Engineering Student's Flexibility for Learning During Education Disruption

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***Abstract*— Due to the recent education disruption, engineering-related module classes have to rapidly and effectively move online because of unpredictable changes. For design-related technical modules, not much literature focused on how students and tutors can adopt the latest technologies in a relatively short span. This paper is an effort to find students' experiences and preferences around various interactive educational tools used in online synchronous teaching, such as interactive live zoom lectures, slide annotations, breakout rooms, recorded videos, and many more, which have been used at the University of Glasgow, Singapore, for the module known as Design and Manufacture 1, during the 2021 COVID-19 crisis and beyond. From this work, we were able to find how an online synchronous learning approach affects design engineering students' learning experience. To understand students' perception of online learning tools to be effective in enhancing their learning during a sudden change in the arrangement of physical classes to online classes due to the pandemic situation. Survey results were collected using google forms at the end of the trimester, which was offered to 65 students enrolled in the module based on the student experience. The response rate is around 70%. The survey result showed that students engaged very well with the technologies and took little time to adjust to online learning. Students found learning very comfortable using the latest online teaching tools during their online learning journey in the design engineering module.**

Keywords*— *Flexibility in learning, Engineering Education, Online Learning

I. Introduction

In this paper, a case study conducted at the University of Glasgow, Singapore of an online approach adopted in engineering education is presented in the context of a requirement for moving rapidly from regular face-to-face teaching to online teaching due to sudden change in Singapore government policies for Covid 19 situation during September 2021.

When the world first faced the pandemic, not much publication was found on how to use digital technology during this sudden urgency [1], where students couldn't travel from one place to another and had to be inside a house and study online using digital tools. Although it's been around two years, plus some work has been taken care of and published as the crises have deepened [2] and become normal in some parts of the world.

The research presented in this paper aims to add some information by investigating how tutors adopted the online strategies to deliver engineering modules and students' reaction to those new strategies – experience and perception of students [3]. Also, how the learning outcomes had been achieved using online synchronous learning during an abrupt change in teaching from physical to online learning due to the COVID-19 situation. The paper outlines the aim of this study, methodology, findings, and conclusion from students' perceptions and experiences.

The general approach to teaching students due to the COVID-19 situation is discussed at the university level. A case study of synchronous online teaching of the module known as Design and Manufacture 1 is explained. The aim behind this work was to investigate students' experiences and preferences around various interactive educational tools used in online synchronous teaching; hence, at last, the paper presents some conclusions based on findings from the students' survey, which can be helpful to look forward in the situation which is similar to Covid 19 situation in future.

II. University's Approach Amidst Disruption.

To understand principles related to engineering design, it is essential to design a module based on team-based open-ended project work [4-8]. The first project-based module for mechanical engineering students is frequently used to orient students to the engineering design process, which establishes the norms for process, performance, and collaboration that will be expected in later design experiences [9]. To fully explain product design to students, which focuses on leveraging students' knowledge concepts learned in previous years based on physical science and their prior knowledge, the University of Glasgow, Singapore, had two different team-based project work modules. The one is known as Design, and Manufacture 1 teaches them how to work in a team for projects, engineering design process, concept generation, concept selection, the final concept, and its soft prototyping using any CAD software. The other module, known as Mechanical Design, focuses on prototyping iterations, testing, and refinement.

The development of the coronavirus started in China in January 2020. The second phase of this pandemic was declared around September 2021 in Singapore and lasted longer, around six months, as a heightened alert [10]. During this period, strict measures were implemented by the Singapore government. Initially, due to the sudden rise in cases, teaching for higher education shifted to home-based learning immediately. This meant that from Sep 2021, e-learning became a mandatory requirement in higher institutions. The Singapore Institute of Technology (SIT) and the University of Glasgow (UoG), where this study is performed, run a joint degree program in mechanical engineering. This joint degree course has a trimester system. In the year 2021, Trimester 1 started in September. It was running in blended mode as students had lectures online (due to the limitation of 50 students in a room) and for studio/lab sessions conducted on campus with less than 50 students in a room. This arrangement lasted for the first two weeks of the trimester out of a total of 13 weeks but later, due to a change in government policies for Covid 19 pandemic, everything converted into the online mode for the rest of the trimester for around ten weeks. As a result, the online mode, which is traditionally known as the e-learning mode for a long back,

has become [11-13] mandatory for higher education in Singapore.

