



Practical problem-based learning during and 'post' COVID; a case study of ENGG1500

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ABSTRACT

CONTEXT

This paper is concerned with the delivery of a large scale, highly practical, design-and-build engineering course through the transition to online learning during 2020 and blended learning in 2021. While the nature of face-to-face project-based learning can be very engaging, delivery faced enormous challenges with lockdowns and online requirements during 2020. The unprecedented nature of this situation, and compressed timeframes in which to adapt provided an opportunity to try a range of novel delivery methods. Some of these methods created for 'emergency teaching' can provide value even as the situation returns to normal – while we believe others should be noted as lessons learnt.

PURPOSE OR GOAL

In this paper, we analyse the efficacy of strategies used in transferring a large project-based course to an online environment in the short timeframe dictated by COVID19. We aim to:

- Determine, where possible, the key parameters that dictated success/failure in this case.
- Discuss application of these learnings to a second, semi-online delivery and evaluate their effectiveness for the future.

We are particularly interested in; informal platforms for content delivery (Discord and YouTube livestreams), involving students in course design delivery and assessment, and facilitating design and build by students in an online environment.

APPROACH OR METHODOLOGY/METHODS

This is a case study of the Course ENGG1500 running over 2020 and 2021 as compared to pre COVID offerings. The Student Feedback on Courses is the main source of both qualitative and quantitative data. Interviews with teaching staff on their experience have also been used to best capture the relevant data. The course ran several parallel discipline specific projects – each with different levels of difficulty and utilising a range of strategies.

ACTUAL OR ANTICIPATED OUTCOMES

Creating less formal engagement platforms for students has been widely successful. Discord was shown to be a superior platform over Blackboard Collaborate and YouTube over Zoom. Students and staff were found to remain highly engaged and supportive when brought into the change process and this involvement of students is believed to be a major success factor.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

While the workload was significantly higher than in face-to-face environment, practical, design and build, project-based learning can be successfully conducted in an online environment. However, consideration must be given to the varying levels of student success.

KEYWORDS

Online project-based learning. Blended mode. YouTube. Discord.

Introduction

Project based learning / lab based (PBL) or experiential learning are common teaching techniques which are often employed to bring greater interaction and engagement with students and course content. This corresponds to more face time for students but can result in high resource consumption, both in terms of capital or consumable equipment for students to construct projects or complete labs, and in terms of staff time as the highly engaged nature of the course with increased face time requires more supervision.

The University of Somewhere, presents a course to all first-year engineering and surveying students (~650 students) ENGG1500, which serves as a means of introducing students to their engineering degree and the skills they will need. The course utilises a semester long, open scope “design and build” project to scaffold the student journey. Through completion of this project students are required to not just create a practical solution to the project but also engage in non-technical skills such as communication, teamwork and project management.

The course design, structure and learning outcomes are described in detail (Cuskelly & McBride, 2017), but the pertinent details are as follows:

- Lecture content focused on generic skills such as engineering problem solving and communication skills delivered to all students en masse.
- Semester-long discipline specific projects to apply and contextualise the content and skills required. 10 different projects ran in 2020, and 2021.
- All projects are open ended without a prescribed solution. Solutions are evaluated on criteria such as technical validity, robustness of design, cost to performance ratio, safety considerations, social and environmental factors, product market fit, ethical considerations.
- All projects require a functional device by test day (in the last week of semester) and it is this testable solution that gives the projects much of their success. Projects are phrased to the students though as an industry body (client) is expanding into a new market and wants to determine which solution they should invest in.
- Assessments via reports, marked peer review, project testing and reflection are all centred on the project.

In semester 1 of 2020, COVID-19 began to impact the course heavily in week 4 of our 12-week teaching semester. On Wednesday of week 4 a decision was made to go online (before online teaching was mandated at our university). By Monday of week 5 in 2020, ENGG1500 was entirely online – the rapid and novel nature of the change meant the transition and delivery was a learning experience.

It was seen as critical to the course to maintain as much of its flipped classroom, practical construction, and teamwork fundamentals as possible, despite the complexities of the online delivery, and lack of established platforms and methodologies.

In 2021 the course was delivered in mixed mode with lectures online and tutorials (workshops) face-to-face. Some changes from the 2020 interventions were maintained in the new blended style.

