Synchronous learning and teaching in engineering education in response to COVID situations.

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Abstract

COVID-19 and the government restrictions in place have seriously affected the face-to-face (F2F) mode of delivery in education and higher education has been one of the hardest hit. Universities around the world had to implement the transition from F2F to online on very short notice. In this paper, the author presents a case study that demonstrates the challenges, steps, and adjustments taken to bring a course that has significant components of communication, teamwork, and project management from a full F2F mode to fully online whilst maintaining as much learner-learner and learner-teacher interactions and students engagement as possible. This has been achieved, not without drawbacks and challenges, via synchronous delivery mode and with private channels and breakout room function to promote intra-team and inter-team communications, and teamwork.

Keywords

e-learning; online learning and teaching; higher education; mechanical engineering education; COVID.

I. Introduction

The COVID and its variants have forced many local governments to put restrictions in place to control the wide spread of such a disease. Needless to mention the effectiveness in controlling the pandemic, these restrictions have caused disruption to the learning activities of more than 1.5 billion learners [1]; and severely impacted the conventional F2F mode of delivery of higher education courses and engineering courses, in particular [2]. This pandemic has also costed the higher education sector and its auxiliary industry millions dollars [2].

Universities world wide have been forced to ramp up their online teaching activities which requires extra expenditure [2]. The universities may also face the possibility of reduction in future enrolment due to drop out caused by learning loss [3] or the perceived less satisfactory of online education [4]. As such it is important for the lecturers and universities to ensure online learning and teaching is interesting for students to stay engaged and the learning experience in the online environment is as close to F2F as possible [5]–[7]. Delfino and Persico [5] have pointed out that technology can be used to support online or blended learning approaches.

Along side the technology required for a successful transition to fully online delivery in response to the COVID restrictions, the modification of course content, design of assessment tasks, and the course delivery method also play very important roles in motivating the students and promote learner-learner and learner-teacher interactions, and peer learning and teaching.

II. Learning and teaching scenario pre-COVID

Pre-COVID, the main mode of delivery was F2F with the exception of some open universities and some open online courses offered by a few universities; the asynchronous delivery has been the main mode in those open courses. F2F has been the traditional mode of learning and teaching, relies on social and physical interactions, for so many years that both students and teachers are familiar with. It is evidence that the traditional courses are still preferred by students despite the increasing in blended and online enrolment over the years as pointed out by Weldy [8]. The students have always been more satisfied with the traditional F2F courses compared to online courses [9].

Dumford and Miller [10] suggested in their work that the online environment may benefit certain types of engagement whiles it may deter other types of engagement. The authors also pointed out that students taking many online courses are more likely to engage in quantitative reasoning but less likely to participate in collaborative learning, and discussion with their peers and lecturers compared with traditional F2F students. This definitely is an important point for the course designers/course coordinators to pay their attention to, in terms of course contents and activities, and assessment task modifications, in the transition to fully online delivery in response to the pandemic.

Lu and Lemonde [11], through their investigation in an undergraduate health science statistics course, concluded that online and F2F deliveries are equally effective in producing comparable student test performance given that students are academically higher performing. For those lower performing students, however, the online delivery may produce significantly poorer test results compared to F2F mode. The authors suggested that care should be taken when providing online courses to students and online delivery should be kept for those courses not requiring high cognitive skill levels. Align with this in the transition to

online due to COVID, the lecturers and institutions must acknowledge these points and monitor student performance to have appropriate and timely actions and adjustments to the course contents and activities to maintain students' engagement.

III. Response to COVID restrictions

The COVID situation escalated so quickly in many countries at almost the same time. This has seen countries closing their borders and moving most of the activities online, including learning and teaching activities. Tough restrictions on how business could operate, and limits on social interactions and movements were quickly enforced. Concerning these restrictions, universities has ramped up the transition from F2F to fully online learning and teaching. Fortunately, the tools required for this transition has been readily available. These are online Learning Management Systems (LMS), i.e., Moodle, Blackboard, Canvas, and video conference tools, i.e., MsTeams, Zoom, WebEx, Skype. On the bright side, most of the universities have been using their current LMSs, therefore, the online transition did not cause much disruption in this area. However, the use of video conference tools in online learning and teaching especially in synchronous mode has not previously been used by many, as such a learning curve and adaptation to the environment and a new tool were required for both learners and teachers.

On top of this, the course designers must adjust the course contents to suit the new learning and teaching environment; the course delivery method as well the mean for learner-learner and learner-teacher interactions also needed to be changed or set up on very short notice. It is also important that the lecturers can actively adapt to the dynamic situation of online learning and teaching and utilise new tools to improve students' experience.

