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Studying the COVID-19 Impacts on Engineering Education

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ABSTRACT

CONTEXT

Throughout the world, the emergence and spread of the COVID-19 epidemic has led to a massive change in the delivery of education. The role of educational providers is to enable the learners to acquire the necessary global competencies and to nurture the skill of developing services that meet the utmost needs of the society by tuning them effectively. Many universities around the world have changed traditional undergraduate classrooms into virtual online learning and blended learning classrooms to cope with these challenges brought by this pandemic. There are more than 100 students studying water engineering courses at the University of Southern Queensland, and at least 70 percent of them attend courses off-campus. As the University has a high number of remote students, there were already established online learning environments before the pandemic. Examiners used a variety of digital learning resources that were flexible by adopting new learning approaches.

PURPOSE OR GOAL

This paper explores how a variety of online learning resources were used to facilitate student engagement prior to and during COVID-19 for Hydraulics II (ENV3104) students. It includes designing and implementing activities within the course, considering learning styles, engineering skills, transversal competencies, and higher-order thinking skills.

APPROACH OR METHODOLOGY/METHODS

This will be achieved analysing reports and data:

- on learning environment resources utilised by the examiner in ENV3104 before and during the pandemic for students e-learning tasks and
- Analysis of survey results of student's engagement, evaluation and progression for ENV3104 before and during the pandemic

ACTUAL OR ANTICIPATED OUTCOMES

The study will illustrate various online learning resources and assessment techniques for the online delivery of engineering courses during global pandemics. These guidelines will provide a framework for quality teaching and evaluative practices in online engineering courses.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

Students in ENV3104 have been more engaged in online learning during the pandemic than before. The progression of students was higher than pre-covid, and the overall satisfaction with the course was high.

KEYWORDS

COVID-19, Hydraulics II, Engineering education, online teaching

Introduction

The World Health Organization declared COVID-19 a global pandemic within months of its outbreak in Wuhan, China, in December 2019, and the virus spread rapidly around the world as a consequence(Ali, 2020; Ripoll, Godino-Ojer, & Calzada, 2021; WHO, 2020). In July 2020, over 15 million cases had been reported to the WHO, resulting in some 620,000 deaths in over 213 countries and territories around the world (WHO, 2020). In terms of its effects on education, these outbreaks resulted in more than 1 billion learners having to miss classes due to the closure of their schools, colleges and universities by the end of June (UNESCO, 2020).

In early 2020, the COVID-19 pandemic began in Australia, resulting in widespread social disruption. As a result of this pandemic, we have had to change the way we interact, approach and deliver education. Engineering universities have to reshape rapidly their teaching systems as digital technologies change society, business, and the way we live. Education was immediately moved online (Bozkurt, 2020), and teachers were forced to adapt their courses and methodologies quickly without prior training in online pedagogy and often using unfamiliar digital teaching technologies. It raised concerns regarding the following: (1) continuous delivery of lectures and tutorials (2) maintaining student engagement during delivery of the course (3) Designing assessment procedures that are designed to assess students remotely and to maintain academic integrity (3) Developing transversal skills and higher order thinking skills, and (4) ensuring that the exam is authentic.

The University of Southern Queensland (UniSQ), Australia, moved quickly to emergency remote learning. During the lockdown, classes were held as normally as possible, with minor disruptions or rescheduling. However, flexible attendance requirements were placed on students during the lockdown. UniSQ offers Engineering Degree program, including Civil, Environmental, Agricultural, Mechanical, Power, and Electrical Engineering (UniSQ-Handbook, 2022). An Engineering course is a technical area and presents a particular challenge for both students and teachers (Chowdhury, 2019).

This paper discusses how teaching and assessment methods were adapted in a hydraulics engineering course during the COVID-19 pandemic to meet the demands of remote learning environments in order to facilitate student achievement. It includes discussion and examples of the development of a wide range of learning activities as well as a new way to assess online exams. Moreover, the paper contains information on how a blended learning approach can be applied to an engineering course to achieve the following objectives: 1) encouraging students to actively participate in online lectures and tutorials, 2) improving the student's ability to study and solve real-world problems through continuous feedback, and 3) reinforcing student knowledge, skills, and competencies.

Methodology

Course description

ENV3104 Hydraulics II is a third-year level course available to Civil, Agricultural, and Environmental engineers at UniSQ (Smith & Gillies, 2022). In addition to undergraduates, a small number of postgraduates are also admitted to the course (UniSQ-Handbook, 2022). It provides students with the hydraulic tools they will need for solving hydraulic engineering problems that are frequently encountered in Australian engineering practice.