In this paper, we discuss our experience adapting this large, PBL course to online delivery, the changes kept for 2021, and the success or failure of the strategies implemented. This work is presented as a practice paper detailing the process and unexpected outcomes, along with permanent modifications made to the delivery of this course. Obviously our adaptation was rapid and not pre-meditated. An extensive literature was not conducted, discussions from Assistant Deans Teaching and Learning and direct consultation with course coordinators of similar courses revealed no strong evidence of a clear best practice, given the unprecedented nature of the situation. Similar courses moved to theoretical projects with more traditional delivery, others cancelled entire courses. We limit our discussion to the

standard Course Experience Survey results and opinions of teaching staff. Our findings presented here are intended to be informative, not prescriptive.

Major 2020 Changes

Our goal was to maintain the spirit of the course as much as possible given the circumstances. This required facilitating the project-driven team design-and-build experience despite social distancing/lockdown requirements and online delivery of the course content and workshop sessions.

Class Delivery Platforms

Uncertainty (both at the time and ongoing) around the ability of university-supported platforms (Zoom, Blackboard Collaborate) to service the ~650 student cohort in a period of drastically increased usage, led to the investigation of alternative platforms that are less commonly used for teaching but well-known to cope with these loads. These platforms were primarily utilised to deliver scheduled classes.

Lectures on YouTube

The conventional, 2-hour face-to-face weekly lectures were replaced by a combination of pre-recorded lecture videos and live-streamed Q&A sessions, both delivered via the YouTube platform. Lecture videos were recorded with a picture-in-picture webcam view of the presenter over Powerpoint slides. These pre-recorded videos were heavily timestamped (an inbuilt YouTube function) for ease of navigation and revision. Videos were uploaded over the weekend several days before the timetabled lecture session each week.

These videos were supplemented by a YouTube live-stream in the scheduled lecture timeslot. The livestream objective was not to deliver new content but to discuss content with students. While some revision or follow-up content was usually presented in the first half-hour, the majority of time was dedicated to Q&A and discussion. Students interacted through the inbuilt YouTube live-chat which was also displayed onstream for convenience. These sessions were deliberately kept informal, and topics related or unrelated to course content were discussed. Obvious preference was given to course content but many students found value in discussion topics such as; active research at the university, industrial experience, program plans and course/degree structure, job opportunities, start-up companies. Totally disparate conversation around strategies for maintaining mental health in lockdown, pets and video games was facilitated because it encouraged extended engagement.

These live sessions were additional and supplementary to the original scheduled classes and students were told they were optional. Average attendance for these classes was approximately 1/3 of the course with more watching the recorded sessions after the fact. This was in stark contrast to previous years, where face-to-face 'help' Q&A sessions run to fulfill a similar purpose, had very poor attendance.

In 2021 lectures were still unable to be presented face-to-face, and it is foreseeable this will continue once class delivery returns to (the new) 'normal' post pandemic. YouTube has been maintained as the platform through 2021 following a similar structure as 2020 and was again well viewed / attended.

Workshops on Discord

A more extensive study into the evolution and use of Discord as a teaching tool is covered in (Reilly, et al., 2021). The key points related to this work are summarised here.

Workshops in this course pre-COVID19 varied in both style and content including presentations of discipline-specific lectorial content, individual analytical calculations, teamwork activities, and team based practical design and construction. In all workshops, the first 1-2 weeks of the course are driven by the workshop leader, but this is quickly merged with student driven activities and the second half of the course entails 100% student driven

teamwork on the project. Despite the challenges associated with COVID19 restrictions, we wished to facilitate this collaborative, student driven learning experience while also allowing mass communication of information.

Any mechanism/platform for our workshops needed to ensure students could maintain the sense of community and belonging, and engagement with the course and their peers that the physical workshop environment provides. It was also important that our multidisciplinary teaching staff had the ability to easily monitor and float between several teams, classes, workshops, and projects.

The Discord platform was used for 8 of 10 projects, with the other 2 using Zoom. Discord is a voice/text communication service best known for video-game chat. It allows for a setup of servers, categories, and voice / text channels. Users are given roles which were linked to permissions to control which categories and channels they can see and contribute to.

For example, a server can be set up for a course, a category can be set up for a tutorial, and channels set up to replace 'breakout' rooms. Additionally, team channels can then be set up, allowing students to have a private place to work either during or outside of their tutorial. Staff can be given permission to a larger subset of these channels related to their own classes projects and administrative duties as required.