This paper highlights the changes and modifications to the Engineering Project Management and Sustainable Design course that was delivered, pre-COVID, as F2F mode to mechanical, civil, mechatronic, and electrical students on multiple campuses. This course used to require one lecturer per campus, a few student teams' supervisors and tutors to run multiple lecture and tutorial sessions on different campuses; there were also a low number of online cohort who accessed the asynchronous contents from their home locations. Of note were the student teams' supervisor roles who would provide support and guidance to the student teams in their design task throughout the semester. In the COVID climate, the shift to online delivery, which means students from all campuses became online students, has, in a positive way, reduced the requirement for having many lecture and tutorial sessions running at various time slots and reduced the number of team supervisors required. In fact, only one (up to a maximum of two staff) was required to run one lecture and one tutorial per week for students from all campuses, this staff was also responsible for the team supervisor role. The overall workload of staff has significantly reduced which translated to more research time for those staff; however, the workload of the particular staff who ran the course was increased; the amount of work depends on the number of students enrolled in a particular semester. Due to the teamwork nature of the assessment tasks of this course, the one staff could handle between 48 and 60 students in either F2F or online mode.

IV. Synchronous Learning and Teaching Mode

Aiming to provide students with the learning experience as close to that of F2F delivery mode as one would like, the synchronous lecture and tutorial mode has been the choice in Engineering Project Management and Sustainable Design course. Synchronous learning and teaching carried out with the help of MsTeams and the additional applications, as required, made available through the MsTeams platform. On this platform, learners and teacher can communicate and interact in real time and the students experience is comparable with F2F classes. In the lectures and tutorials, share screen function was used and explanation of concepts and examples were hand-written directly on the PowerPoint slides; this replicates the use of projectors and whiteboard and markers in the F2F environment. Students were encouraged to ask questions on the fly by enabling their microphone and talk or typing the question in the provided message box. The lecturer would response to those questions in real time similar to that of the F2F lecture setting. These synchronous sessions has allowed for real time interactions mainly between learners and teachers; the learner-learner interactions and discussions were encouraged by the teacher via the breakout rooms in which students were divided in to smaller groups for discussion or problem solving tasks. MsTeams was the choice for synchronous delivery as well as the mean for learner-learner and learner-teacher communications outside the virtual classroom hours.

At the start of the semester, students were automatically given access to Moodle via the university enrolment system; instructions on how to access MsTeams and how to navigate on Moodle and MsTeams were provided on Moodle and on the university website. Note that Moodle and MsTeams are used as LMS and communication platform, respectively, at the Federation University Australia. Students were allowed one week prior to the semester start (O week) to navigate their way on Moodle and enrol themselves to MsTeams teaching channel(s). By the first week, those who struggled to access MsTeams were contacted via email with MsTeams enrolment instructions and enrolled to MsTeams teaching channel(s) by the lecturer.

The synchronous learning-teaching activities were conducted via MsTeams and recordings of these sessions made available for students to access also via MsTeams. The recordings allowed students to rewatch for a better understanding of important concepts introduced in the lectures, and allowed for those students who missed the synchronous sessions to watch at their convenient time. Access to Moodle has also been integrated to MsTeams for seamless learning experience. In addition, the hand-written notes taken in lecture were provided on Moodle as pdf printouts.

A. Software Accessibility

The software required for the Engineering Project Management and Sustainable Design course are readily available to students. Access to MsTeams for synchronous sessions can be via either the students' preferred web browsers or a native app on their computers. Access to the computer aided design (CAD), 3D CAD, and word processing packages are possible via a licences linked to student's email addresses. Project management software is available as a freeware, a free version of commercial software, or free cloud services.

Instructions on how to get the software ready for the course were provided on Moodle; further instructions were also provided by the lecturer during the first lecture. The utilisation of software was also integrated in the first three weeks' lectures and tutorials to gradually familiarise students with the tools and the design task requirements, design techniques, and project management aspects.

B. Orientation

The first communication attempt between the lecturer and students was via the announcement and discussion function on Moodle, which was automatically forwarded to students' email inbox. This first attempt provided students with the introduction to the course contents and initial requirements, instructions on how to navigate through the content on Moodle, and instructions on how to access the MsTeams channel(s) for online classes and important features of MsTeams. In the first week of the semester, besides running the lecture and tutorial the lecturer made sure that all students enrolled in the course had access to MsTeams. The lecturer also reached out to those who struggled to find their way in the online environment and provide necessary and timely assistance.

C. Timelines and Team Forming

The timelines for learning and teaching activities were detailed on Moodle and in the first lecture, which has been accessible through My Student Centre (MySC); the schedule for lectures and tutorials were also set up in MsTeams so that students have a copy of the teaching schedule in their MsTeams calendar and they would get a notification prior to the start of each session.