The course is divided into 16 short modules. Some of the modules are small and serve primarily as a revision of what was previously covered in the preceding course in Hydraulics I. The objective of this course is to introduce the principles of hydraulic theory and apply them to the solution of problems encountered in engineering hydraulics and to the design of hydraulic systems and structures. In Hydraulics II, the conservation of mass, momentum, and energy is reviewed, extended, and applied to a variety of hydraulic systems. It presents and applies new material on unsteady pipeline and open channel flows, loose boundary hydraulics and coastal hydraulics

Throughout the academic year, this course is offered every year in Semester 1 (February to June), and it is a one-unit course (the expected workload for students is 155 hours). There are usually more than 100 students enrolled in this course each year, with more than 70% of enrolled students coming from online or external sources. Course content (modules), weighting, and corresponding learning objectives (learning outcomes) are provided at the course specification ("ENV3104 Hydraulics II Course Specification," 2022) for ENV3104.

Course delivery

There is an online learning management system (USQ Study Desk www.usqstudydesk.usq.edu.au) available to all students, regardless of whether they are studying on campus or online. It includes lectures, course materials, assignments and discussion forums. Every week, there is an engaged session and a tutorial conducted on campus, livestreamed via Zoom (https://zoom.us/). The Study Desk platform also provides recordings of live lectures and tutorial sessions.

This course includes concise theories, worked examples, calculations, formulae and theoretical concepts, which are strongly linked to tutorial sessions, during which students solve problems based on Australian water engineering practices [24]. Tutorial sessions help students to understand the calculations, application of hydraulic tools necessary for the solution of water engineering problem. Students solve the equations governing both steady and unsteady gradually varied channel flow and apply them to the solution of practical flow problems including backwater profiles; runoff on a plane surface and routing of a stream hydrograph; design erodible and vegetative lined channels.

Students learn to develop a computer program (using any programming language or spreadsheet) for an explicit numerical solution of the kinematic wave equations applied to the problem of runoff from the surface of a sealed car park subjected to a storm rainfall. In addition, they learn to design crest weirs, gated control structures, pipe conveyance structures, spillways, critical flow measuring flumes, and gulley control structures using the minimum specific energy concept.

A blended learning approach was designed in order to support student learning during the pandemic in order to adapt teaching and learning processes to the lockdown situation. The following changes (Table 1) were made to support student learning during the pandemic:

Table 1: Changes in the delivery of Hydraulics II during and after COVID-19

Type	Pre COVID-19	During or Post COVID-19
Exam	Face-face Exam	Online or take home or Alternative assignment.
Lecture	Face-face and online	Online using zoom and Panopto
Academic Integrity	Turnitin	Use Turnitin for plagiarism check. Randomised questions in the exam with different sets of wildcards.
Student Consultation	Face-face or phone call	Zoom or phone call
Exam duration	2 hours invigilated exam	3 hours non-invigilated exam
Exam type	Paper based	Moodle quiz on study desk with submission of working

Course Assessment

The course is based on a blended learning pedagogical model. Students are exposed to a variety of interactive tasks as part of the course content and assignments that use a constructivist methodology. A traditional assessment approach is used for this course, with two assignments (each weighted at 25%) and a 3-hour online examination (50%). Submissions of both assignments are

done individually through the provided link on the study desk. At the end of each assignment, students will find a marking scheme outlining how each component is weighted. A student must receive at least 50% of the total weighted marks available for the course (primary hurdle) to pass. Assignment 1 contains two questions that cover Gradually Varying Flow Profiles and Numerical Solution of Kinematic Equations, while Assignment 2 consists of three questions that cover Pipeline and Open Channel Flows. There are self-assessment questions in every module of the study guide. Attempting these before the final exam gives students an opportunity to test their understanding.

In the first assignment, students are tested on learning objectives 1 and 2 from modules 1 to 5 ("ENV3104 Hydraulics II Course Specification," 2022). This involves evaluating and applying equations for the description of open channel flow and solving equations governing both steady and unsteady gradually varied channel flow as well as designing erodible or vegetative lined channels. Students are required to investigate the behaviour of a large parking lot under a short duration high intensity rainfall event. Their first step is to simulate the water depths and flow rates under a specified rainfall pattern, and then modify the model to accommodate their chosen design storm hydrograph.