These channels are perpetual – they are set up once at the beginning and remain through the entire course with students having access 24/7. While students were expected to attend during their scheduled class time, they were also able to work effectively as a team outside of scheduled class time. This proved enormously beneficial for students to undertake teamwork, communicate effectively, and build a sense of community – students would log into Discord to socialise as well as work. At any given time during the week, hundreds of students were logged into Discord, regardless of if they had classes that day or not.

This consequently changed the communication dynamic. While information was posted on the official Blackboard site and sent via email, it was replicated on Discord, and this is where most students engaged. Discord quickly became the main:

- source of information delivery (in combination with YouTube lectures and livestreams),
- way for students to get help both inside and outside of class,
- communication method with course coordinator,
- and community for students to engage with peers for both on and off topic discussion.

As a result:

- email traffic was almost entirely replaced with Discord messages,
- meeting requests replaced with Discord calls,
- course wide announcements consumed via Discord,
- workshop classes conducted as Discord sessions,
- and lectures reached through Discord links.

The centralisation of these activities proved enormously beneficial from an administrative perspective for both students and teaching staff.

The communication aspect of Discord proved useful enough to transcend the fact that it was originally selected as a platform to deliver online workshops and a Discord server was adopted in 2021 despite having face-to-face classes.

Despite the additional benefits it provided, Discord was most importantly used as a way of teaching with a flipped classroom online. From a teaching point of view, the ease at which workshop leaders could 'float' between team channels with a single button press, and students could ask for help was critical. The feel of teams working independently within a class, and a tutor walking around and helping out as required, was able to be maintained in

Discord. Additionally, the ability to effectively communicate with students in the course, a specific project, in a specific group, or at a personal individual level is helped.

From an administrative perspective, Discord allows the use of open software 'bots' running scripts to be mounted onto a server. There are many prewritten bots that exist to serve many functions and custom bots can be readily created in Python. Bots were used to automatically sort students into projects, workshops and teams, and manage their permissions. This along with all channels being perpetual, drastically reduced the administrative load in running these classes.

Projects

Project and testing scope

All project descriptions in the course are opened ended to facilitate diversity of thought and design, however the resources available are deliberately limited (budget, restricted use of tools), and project testing conditions are traditionally rigorously specified (wind tunnel testing at 10 m/s, volume constraint of 500 x50x500 mm) to ensure fairness and a consistent baseline measure of success.

In response to lockdown/social distancing restrictions many students were impaired in their ability to physically construct their solutions and almost all were prevented from testing their solution as prescribed.

A policy of "design what you want, build what you can" emerged. All teams were expected to do the conceptual design, then could either proceed with construction or 'detailed design' as resources and conditions allowed. Students were encouraged to validate their design decisions as much as possible throughout the process by small scale prototype testing, simulation or experimentation. Normally this design validation serves as a steppingstone before project testing however for many students it was the only available testing system. It was important that the courses learning goals focused on giving students an experience that would enhance their ability to be successful in the future – not necessarily to achieve the original tasks.

In many projects, determining a way to demonstrate the effectiveness of the design – or often to simply demonstrate they had the underlying skills required – was incorporated as an aspect of the project. Teams that were largely unaffected by University closures could construct their own testing facilities similar to that which would have been used at the university. Others created scaled down or modified versions to fit the resources they had access to. Often students deliberately designed tests to demonstrate the aspects of their design they wanted to draw attention to. In many ways these student-developed tests became better for highlighting the novel and beneficial aspects of specific designs than the one-size-fits all standardised testing that had been attempted in the past.

Allowing students to lead the development of their own testing procedure (in combination with tutor advice) is believed to have been a major contributor to the success of the course. Students did not feel as disadvantaged due to lack of resources and felt empowered to demonstrate what they had achieved. It was also noted that students seemed to form a better understanding of the problem scoping process in this environment. As a result, detailed marking rubrics were removed for almost all projects in 2021 and student teams required to nominate aspects of how they wanted their projects tested and assessed (within reason).

This process was overall effective. The flexibility in what was considered a successful project outcome allowed students to engage in the course as best they could given their circumstances. It helped combat students feeling disadvantaged based on the circumstances outside of their control.

Assessment

The majority of assessments in the course are various forms of reporting based on the project and these remained largely unchanged despite the changes to the course structure. The primary change was to the 30% 'project testing' assessment. Acceptable project deliverables were expanded to include the option of a 'Design Report', a document that would allow a hypothetical team of 4 first year engineers to successfully construct a working solution if not affected by COVID19.