Students and educators faced many implementation challenges in other parts of the world mentioned in literature [14, 15], but they were overcome and achieved many significant results. As online education becomes the norm during covid 19, universities need a structured and readily accessible learning management system (LMS) [16]. To be ready with this requirement, some basic guidelines were given by the university where educators have to upload some lecture material, PowerPoint slides, the live recording of the lecture, and supportive other documents on the LMS. During this E-learning phase, LMS becomes a sustainable, accepted model in this technology development [17, 18]. Zoom platform was used to deliver an online lecture as well as for studio sessions where breakout rooms were used by educators. Recorded videos became an essential part and core support for students during these e-learning periods [19, 20]. Due to the requirement of accreditation and some basic pedagogy for engineering, such as student engagement and active learning, some [21, 22] additional learning facilities for e-learning were used are listed below,

- xSiTe: Learning management system which was used to circulate news, upload lecture notes and other related materials, posting of online links for live online lectures and studio sessions, chat during live sessions, quizzes, grading, grouping, and many other activities.
- MS-Team, along with xSiTe for instant messaging and group chat.
- MS Office tools such as Outlook, Sharepoint, and Forms.
- MS PowerPoint and zoom for online delivery, lecture recording, and breakout rooms for group discussion.

III. Online Teaching Adjustment In A Design and Manufacture 1 Module

The effectiveness of the flexible online learning approach due to Sudden Change in Government Policies for Covid 19 Situation has been examined through a second-year Mechanical engineering module in design specialization, entitled MEC 2131' Design and Manufacture 1'. There were 65 students enrolled. The module contributed five credits.

A. Module Background

This module consists of lectures, case studies, lab sessions, projects, and CAD modeling/visualization. It aims to introduce the systematic industrial design process, including defining the customer needs, concept design generation and selection, embodiment design, detailed design, etc. Students learn how to create/sketch out product/engineering ideas and drawings to effectively communicate design ideas and solutions using freehand sketching, which ensures that students can effectively communicate design concept ideas and solutions. In contrast, the CAD tool doesn't do that. Students will be exposed to the working team dynamics, the engineering design process, report writing, oral presentation, and project management during project work. There was no exam and a 100% continuous assessment module.

The primary learning outcomes for this module are for students to be able to:-

- Apply the engineering design process in a collaborative engineering environment.
- Sketch out product/engineering ideas and produce engineering drawings creatively to effectively communicate design ideas and solutions; and
- Present the design concepts and final design technically through reports and oral presentations.

B. Standard Module Structure

The lectures cover the theory and methods used in engineering product design, the development of concept generation and methodology, and the examination of case studies. They also cover the design, analysis, and simulation for manufacture alongside 3D printing and tooling concerns. The lab sessions involve the development of creative thinking and problem-solving skills and work on a small group design project that links these to engineering requirements. The student selects a project from a shortlist; each project aims to allow the students to apply their acquired creative thinking and problem-solving skills to develop a conceptual design for a product that extends the application of an existing product into new markets and/or develops the design to expand sales in existing markets and reduce manufacturing costs. The lab session work also involves the detailed design/modeling and analysis of a component or small assembly for high-volume manufacturing. This will be achieved via a small group design project that applies knowledge gained through the lectures and the creative thinking and problem-solving skills practiced in the first year of engineering studies. The project provides a challenging technical problem to which the student can develop and present workable and manufacturable solutions at various levels of automation.

C. Module Delivery under Educational Disruption

A fully flexible online approach was implemented within the Design and Manufacture 1 content [3]. This includes synchronous lectures and studio sessions to improve delivery effectiveness [23, 24]. The teaching delivery also allows for annotation of teaching material [25, 26], live online classes, and studio sessions using breakout rooms via the zoom platform [27]. Adopting this kind of module delivery helps achieve better student engagement during the COVID-19 situation [28, 29].

- A laptop was used to deliver live lectures on Zoom. Synchronous teaching was used when providing both lectures and studio sessions. Digital ink helped use the digital whiteboard smoothly and replaced the physical classroom whiteboard.
- In planning for an interactive online teaching approach, it was decided to maintain the contact hours of teaching and studio sessions as per the original timetable, though online rather than in a physical classroom.
- Informal opportunities for students to discuss modular issues ('Office hours') were arranged upon request, either through chatting by text or using audio/video short sessions for further interactive discussion.

Discussions between the tutor and students took place privately on the MS-Teams platform to enhance students' engagement and provide pastoral care.

