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Adaptation of learning and teaching a general engineering subject in epidemic

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ABSTRACT

CONTEXT

Engineering 1 is the first subject in the Engineering Program at College of Science and Engineering, James Cook University. In general, this subject is delivered in a traditional setting to a cohort of more than 120 students. The subject assessments comprise two group design projects, three in-class quizzes, and three Computer-Aided Design (CAD) tutorials.

PURPOSE OR GOAL

As the epidemic forced the learning to sway between online and offline several times in one semester, the subject learning and teaching was adapted in the way Engineering 1 can be taught either online or offline.

APPROACH OR METHODOLOGY/METHODS

Using some pedagogical perspectives, the subject Engineering 1 was analysed to identify the common learning and teaching approaches and typical challenges in online and offline delivery. Then, several major points of the adaptation were proposed and undertaken:

- ***Change of staff***. Before the epidemic, Engineering 1 was taught by several professors from various disciplines to give students a panorama of engineering career options. The bulky teaching team was streamlined to adapt to new conditions.
- ***Change of tools***. Solidworks, the CAD software used in Engineering 1, has no internet access. The use required some VPN connections, which slowed down the learning. Fusion 360 was adopted because it was accessible from home with ease and across any computer operating platform.
- ***Change of teaching***. Learning content and materials were adapted so that they can be used either online or offline.

ACTUAL OR ANTICIPATED OUTCOMES

The adaptation results were positive. The student feedback had increased significantly and there was a slight increase in enrolment in Engineering, given the general decrease trend in other disciplines.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

The positive outcome confirmed the smooth transition in learning and teaching in Engineering 1. The framework may be effective for other subjects in Engineering Education.

KEYWORDS

Online, offline, learning, teaching, engineering, epidemic, redesign

Introduction

Engineering 1 (EG1000) is the first subject for first-year students in the Engineering disciplines at JCU. This subject introduces the concept of an engineer as a professional problem solver. The topics covered include i) Engineering Society; ii) Engineering Communication; iii) Engineering Problem Solving, Design, and Management; and iv) Engineering Safety. This subject comprises two pedagogical approaches: project-based learning and traditional lecture-tutorial-based learning. A similar subject can be found in the curriculum of Engineering programs in other Australian universities, such as ENGG1100 at UQ or ENG1012 at Monash (Monash 2022, The University of Queensland 2022).

The COViD-19 pandemic had a significant influence on teaching at all levels as it required a physical distance among students and educators. Normal blended on-campus learning models have to be modified for distant or hybrid learning (Ożadowicz 2020, Kapilan, Vidhya et al. 2021). As much of the teaching content was moved online, it made for some significant difficulties for the project-based learning in EG1000. While the lecture-tutorial-based content can be digitised easily, student projects require hands-on activities and close collaboration. The situation became more challenging due to the lockdown intermittence (Papadopoulos, Rasterhoff et al. 2022). This required frequent changes in the teaching plan as teaching activities had been being switched between online and offline every few weeks.