This report could be combined with prototypes and/or a full-scale build. Students were given the option of completing any combination of the Design Report and Project Testing with the ultimate goal of convincing their client of their solution. This allowed students to focus entirely on the design report, the project testing, or any combination to succeed depending on their abilities/resources.

General findings

Project independence

Due to the nature of the course with many different projects with different constraints running simultaneously, a large amount of freedom has always been given to projects, tutors and even individual teams to determine how they meet the learning goals. This flexibility was increased with the changing circumstances. While an online-only mode was enforced, individual projects were given a large amount of autonomy to interpret, influence or outright overrule certain course wide requirements or recommendations to better suit their own constraints (with approval).

This was realised in a number of ways. For example, software students were producing an app which could be tested remotely, thus all software teams were required to complete the project with no substantive change to the test day procedure. In contrast, civil students could only complete full scale project testing if they could first establish safe and reliable testing conditions of a 200 kg suspended load, and as such only a handful of teams conducted full scale testing with most opting for simulations and design reports with minimal testing.

Flexibility was also given to teaching staff to nominate in the platform they used to run workshops (Zoom or Discord) and how they engaged with it. While this made overall course management harder, the limited timeframes available meant training all staff to use novel teaching platforms was not always viable. Letting teaching staff use a platform they were already familiar with meant staff members felt more comfortable and confident in their own teaching, which was seen as an overall positive. Given adequate preparation however moving all staff onto Discord would be ideal. A clear divide emerged with younger staff adopting the Discord platform successfully and senior staff using the more traditional Zoom platform.

Student engagement in transition

A deliberate effort was made to 'lean into the disruption'. At no stage were students shielded from the complexities of the situation or from the decision-making process – instead they were integrated as much as possible. This resulted in a general understanding of the process, a constructive student body and strong engagement.

Students were consulted on how to solve the problems related to online delivery to ensure solutions would be suitable to them. Constant student input was sought before decisions were made as well as constant feedback on decisions made. Students often proved very knowledgeable in the 'best practice' for how to operate online platforms and provided useful feedback. Far more importantly this created a sense of staff and students working collaboratively to solve a problem creating 'buy in' from the students.

Once 'buy in' was established students became highly engaged with a clear desire to see the online delivery of the course be successful. Students were helpful to other students even if it provided no benefit to themselves. One highlight was that some students voluntarily and independently purchased Discord 'server boosts' to show their support for the course. Discord is a free service but a paid 'server boost' allows for novelties such as more emojis and personal customisation, as well as increasing quality of video and audio streams.

We believe that having learning objectives centred around professionalism and industry practice was very important to the success of this course. Teamwork, online delivery, change of scope, and disruption were taught and viewed as a **feature** of the course, as they are now a feature of modern engineering.

Interestingly, anecdotal evidence suggests that projects with more tightly structured weekly milestones and constraints realised lower diversity in solutions, required more attention and maintenance, and had lower student satisfaction.

Overall having students involved in the decision-making process made for a more engaged and helpful student body with better course outcomes.

Staffing

The success of the rapid migration to online delivery is also largely attributed to the agile nature of our teaching staff. ENGG1500 employs predominantly senior undergraduate or early postgraduate students for much of its development, delivery and management.

In general, these 'student teachers' adapted to the changing situation far more rapidly and competently than seasoned academics. Our student teachers largely drove the migration to new platforms, reworked the projects for online delivery, and established the engaging culture of the course.

We suspect that their ability to empathise with the current student body, their generally superior knowledge of student culture and communication methods, and lack of indoctrination into established methods are factors in their success.

Untraditional Platforms made for effective workspaces

Concerns were initially raised around perception, teaching efficacy and professionalism of both YouTube and Discord. These were quickly tempered by both the superior functionality that these platforms provided, and positive student experience.

Both YouTube and Discord proved more than capable of handling the high student 650+ load and performed more reliably than officially supported platforms. No dropouts or down time were experienced, latency issues were substantially reduced, and the barrier to entry of platforms is noticeably lower than more traditional systems.

Both the YouTube videos and Discord invite were made entirely public to reduce complexity in accessing content. This was mainly due to the extremely rapid nature of the transition required mid semester to novel teaching platforms. This created the opportunity for bad actors to become involved in the community and could have led to an unprofessional environment. However, this was not observed at any stage. In fact, the exact opposite was seen. A level of professionalism higher than what is seen in face-to-face classrooms was generally demonstrated by students across the board. Only a handful of comments ever required moderation and no students ever needed to be reported for unprofessional behaviour. Both YouTube and Discord provide excellent moderator functions were users can be given permission to moderate other users in various ways to ensure content stays within community guidelines.