Student grouping was not forced or arranged by the lecturers. Students were encouraged to communicate with each other during the first week lecture and tutorial, and outside the class time in the second week via MsTeams and Moodle discussion forum; students were encouraged to get to know one another prior to the team/group forming. Students then enrolled themselves in teams. Each team, of three to four members, was provided with a private channel for intra-team communication. A private common channel for multiple teams working on the main-project to have inter-team communication and collaboration was also set up by the lecturer. Those students who enrolled late in the course would be allocated to the existing teams with the agreement of existing team members. It is important to note that each team would work on a sub-project; and three to four teams would collaborate with each other to complete the main-project. The main-project consists of three to four sub-projects, the details of which will be provided in the following section, each team was tasked with a sub-project as their assessment task.

V. Design of Assessment Task

The assessment tasks are of individual and teamwork types. The final test is the only individual task which is undertaken via Moodle quiz at the end of the semester. This task includes the theory introduced in the lecture topics and case studies in the forms of multiple choice, true-false, short answer, and essay questions. Students must complete this task individually at a timetabled slot. The teamwork design assignments comprise of multiple tasks which represent stages of team forming, tasks allocation, design choices, project proposal, design process, project management, teamwork, and team communication activities.

The main focus of this Engineering Project Management and Sustainable Design course is to provide students with communication, interpersonal, tracking progress, maintain ethical and professional conduct, and collaborating with others skills in a diverse group settings [12]–[14]. These skills are essential requirements which student need in order to work effectively in a team to complete a given task or project. This course also focuses on developing student teamwork and collaboration skills; as pointed out by Hughes and Jones [14], these are highly rated by prospective employers in contributing to job success. In addition to those, the assessment tasks are designed with an intention to offer students an opportunity to sharpen their research, problem solving, and design skills.

The design tasks set out in the form of a main-design project which can be divided into sub-projects. These sub-projects are tightly linked with one another. An example of such a main-project is shown in Fig. 1 below; in this example the main-project comprises of four sub-projects.

- Design an automatically (or manually) controlled sluice gate system to control the upstream water level and the water flow.
- Design a lock system that allows boat traffic between the upstream and downstream sides of the river.
- Design a fish ladder for various types of fish species to migrate between the upstream and downstream sides of the river.

- Design an overpass/underpass for light-traffic (definition of light-traffic can be outlined by the team members)

The Design project (multiple assessment tasks) – Teamwork

The main design project is:

Design a river weir with a lock to accommodate boat traffic between upstream and downstream, a fish ladder, an automatically (or manually) controlled sluice gate, and an overpass/underpass for light traffic.

which consists of the below **architectural/conceptual** sub-projects:

Fig. 1. An example of a main project that contain multiple sub-projects.

The sub-projects can be changed or mixed by the lecturer and listed as various options for the student teams to choose from. The number of sub-projects, vary from three to five, can also be flexibly changed by the lecturer to suit the number of students enrolled in the course or the total number of students and teams allocated to the main-project. Students are task to form teams, each team is required to find the other three (or four) teams to form a big team to complete the main-project. As such up to four teams will work together to complete the main-project; each team, with a team leader, is responsible for a sub-project. The sub-projects are allocated in the big team meeting where the big team would base on the strengths and weaknesses of its members to assign the sub-project accordingly. The teams are then required to contact the lecturer so they can be the team supervisor throughout the semester.

With the intention of providing a guide and an example for the student to base on and start their project, a current weir with a boat lock, sluice gate system, and a fish ladder in operation has been provided. The location of the selected site is shown in Fig. 2. The main-project and its subsequence sub-projects can also be flexibly changed by the lecturer over the years or between big teams. To add more options to this design task, students can be allowed to select their own site location for their design task, given that they can nominate a site and a main-project within the first two weeks of the semester.

Fig. 2. Location of a site that was selected for the design project (from Google maps).

The main-project requires three to four teams to work with each other. Each sub-project requires three to four members. The three to four teams working to together are required to maintain intra-team (between team members) and inter-team (between different teams) communication for the main-project to be completed and successful. The relationship between the main-project, and the teams and their sub-projects is shown in Fig. 3 below. In this figure, the solid arrows represent the inter-team communication and the dashed arrows represent the relationship between the main-project and its sub-projects.