Assignment 2 is based on the material covered in modules 10, 12 and 8. It involves solving simple pipe networks with an appropriate method, applying rigid column theory to unsteady pipeline flow in order to analyse mass oscillations in pipelines and calculate maximum allowable rates for valve openings and closings, and designing hydraulic structures that include fixed and movable crest weirs; gated control structures.

This year (2022) the exam was worth of 500 marks (50%) out of 1000 (total for the subject) where last year and all previous years it was worth 600 marks out of 1000 (total for the subject)("ENV3104 Hydraulics II Course Specification," 2022). There were five questions on the final exam, and students had to answer all of them. In the first question, there were multiple-choice questions and short questions that cover some learning objectives in the course. In the multiple-choice section, there was no negative marking for incorrect answers. Other questions were predominantly mathematical-based and were selected at random from different modules. Each question is made up of either 1 large question or 2 smaller ones. The students were given a mathematical formula sheet with the exam paper. In the exam, students were allowed to use a non-programmable calculator.

Academic Integrity

The assignment questions were designed for different design parameters with individual student numbers. For each assignment question, there were separate submission links, and Turnitin (https://turnitin.com/) was used to check plagiarism percentages. It was recommended that students submit electronic versions of all computer code or spreadsheets used in order to ensure that the examiner could validate the models. Additionally, every course has a mandatory academic integrity module this year. Upon completion of this module, students will be eligible to take the course's assessments.

The online exam was created using a Moodle quiz with randomised numbers for each variable. The format of the exam was similar to previous years, however, students had to upload their work into the link provided within the quiz in order to take the exam. There was a strong preference for handwritten work. Question 1 included five short and five multiple choice calculative randomised questions. The remaining questions were mathematical-type questions with wildcards combined in various ways to maintain academic integrity.

Student engagement

The number of students enrolled in the course in S1 2022 was 106, and the number of on-campus students was 29 and the number of online students was 77, respectively. The majority of the on-campus students were located on the Toowoomba campus (21) and the remaining eight students attended the Springfield campus. Weekly interactive sessions and workshops were held at Toowoomba Campus via Zoom livestream, whereas a combined 3h workshops were held at

Springfield Campus. During class time, engaged session and tutorials were recorded and later uploaded to Study Desk.

In order to engage student on the course, following strategies were applied in the course in S1 2022

- All pre-recorded lectures and tutorial recordings were made available on the Study Desk to students. The students were asked to view pre-recorded lectures before coming to the tutorial class, and then to actively participate in the tutorial class by solving one question from a relevant module.
- The students were asked to complete self-assessment questions each week from the relevant modules in order to test their level of conceptual understanding as well as to assess their ability to apply their knowledge and skills to calculations.
- In order to prepare for the assignment, students were given formative assessment tasks to complete before they attempt the assignment in the course. Feedback on the formative assessment tasks was provided in a timely manner.
- There was a practice online exam on the study desk that followed the same format as the main online exam. Students could solve practice online exam questions and check their solutions using the provided answers.
- In each module, there was a dedicated discussion forum where students could ask questions and other students and the examiner could provide answers to the questions. There were also separate discussion forums for the two assignments and the final exam
- All past exam questions and answers were included in the StudyDesk materials so that students could solve them independently and ask any questions in the forums

As most of the students were online students, ensuring the engagement of these students in the course was very challenging. By using UniSQ course analytics, it was possible to track the students' engagement in the course by tracking their participation in accessing relevant course materials and in discussion forums during the delivery of the course.

Assessment of the learning experience

An online survey was conducted through Study desk to evaluate how students perceived the online exam experience and how they felt about the teaching approach, their development of transversal skills, and other relevant aspects related to their study experience. The survey was conducted using My Opinion survey. In my opinion, there are questions relating to the course and the teaching quality of the course team members. The students grade each question from 1 to 5 (strongly disagree = 1; disagree = 2; neither agree nor disagree = 3; agree = 4; strongly agree = 5).

Results and discussion

Student engagement

Students' engagement in the course was evaluated based on their participation in accessing important course materials and actively participate in the discussion forums. Students were able to click on the resources and download it as many times as they wanted.