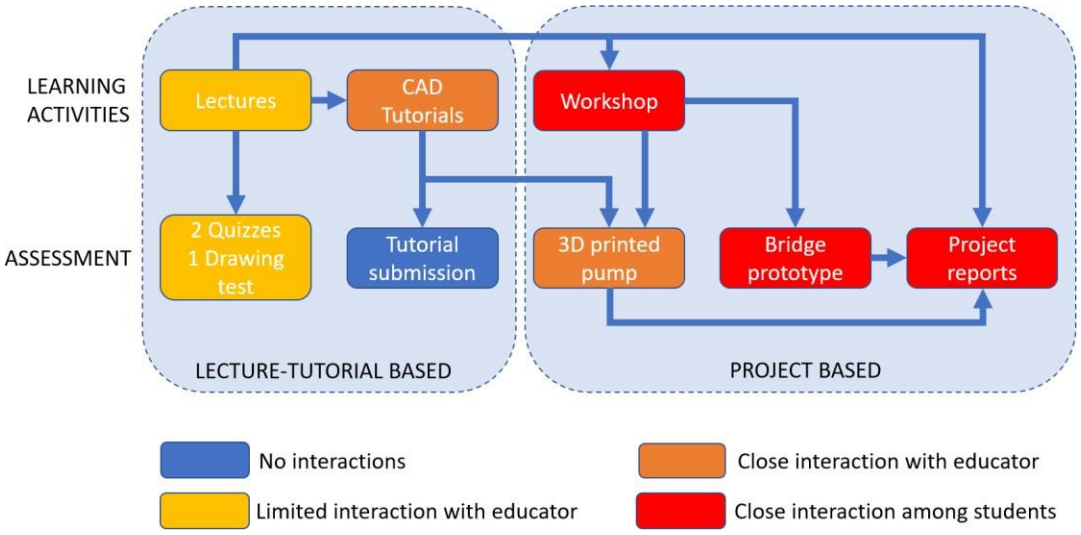

Figure 1. Interaction analysis for EG1000

Hence, EG1000 was revised thoroughly with focus on interaction (Figure 1). Then, teaching activities were adapted by interaction with a) staff; b) learning materials; and c) assessment content. The adaptations were done with two notary stars. Firstly, teaching activities must be simplified, so they can be accessed in both learning models. As the lockdowns were often announced over weekend, there was no time to plan for change. A simple activity can be adapted more quickly. Secondly, non-contact supports must be endorsed as they would work in both conditions (Rim, Shin et al. 2021).

Subject adaptation

Teaching staff

Before the pandemic, EG1000 was lectured by five professors and several invited professional engineers from different disciplines. This enhanced the experience of students (Brundiers and Wiek 2013) and helped them to decide which discipline to study in the next year. However, the bulky teaching team cannot be adapted quickly to the new learning conditions. Moreover, student engagement can be damaged. If the teaching was undertaken in an auditorium, lecturers could estimate the understanding of the class by eye contact. Then they can repeat and give more

explanations where needed (Litzinger, Lattuca et al. 2011). This was not possible for online learning, where both students and lecturers looked at Power Point slides in a small screen. A sad fact was that many students did not remember what their educators looked like due to too short face-to-face contact time. Hence, the teaching staff was streamlined. EG1000 was lectured by just the Head of Engineering with help form a tutor leader. A few professional engineers were still invited for short industry specific presentations, but the learning content was not assessed.

The reduced teaching team was flexible and well adapted to different learning models. The communication among the team was more efficient and effective. Nevertheless, the teaching plan was revised several times with internal and external reviewers. Apart from Bebegu Yumba campus in Townsville, EG1000 was also taught simultaneously at Nguma-bada campus in Cairns. However, the student number at Nguma-bada was approximately 30, which was significantly smaller than the 120+ at Bebegu Yumba. There were also some specified training sessions for tutors about online blended learning.

Learning materials

The lectures and tutorials were moved online during the lockdown, and online learning was a must at some points due to the restrictions. Online lectures were recorded via the Collaboration tool on the Blackboard portal. Meanwhile, all tutorials were made available on YouTube from the beginning of the semester. There were two good advantages. Firstly, students could take advantage of the timestamp, which was an interesting feature of YouTube. When they needed information about some specific skills or commands in *Computer-Aided Design* (CAD), they could skim through the list of timestamps in the video description and go directly to the right time. Secondly, students could take advantage of the flipped class and be flexible with teaching activities during the intermittent lockdown.

A major and necessary change of EG1000 was the switch to Fusion 360 from the previously well-used Solidworks. The biggest motivation was the access for students. Solidworks could not be installed on MacOS with an ease. This was a challenge for many students who wanted to keep working on their high school laptop. During the lockdown, students could not have access to university computer laboratories. Also, the concurrent license via VPN for Windows OS required some training for many students as they were not familiar with it. In contrast, Fusion 360 had web access and cloud storage, which facilitated off-campus access. In fact, this program integrated well with AutoDesk environment. Besides, educational license of Fusion 360 is free as many other programs of AutoDesk. Last but not least, students could work in an online team with the same design in Fusion 360. It was an authorial experience that students were excited about this feature. They could invite tutors to their team for some direct comments (Figure 2).