D. *Lecture preparation during the outbreak*

The total number of students enrolled for this module MEC 2131 Design and Manufacture 1, was 65. Before starting the trimester, the government rule was allowing lectures to be online (as students enrolled were more than 50), but studio sessions with the capacity of 50 students can take place on campus with a group size limit of 5. Considering government rules, we planned to deliver lectures online and studio sessions with two different teams having 33 and 32 students, respectively, on campus. Students were divided into groups of 4 or 5 on each team. xSiTe was used as a learning management system to upload the module brief, profile, and all other details.

Fortunately, all students enrolled in this module were domestic students only. In the first teaching week, a student representative was nominated by students to facilitate communication among the students and the convenor for each team. Online lectures were delivered using Zoom and PowerPoint, recorded, and later uploaded for students' reference on xSiTe. The students used their own devices and internet connections to access the teaching material and engage in the live classes. All students confirmed that they were able to watch the uploaded videos smoothly. The virtual classroom was booked on Zoom, and the invitation was sent to all students through announcements on xSiTe. Studio sessions were conducted physically at the campus. After two weeks, due to the sudden rise in the number of Covid patients, government rules were changed, and now just a group of 2 students can work together, and studio sessions are also not allowed on campus. So suddenly, there was a change in teaching pattern, and have to shift studio sessions also online along with lectures.

E. *Online lecture delivery*

We followed the timetable and Zoom platform to conduct live lectures announced before starting the trimester for lecture delivery for 1 hr per week. We also took advantage of different features of the Zoom platform, such as chat, polls, quizzes, whiteboard, raising hands, and many more. We asked questions, shared recorded lectures, and shared annotated slides using electronic ink during classes to support palliate students' issues.

F. *Studio Session*

During the studio session, students were expected to work on some projects. Studio sessions are used to reinforce and deepen understanding of the module material. Students are expected to actively participate in the studio and go through provided study material to teach themselves relevant skills in Mechanical Engineering. Concepts from "Team-Based Learning" are used. Students work in groups on a project involving knowledge learned from the class and applying the outcome from the weekly studio. For both groups, the pre-planned timetable was also followed for delivering studio sessions online using Zoom and many features of it. In addition, the discussion took place with individual teams on their weekly progress for the given project using breakout rooms.

Students were asked to submit an interim report, interim presentation, logbook, final report, and final presentation in xSiTe folders as a part of the assessment. Also, an online quiz was conducted at mid of trimester as a part of the assessment.

IV. METHODOLOGY

The current study mentioned in this paper attempts to understand how MEC 2131 Design and Manufacture 1 students perceive various online learning tools to help enhance their sudden learning change during the covid-19 situation. In this study, a questionnaire was designed using google form and given to all 65 students who enrolled in the module, and Forty-five students completed it. Students answered questions regarding the teaching method's helpfulness, the technology used for teaching, student engagement, and student preferences.

The invitation to participate in the survey was sent to all students as an announcement on xSiTe, with a few follow-up reminders. Around 70% of students completed the entire survey.

V. RESULTS AND DISCUSSION

The survey questionnaire responses are described in the following paragraphs.

The students were asked to provide their feedback to know if their intervention was successful following questions were asked using a rating. (Students need to give their answer in terms of rating from 1 to 10, where one is least helpful, and ten is most helpful, Except for the question. 3, which is an open-ended question.)

1. Did you find it easy to use online technology?
2. Did the online, live lectures used in this subject help you learn effectively?

Results on learners' perception of the Questions listed above are illustrated using an excel clustered data chart below in Fig1.

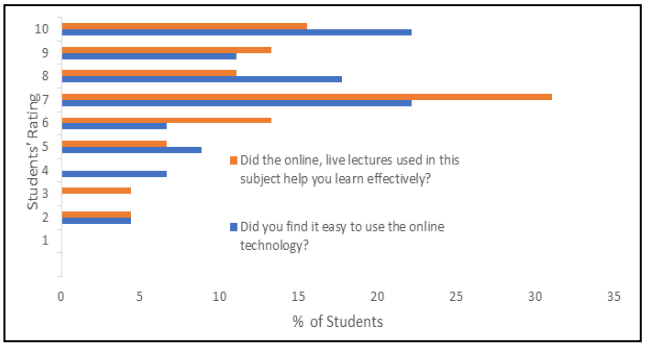

Fig. 1. Students' response to the success of online technology and lectures.

Around 73% of students rated seven or higher than seven as their satisfaction rating out of 10, where ten is most helpful. Students felt that they found the technology easy to use, and online live lectures helped them learn effectively.