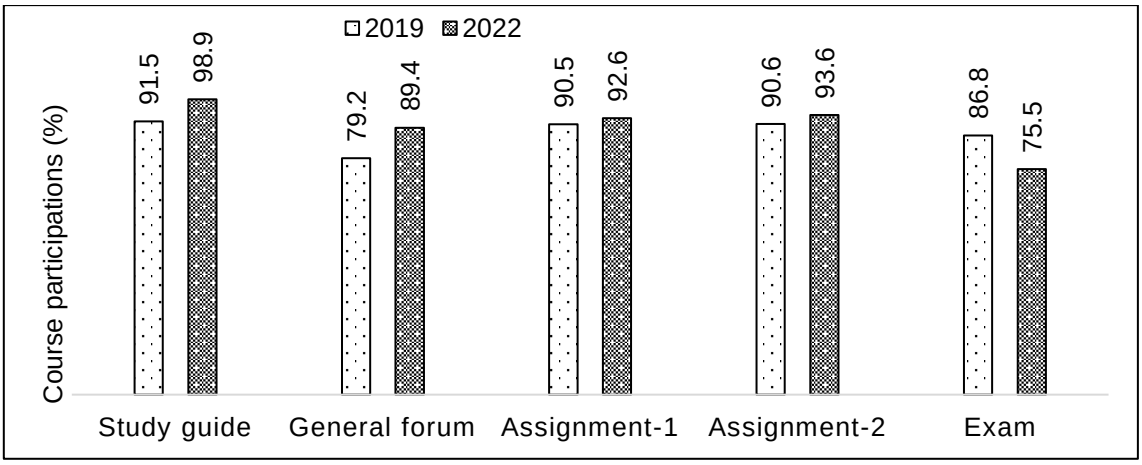

Figure 1: Student engagement analytics in Hydraulics II

Fig 1 shows how many students accessed important course materials in 2019 and 2022. It is estimated that approximately 91.5% of students had access to the study guide in 2019, and that number increased to 98.9% in 2022. In both assignments, the number of students participating in posting questions in the forum increased from the previous year. Since the final exam has moved from being a closed book to an open book type online or take-home test or additional assignment, students are less likely to participate in the exam discussion forum. The number of students participating in this course-related general question posting activity in 2022 was significantly higher than that of 2019 in terms of participation.

Student evaluation

As part of the course evaluation process, the students were asked to provide anonymous evaluations and feedback on the course. Figure 2 shows a summary of the mean scores for students' overall satisfaction with the course as derived from the My Opinion survey. A comparison of scores between 2019 and 2022 is shown for three different modes of delivering the course. An overall score of between 4 (agree) and 5 (strongly agree) was considered to be a very good score in most situations. Students' evaluation scores are displayed separately for students on campus and for students who are enrolled online. According to figure 2, the Toowoomba on-campus students (33.33 % of respondents in 2019, and 16% in 2022) expressed their satisfaction with the course at a very high level, and their satisfaction levels (mean scores) were higher than those of the online students (39.13% respondents in 2019, and 34% in 2022). In all of the satisfaction questions, Springfield on-campus students (50% respondents in 2019 and 38% in 2022) provided the highest satisfaction scores. As can be seen from Figure 2, student satisfaction with the course has increased compared to the previous evaluations.