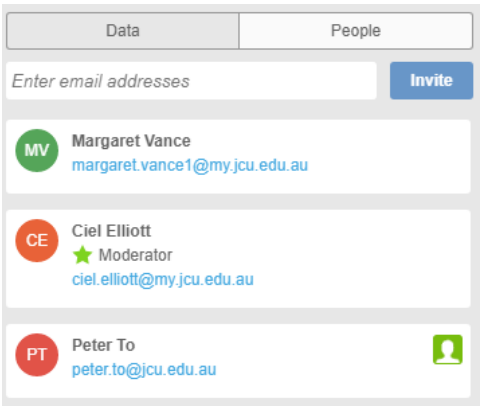

Figure 2. Invitation feature of Fusion 360. Peter To was the tutor leader.

The biggest challenge was project-based learning. In EG1000, students must complete two design projects, which required hands-on activities. Online workshops turned into Q&A sessions as students could not have chance to put their hands on equipment. However, the use of hot-glue guns required for the building of the bridge prototypes did not cause any trouble, thanks to a thorough risk

assessment with Risk Ware and detailed instruction. Regarding the pump prototype, students prepared the design online using Fusion 360.

Although no mandatory requirement was given, students were recommended to work sequentially and in parallel, rather than together. For example, two students could build two parts of the bridge, and the third student could assemble them. The report could be written by all three students using Google Documents. Before submission, the report format and voice could be checked to ensure the unity. The flexible recommendation worked well during the intermittent lockdown. It is authorial experience that if the learning condition is unpredictable, instruction should be turned to recommendation as much as it could.

Assessment content

There was not any significant problem for lecture-tutorial based learning. Quizzes and the drawing test were moved online easily. SafeAssign tool could be used for quizzes to detect plagiarism. No eye tracking software was used as it increased tension for students. They might also need to look down to draft answers. The drawing test had extra time for scanning submission with various mobile phone applications. As tutorials were available online, the need for support in CAD design was not huge and could be done online via screen share.

The project-based learning required more adaptations. For the assessment of the bridge prototype, students wrote a detailed note to indicate how they want their prototype to be held and tested. For the pump prototype, students sent their design to technicians to 3D print. They instructed the technicians on how they wanted them to be assembled and tested. All tests were recorded for students to compose their report. Results from load cells, displacement sensors, pressure sensors, and flow rate sensors were recorded in real-time by a web-based program. The reports were prepared in and after online group meetings.

Impact

Student evaluation

Student evaluations were undertaken at the end of semester via formal student feedback on Learn JCU website. The enrolment was reduced due to the impact of the pandemic, but it had a slight increase after that. Given the continuous downtrend of JCU enrolment (Cognos 2022), it may be considered as a bright spot. Interestingly, the feedback rate was reduced after the change had been implemented (Figure 3). As the feedback is not compulsory, its rate would also reflect the satisfaction of students. If students are not satisfied with the learning, they may have more motivation to voice for change.

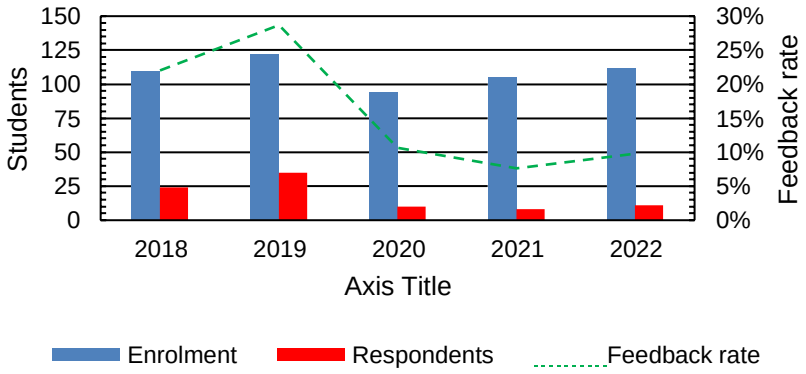

Figure 3. Enrolment and feedback rate in EG1000 at Bebegu Yumba campus

Students gave anonymously numerical response to 5 fundamental questions and the overall estimation. The response is based on a five-point scale. However, it may be easier to analyse in satisfaction scale. All evaluation below 4 is considered as “not satisfied”. It is clearly that the