As aforementioned, each sub-project comprises of tasks that show the team forming, data collection, assumptions made by the teams, and the planning and design stages of the sub-project. These tasks are named as brief report, progress report 1, progress report 2, final report, and final presentation. Each team needs to demonstrate their effort and progress of their work in stages so the team supervisor/lecturer can give the team progress mark, provide formative feedback based on which the team can learn from their mistake(s) and make improvements in the next task; the supervisor also provides timely assistance and

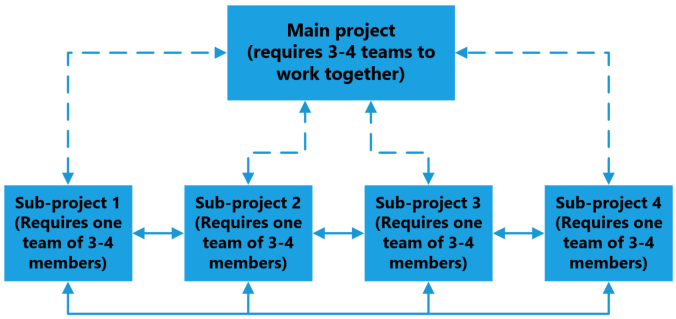

Fig. 3. The relationship between the main-project and its sub-projects.

guidance. The progress reports come with meetings with team supervisor; each team also need to present their work to the whole class at the end of the semester. The requirements and expectations for each tasks are detailed in an assessment task description sheet and uploaded on Moodle.

To support the teams, the university library are liaised with to provide students with teamwork and report writing workshops. A guest lecture is also arranged in which a project manager from the industry can share with students their project management experience in a MsTeams live session; students will have an opportunity to learn how project management is carried out in the industry and how the theories and techniques introduced in the course are applied. A report template is also made available to students.

Of importation note is that the individual mark of each team member is calculated based on their percentage of contribution to the completion of the team work/report. The individual percentage of contribution is decided by all team members and signed off by the whole team before including on the second page of their report. This percentage of contribution has been introduced to encourage team members to pick up more load when other members could not; and this extra load absorption is rewarded with extra mark in each stages of the design task.

VI. Challenges and Opportunities

The main challenge in delivering this Engineering Project Management course has been to encourage students to communicate with each other in the online environment (MsTeams and Moodle discussion). Students attending the course are from different cultural background and of different gender [15]; they may have different previous achievements, motivations, and self-efficacy [15], they may have different levels of technology literacy. This has required the lecturer to break the ice [16] and re-energise [16] and start a conversation with the whole class or direct students into breakout rooms as small groups where they feel more comfortable communicating. When this initial spark can happen, the following tasks and difficulties would be much easier to handle.

The next challenge has been to teach students how to communicate with one another and maintain the line of communication between the teams and between the team members. The lecture/teacher must be the role model in this case [17].

Another challenge has been that the main-project may not be successful as planned if one of the team failed to deliver their sub-project. In the design phase of the assessment task, a plan B has been considered. If this case would happen the main-project would fail but the sub-projects could still success. The quality of the work/end products of individual team would then determine their marks and grades.

Over multiple deliveries of this course in both as F2F and online mode, I have observed that initially students engagement to the course activities and contents varies based on the mix of students' differences as highlighted above. However, the enthusiasm, and the organisation and management skills of the lecturer do help bridging that gap.

This course provides the students with an opportunity to sharpen the CAD design skills they have learned from previous courses, at the same time equips students with the essential skills to work effectively in a team environment and the basic communication and project-management skills. Students also have the chance to learn from the experience of a project manager.

VII. Discussion and Conclusion

Students feedback from this course has been a mixed of highly satisfied with the contents and activities to not satisfy at all. There are two modes for students feedback, an official channel and an in-class unofficial channel. The official channel is via the Federation University wide Student Evaluation of Learning and Teaching Survey (SELT), which seeks students feedback for both the course and the teacher. Over the years, mainly due to the start and end time of such a survey the response rates of this method have never been very high. However, observations show that the responses tend to be on the extreme ends; those students who spent time completing the survey fall into two categories. The first group are those who appreciated the

approach, delivery method, course materials and think their study have been positively impacted; the other group are those who, for various reasons, were totally dissatisfy with the course, the teachers, and the tutors.

The unofficial channel of student feedback is the learner-teacher conversation during and after lectures and tutorials. Through the conversations with students during the semester and the meeting with the groups, the teacher/supervisor can provide additional formative feedback to the groups and the groups' reports. Via this feedback mode the link between proactive and self-driven students with high SELT rating can easily be matched; at the same time, the link between lower performing students and low rating is evident. During the semester, it has been observed that those lower performing students always wait for others to tell them what to do and contribute the least possible to the group work in order to pass the course; on the brighter side, at least these students do learn some skills through the progress of this course.

The online mode of delivery of Engineering Project Management and Sustainable Design course in semester 2 2020 (during the lockdown period in the state of Victoria, Australia) can be considered very successful. This semester has seen many teams completed their designs in either Inventor or Fusion360 with detail considerations for installation and maintenance of the structure and moving parts in their sub-project, and detail Gantt charts for project manage purpose. Of note is that it were the teams' decisions on the CAD design and project management tools to use based on a recommendation list provided by the lecturer/supervisor. It is also of important note that there were teams that did not perform well at all and this can be linked to the lack of motivation, time and task management, and intra-team and inter-team communication.

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