). In total, my videos have been viewed over 246,000 times, with a total watch time over 19,000 hours since 2016. In addition, I have disseminated my work through a Q1 paper on strategies for designing effective worked example videos in engineering[4].

Engaging, timely and quality feedback for students: Feedback is essential to the student learning process[5] and is regularly cited by educators as one of the most challenging aspects of their job. There is always a conflict between the desire to provide quality feedback and available marking time, knowing quality feedback is essential for student learning[6]. This problem is amplfied with large classes that necessarily use large teaching teams, making the need for consistency and transparency in assessment even more critical.

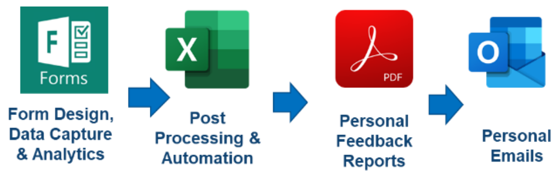

Figure 2 - Forms based marking process

To resolve this conflict, I developed a systematic online forms-based process in my first-year electrical engineering subjects to assess and provide detailed individualised feedback to students (Fig 2). The form contained two key components – check boxes to award partial marks for each question according to students' performance, and options for tutors to provide tailored text-based feedback. The text-based feedback portion of the form allowed tutors to select from detailed comments addressing common errors, as well as provide open text to elaborate. The carefully prepared criteria and feedback comments allowed tutors to complete the form efficiently and consistently, with less ambiguity. Post-implementation interviews with tutors elicited overwhelmingly positive responses. "I would say this was the best marking experience I had throughout the semesters. This is much easier, much faster. And I think both sides, markers and students benefited from it." (Tutor interview, 2019).

To release results and feedback to students, I incorporated a personalised email approach which has been shown to increase engagement and performance[7]. This involved post-processing collated results into feedback reports (Fig 3). I delivered these via personally addressed emails, which students were more likely to access and engage with. I received significantly fewer student queries and applications for remark than in previous semesters, implying students felt the feedback was clear and transparent. Another advantage of this system was that trends could be easily identified forming useful feedback as an educator. For example, one semester I found referencing was a class-wide weakness, so I implemented further support for developing this skill. The feedback form has been used for three years so far, with over 3000 feedback reports generated. I have shared the approach through a seminar for my faculty and supported three colleagues to adopt the method in their subjects.

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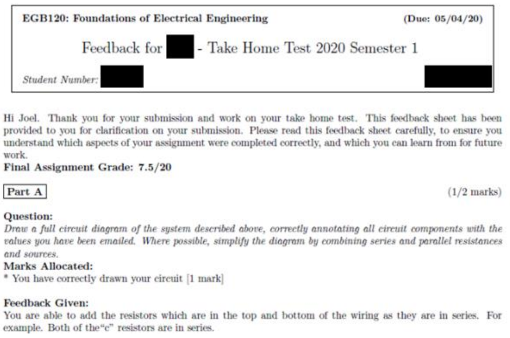
[3] Guo, P. J., Kim, J., & Rubin, R. (2014, March). How video production affects student engagement: An empirical study of MOOC videos. In Proceedings of the first ACM conference on Learning@ scale conference (pp. 41-50).
[4] Dart, S., Cunningham-Nelson, S., & Dawes, L. (2020). Understanding student perceptions of worked example videos through the technology acceptance model. Computer Applications in Engineering Education, 28(5), 1278-1290.
[5] Hattie, J., & Jaeger, R. (1998). Assessment and classroom learning: A deductive approach. Assessment in Education, 5(1), 111-122.
[6] Ramsden, P. (2003). Learning to teach in higher education. Routledge.
[7] Voghoei, S., Tonekaboni, N. H., Yazdansepas, D., Soleymani, S., Farahani, A., & Arabnia, H. R. (2020). Personalized feedback emails: A case study on online introductory computer science courses. In Proceedings of the 2020 ACM Southeast Conference (pp. 18-25).

With the success of the online form, I pursued the same approach for peer feedback in a third year subject I coordinated with approximately 120 students enrolled each semester. Peer feedback was important for students to succeed as they needed regular feedback from a diverse range of people. I used a form to collect positive and constructive feedback from tutors and students for each group project, which was collated and distributed using personal emails. In a student survey specifically about the approach, 100% of respondents agreed the personalised emails made them feel more connected to the subject. Students also regularly commented on the usefulness and accessibility of the feedback they received, which benefited their overall engagement and performance in the subject: "I felt more connected with the unit, I genuinely felt that I wanted to work and improve my grades. Thank you, you should definitely do this across the board for other units." (Student response to personalised email survey, 2020). These technology driven and **innovative feedback and assessment** strategies were key in enhancing student learning in a scalable manner.