satisfaction over EG1000 at Bebegu Yumba campus has been improved and maintained a good level above 85% (Figure 4). Nevertheless, not all of aspects were positive. The worst indicator was the Timely Feedback from educator (Figure 5). Students pointed out that some assessments need one month for the results to be posted. Thereby, the satisfaction over Subject Organisation also reduced slightly to 73% in 2022. The main reason for this might be actually not related to the change, but availability of tutors and the unbalanced teaching load of the leading tutor (also a lecturer and coordinator in other subjects) in the two recent years. Note that, when the teaching team was reduced, role of each member increased. Hence, if something happened to a member, it might not be easy to alleviate.

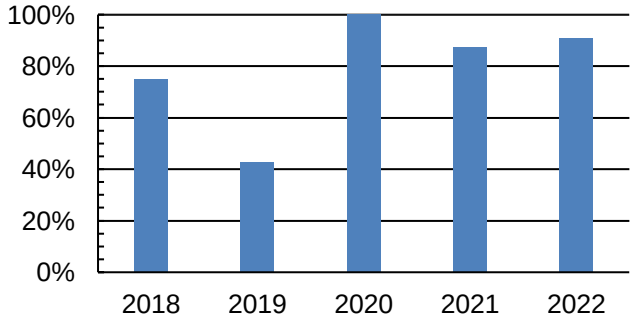

Figure 4. Overall satisfaction over EG1000 at Bebegu Yumba campus

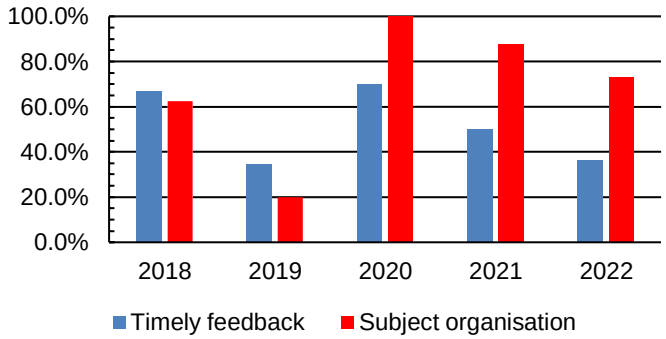

Figure 5. Satisfaction over timely feedback from educator and subject organisation

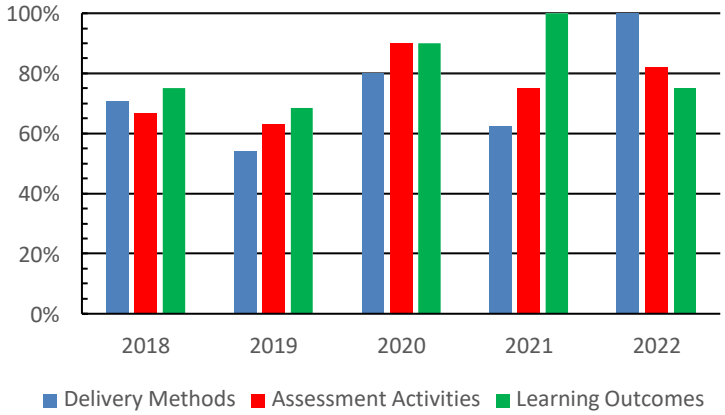

Figure 6. Satisfaction over Delivery, Assessment, and Outcomes

The evaluation on Delivery Methods fluctuated widely, but it remained positive. In 2022, it got 100% satisfaction. Nevertheless, about two thirds of respondents mentioned that they prefer face-to-face learning rather than online experience. Hence, this evaluation may also get some help from the ease of community restriction. Satisfaction over assessments was steady at above 60% before the change and remained above 75% after it. Note that, the overall performance of students in projects was also

improved. In 2018, just about 35% students had water head of their pump above 5m. In 2022, this number was 46%. It was a surprise to see a sudden fall in 2022 of the satisfaction over the clearance of Learning Outcomes. This evaluation got the max satisfaction in 2021.