Some channels were deliberate created in Discord to allow for more social off topic conversations which allowed the 'on topic' channels to be kept free of distractions. This allowed the platforms to provide both a social community and a professional teaching environment.

The leakage of Intellectual property has been raised as a concern on these platforms. Fair use policy on YouTube clearly outlines what can and cannot be delivered and the rules for education are generally easy to comply with if presenting ones on content. However, content built heavily on previously published work needs to be thoroughly investigated before being placed onto these platforms.

In some cases a barrier to entry for staff may exist in adopting these platforms. Not all staff have experience with this style of platform and some retraining on both technical aspects and teaching approach was required. Younger staff however adopted these systems without the need for substantial training. The only concern that emerged with younger staff was that because they engaged with these platforms in their spare time they would often end up doing more work than they were paid for. While most enjoyed their jobs and happily helped students outside of paid hours (stating they did it because it was fun), ensuring staff are adequately rewarded for their hard work is important.

Student workload

A distinct increase in workload was seen for most students after moving to online delivery. Many students adapted well and while online delivery of PBL courses is clearly possible, it is remarkably challenging both on staff and students.

Despite numerous strategies and continuous monitoring, support and intervention by teaching staff, a subset of students struggled with the course delivery and the workload within many teams was asymmetric. This caused frustration for some students and teams either because they were falling behind or their team members were. Interestingly many acknowledged this uneven distribution but accepted it without complaint given the circumstances.

Changes retained/made for 2021

2021 saw the return of face-to-face workshops and tutorials, while lectures remained online. Some of the modifications to the course that were born out of necessity were maintained, while other aspects improved for the new offering:

- Discord was maintained as an extremely effective communication platform.
 - Team channels allowed students to work collaboratively outside of their regularly scheduled workshop to great success.
 - Additional automation of some aspects of the administration greatly reduced the overall workload of the course.
 - Heavy use of Course_Q&A, Assignment_help, and project specific channels greatly reduced workloads and improved student experience with timely feedback and community peer to peer support.
 - When local flooding caused campus closures face-to-face classes were moved onto online Discord classes within hours and ran successfully.
- Lectures were kept on YouTube to strong student satisfaction.
 - The video quality was improved moving from picture in picture lectures to green screen slides with a centralised presenter, specifically created for online lectures. This significantly increased views and engagement.
- Weekly YouTube livestreams were maintained and continued to reach a large number of students.
- Project scopes were expanded and marking rubrics removed. Students were encouraged to contribute to the way they were marked.
 - A higher diversity of solutions was seen and a better understanding of the projects was developed by students when less structure was given on project marks.

Course evaluation survey results

Due to the unexpected nature of the transition to online an ethics approved target study could not be performed and so quantitative analysis is difficult. It is acknowledged that much of what has been reported has been formulated on the personal experience of teaching staff and informal feedback from students. The experiences reported should be viewed as informative not prescriptive.

In an effort to attribute some metrics to the success of the strategies presented analysis of the Universities official Course Evaluation Survey (CES) was performed.

Comparing the main metric of student satisfaction the overall course went from 4.10 in 2019 to 4.16 in 2021. While this change is likely within the measurement error it is believed significant that an entirely practical course was capable of rapidly transitioning to online and not suffer a loss of student satisfaction.

In 2021 the course achieved a satisfaction score of 4.51 – the highest since its conception in 2017. This is largely believed to be due to the improved communication via Discord and YouTube livestreams and greater independence in projects.

A simple thematic analysis of the 2020 qualitative comments (part of the CES) revealed a 100% positive response to the use of Discord. A 100% positive response to the use of YouTube and an overall 83% positive response to the way this course was taught online. Comments for the 2021 offering are not yet available at time of writing. It should be noted that as the questions in the CES did not target the online platforms deliberately this analysis should only be considered indicative.

Conclusions

Large scale problem-based learning can be delivered online in an emergency teaching situation. Success was largely due to the use of novel platforms such as Discord to maintain student driven engagement in flipped classrooms. An effective teaching culture was created by engaging with students in less formal online platforms and this was received with almost unanimous positivity by the student body. Giving both teaching staff and more importantly students, autonomy to control their own learning, ways of meeting course outcomes, and the culture of the online platforms all proved highly beneficial.

Learnings from an online delivery have be used to enhance the quality of a PBL course when returning to face-to-face delivery.

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