EGB120: Foundations of Electrical Engineering **(Due: 05/04/20)**

Feedback for [redacted] - Take Home Test 2020 Semester 1

Student Number: [redacted] [redacted]

Hi Joel. Thank you for your submission and work on your take home test. This feedback sheet has been provided to you for clarification on your submission. Please read this feedback sheet carefully, to ensure you understand which aspects of your assignment were completed correctly, and which you can learn from for future work.

Final Assignment Grade: 7.5/20

Part A (1/2 marks)

Question:
Draw a full circuit diagram of the system described above, correctly annotating all circuit components with the values you have been emailed. Where possible, simplify the diagram by combining series and parallel resistances and sources.

Marks Allocated:
* You have correctly drawn your circuit [1 mark]

Feedback Given:
You are able to add the resistors which are in the top and bottom of the wiring as they are in series. For example. Both of the"c" resistors are in series.

Figure 3 - Example feedback sheet

Student conceptual understanding: Misconceptions in student understanding can thwart the learning process if students are not made aware of them and supported to overcome them[8]. Developing this deep conceptual understanding is especially important in the engineering disciplines, given it dictates whether students can transfer their knowledge to new problems. For example, the concept 'time' has many underlying elements which if not understood at its foundation, can impede learning into the future. Catching these misconceptions quickly amongst a large class is challenging. Therefore, I focus on providing students with clear fast feedback by **integrating formative assessment strategies to enhance the learning process**.

Multiple-choice questions are an efficient assessment method, but they only provide limited feedback to students on their learning. For example, students could answer a question correctly but for the wrong reason, sending an incorrect feedback signal. In a classroom context an educator could ask for the reasoning and provide corrective feedback, but this takes time and resourcing. Automating the process means students can still receive tailored, immediate feedback but in a highly efficient capacity. As this is highly beneficial in large cohorts, I subsequently set out to do it in *Signal Analysis* (a second-year electrical engineering subject).

In *Signal Analysis* I transformed a validated set of multiple-choice questions into augmented conceptual quizzes by asking students to *justify* their selected multiple-choice answer. To provide tailored, immediate feedback to students on their conceptual understanding, I developed a methodology and subsequent computer program[9] that used key criteria to extract meaning automatically from the text. Examining these criteria allowed for a students' conceptual understanding to be assessed automatically, with corresponding feedback provided. It is important to note that this technology is designed to go beyond just determining if a student response is right or wrong – examining reasoning meant that the deeper level of understanding was assessed, such that the feedback could address learners' specific challenges and direct to relevant resources. This scalable solution reduced the burden on educators to provide feedback, while **fostering self-regulated learning** by supporting students to overcome critical misconceptions. When measured during a single semester, a cohort of approximately 200 students used the tool over 500 times. In a survey on the tool, 82% of respondents agreed the tool helped them identify gaps in their understanding. Given this success the tool continues to be in the subject four years on, even though I am no longer directly teaching. I have disseminated this work through presentations at several conferences including the Australasian Association for Engineering Education, and it has been accepted for publication in a Q1 journal article.

Conclusion: My innovative technological approaches to teaching have influenced and motivated students to learn electrical engineering: "Best tutor ever, he's an inspiration to all students, very helpful and his explanations are awesome" (Student, 2018). My strategies have supported students to learn **independently** through **timely and targeted feedback** delivered both formatively and summatively. Additionally, I have enabled others to enhance their own **approaches to learning and teaching** through using student feedback data. The impact of my teaching practice is evidenced by improved learning outcomes, enhanced student experience scores, and usage of my innovative technologies. This impact has also been recognised through Senior Fellowship (2020) and Associate Fellowship (Indigenous) (2020) of the Higher Education Academy, and a Vice Chancellors Performance Award (2016). I aim to continue innovating my educational practice to enhance learning of electrical engineering concepts, especially through engaging large and diverse cohorts.

[8] Smith III, J. P., Disessa, A. A., & Roschelle, J. (1994). Misconceptions reconceived: A constructivist analysis of knowledge in transition. The journal of the learning sciences, 3(2), 115-163.

[9] Cunningham-Nelson, S., Goncher, A., Mukherjee, M., & Boles, W. (2017). Pointers to conceptual understanding. In Proceedings of the 28th Annual Conference of the Australasian Association for Engineering Education (AAEE 2017) (pp. 687-695).