A comparison of teaching with other subjects has been undertaken to evaluate the EG1000 within the circumstance. Due to the change of evaluation system in 2022, data of division and large class is not shown to public. Hence, 2021 data is presented as the latest result (Figure 7). As the feedback is in 5-point scale, it is obvious that the overall result of JCU is positive, and teaching in EG1000 is evaluated mostly higher than the average. The result of large class (with more than 50 students) and College of Science and Engineering (SCE) are consistent with JCU score.

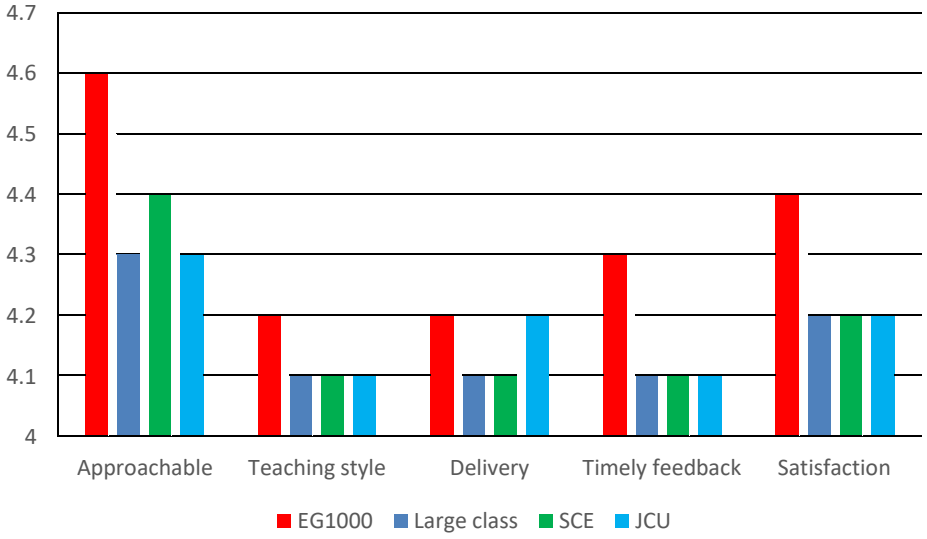

Figure 7. Teaching evaluation for staff in EG1000

In responses to two free-form questions about the worst and the best aspects of EG1000, students reached a consensus that feedback must be released quicker. It is understandable due to increasing number of students and the reduction of teaching staff in this subject. Nevertheless, the score of feedback is still higher than the average score in similar subjects (Figure 7). The appraisal of the best aspects is varied. Teaching style and creative assessment got slightly more attention. A student pointed out “The hands-on work and making something useful in helping us learn better”. In fact, it required plenty of effort to organise hands-on activities during the intermittent lockdown.

Student performance

Although there was an obvious increase in student evaluation, the student performance was steady. The mean values were approximately 65%, which was the Credit grade (Table 1). Note that, in 2020 several students did not attend, but they did not withdraw. The zero results dragged the mean value slightly down in these years (Figure 8, Figure 9). The change of tutors and examiners seemed to have a negligible impact on the results. Due to the change of staff, the full data analysis for 2018 was not available.

Year	2019	2020	2021	2022
Mean, %	67.16	65.54	64.41	68.17
Deviation, %	15.11	22.03	10.44	15.19