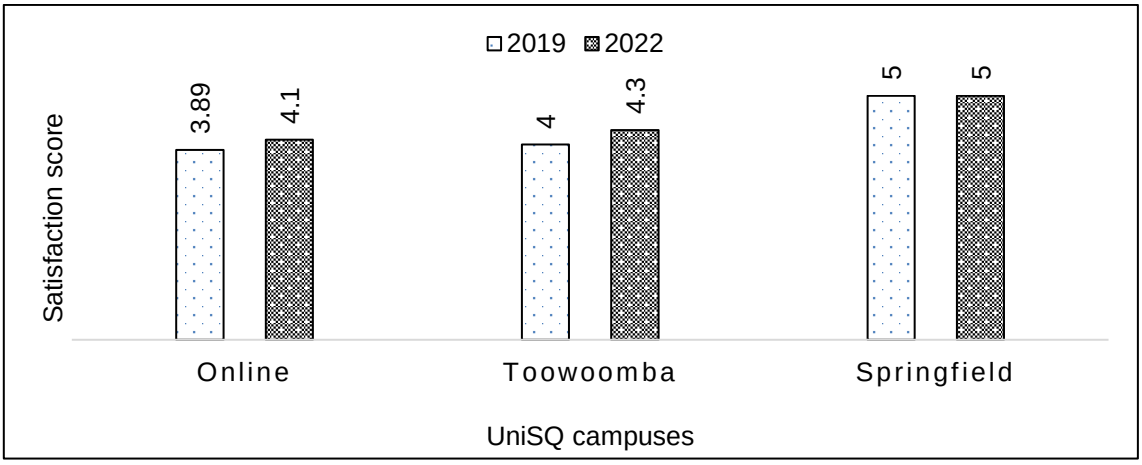

Figure 2: Comparison of student evaluation in Hydraulics II

According to the results, students from both campuses who took part in the course were fully satisfied with its contents and the way in which it was delivered. Several online students have commented on how they appreciated StudyDesk's flexibility, real-world examples, assignments, and discussion forums, as well as its easy-to-follow, well-structured materials. Both the on-campus students and the online students recommended that the course be improved by including more worked examples and live tutorial sessions as part of the curriculum. The online students recommended that the lecture and tutorial video quality be improved, and they also suggested that excel training be included in the course, so that the students could perform data analyses using excel.

In the majority of online students' responses, flexibility was the most important aspect of their job, and they preferred online delivery of their coursework as the most convenient method of learning. The online students have the benefit of being able to interact with their classmates and with the academic staff through the discussion forums and through separate group zoom sessions. It was appreciated by all students that academic staff responded timely to their posts in the forums and that they provided feedback.

Student progression

Figure 3 shows a comparative analysis of the student progression before and during COVID 19. In the transition from 2019 to 2022, there was a significant improvement in the student progress that was attributed to the hybrid approach and the delivery of the course in a completely online format.

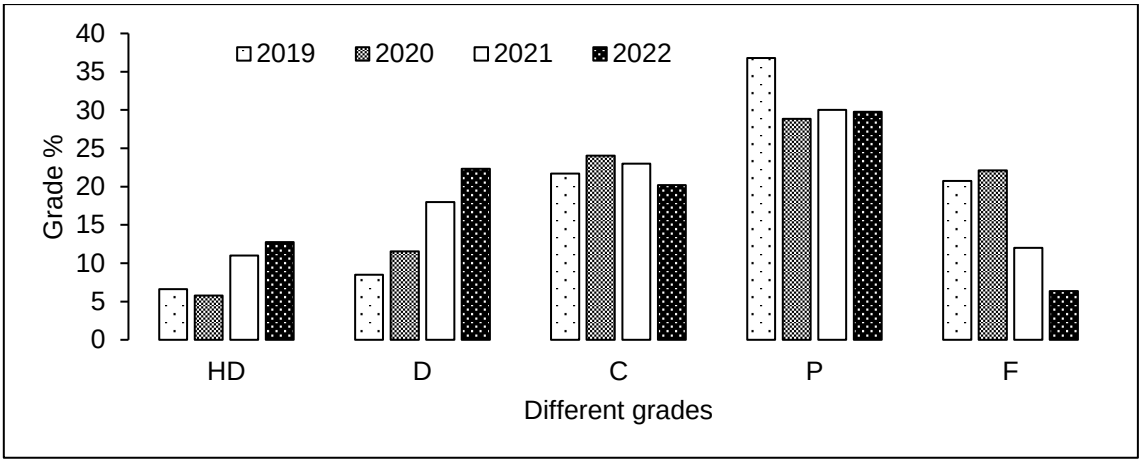

Figure 3: Student progression before and during COVID-19 (HD: High distinction, D: Distinction, C: Credit, P: Pass and F: Fail)

As can be seen from the graph, in 2019 there was a 20.75% % failing grade whereas in 2022 there was a only 6.68% failing grade. Since many students were working from home during the period of the COVID 19, they had the time and opportunity to spend additional time studying and practicing their study materials, since they were not required to travel to and from work during that period. In addition, there was no exam hurdle during the COVID-19 period which was reflected in their final grade. There has also been a significant increase in the percentage of HD grades compared to 2019. It was observed that students who put significant efforts into their assignments were able to receive a HD grade in the course. There was a high degree of success among students in their feedback regarding open book type exams, and students wish to see this type of exam continue at UniSQ in the future.

Conclusions

There was a dramatic change in the way students learn as a result of COVID-19, but the application of innovative methodologies managed to align course competencies and skills with the needs of individual students, maintain class dynamics, and motivate learners to learn. An innovative blended learning approach was used considering different types of teaching styles while emphasizing the

active participation of students. A variety of other activities were also provided to the students in addition to the online lectures, tutorials, and problem-solving assignments that were offered to students during the course. The online learning has significantly increased in terms of student engagement than it did before. Peer-review of created problems and recorded solutions is also an option that can be explored in the future as a way of enhancing the acquisition of higher-level skills and competencies.

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