Table 1. Statistics of student performance in EG1000

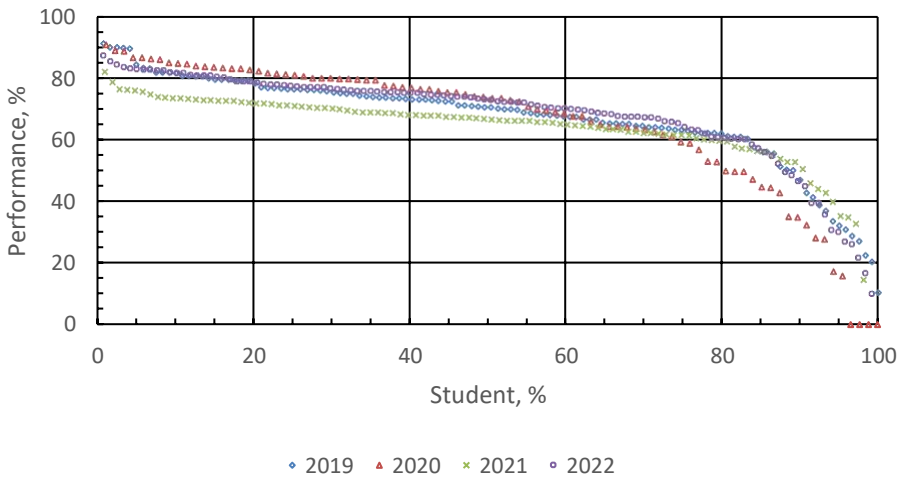

Figure 8. Cumulated performance of students in EG1000

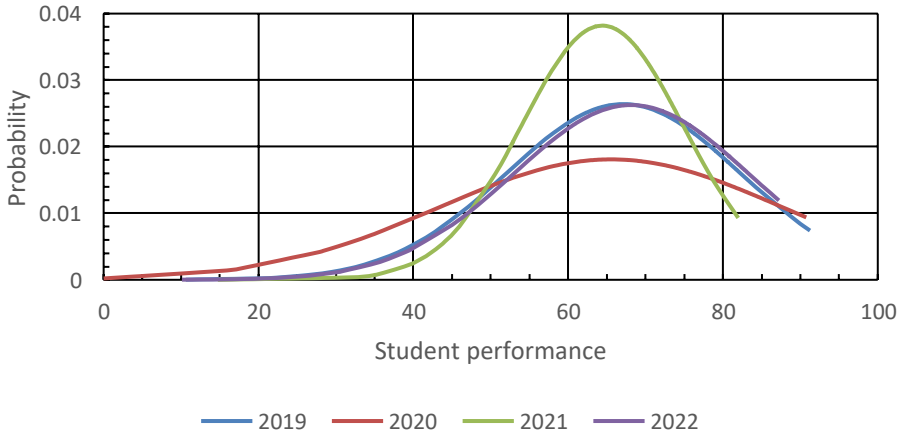

Figure 9. Normal distribution of student performance in EG1000

Interestingly, the performance distribution before the pandemic in 2019 is almost coincident with distribution in 2022, which has minimal impact from the pandemic. Nevertheless, assessment since 2020 was more challenging for students. For example, in 2019, students could build their bridge in one piece. Since 2020, students must build in two pieces. They had only ten minutes to assemble the bridge before the test. This forced the students to have an insight into connections as hot glue could not gain strength in this short time. The changes were implemented to engage and challenge students. This kept the results in the typical bell curve shape.

Conclusion

In general, there are five circumstances that a subject needs a redesign: a) Obsolete teaching approach or learning models; b) New essential learning materials or content, such as computational tools; c) Mismatch between visions/expectations of students, educators, employers, or professional organisations such as Engineers Australia; d) restructure of the discipline or institution; or e) other changes of learning environment. The adaption to EG1000 can be classified in the last category with a small conjunction with the first category.

The teaching of EG1000 faced several serious challenges as the teaching conditions and plan kept changing due to the intermittent lockdown. The subject was revised and some adaptations in staff, materials, and assessments were implemented. The student evaluation reflected some obvious positive impacts of the change in student engagement. Besides, the enrolment in EG1000 and

Engineering had a slight increase, given the continuous downtrend in other disciplines, including healthcare. Nevertheless, the student performance was steady, and the total mark distributions were in the typical bell-curve shape.

It is an authorial experience that when the teaching conditions change frequently, there are two notes to keep in mind: 1) Simplify teaching activities as they can be adapted quickly to the new conditions; and 2) Provide non-contact supports, which can be useful in any circumstances.

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