The student mentioned that this module delivery is better than other modules as it focuses more on communication and brainstorming with peers instead of utilizing much technical understanding than other modules. Students praised about effort taken by educators to teach them online. These results reflect that online live lectures will be one of the motivations for students' engagement during online course delivery.

To understand which tools were more impactful for students' online learning following questions were asked during the survey.

1. Did you feel that the use of the electronic whiteboard improved your learning experience?
2. Do you think that the teacher's annotations on the lecture slides advanced your understanding of the content?
3. Were the live lectures better than the prerecorded lectures for helping you learn?

The results are presented in Fig. 2 below.

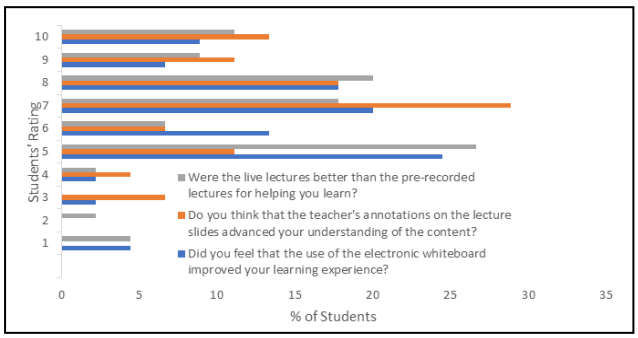

Fig 2. Evaluation of students' preferences

Around 91% of students were satisfied with using a whiteboard during their online module delivery. 89% of students preferred annotations on lecture slides during lectures for more understanding. 91% of students preferred live lectures over prerecorded lectures by rating either five or higher on a scale of 10 as most helpful. This result demonstrates that using a whiteboard and annotation on lecture slides is considered the most helpful tool in their learning. Also, annotating slides during lectures improves their understanding of the concept, and more preference is given to live online lectures over prerecorded lectures.

Students were asked to rate their experience with distraction during online class compared to in-class learning.

The results are presented in Fig. 3 below.

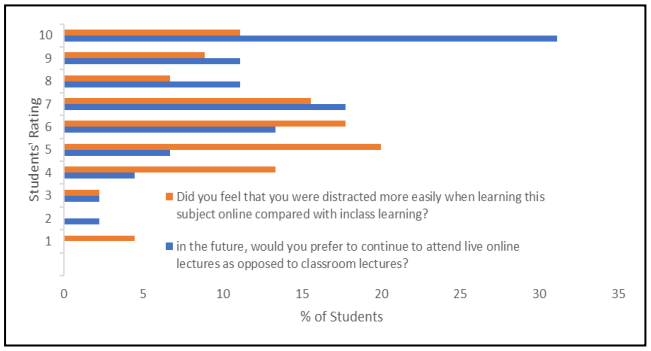

Fig. 3. Student Preferences and Distractions

Around 80% of students found no or some distraction during online lectures, and thus it seems that students are happy to replace in-class studies with online studies if it's a matter of distraction. Also, in the response on future preference to replace classroom lectures with online live lectures, almost 91% of students are ok with going ahead with the online live lecture.

Some of the responses we got on the open-ended qualitative question, 'You felt this module was better or worse than other modules taken online? Why?' were listed below.

"*It was alright because we did not have to create a physical prototype.*"

"*Better cause it's more on communication and brainstorming with peers instead of utilizing much technical understanding compared to other modules.*"

"*Better since it is interesting and has practical uses in life.*"

"*Better, the subject is theory and project-based, which can be easily clarified through zoom.*"

"*I think that online lecture is useful because it is recorded, and it can be reviewed again.*"

VI. Recommendations for Future

Considering the students' responses to the survey and their comments, the following essential recommendations are presented:

1. Online technology for learning is simple if the institution selects the platform very carefully.
2. Online live lectures are more efficient than prerecorded lectures during online teaching as students find themselves more engaged in live lectures.
3. Simply delivering a lecture like a webinar will not be effective, so teacher annotations on slides during the online live lecture were considered the most helpful intervention in students' learning.
4. It turns out that live online lecture improves students' engagement compared with prerecorded lectures. Therefore, live online lectures should be the priority for effective online lecture delivery.
5. Aiming for comfortable and engaging online learning during education disruption, a combination of online live lectures with an electronic whiteboard and slides annotations will be much more beneficial. Uploading learning material in advance for students' use, prerecorded lectures, supporting videos, and extra notes will help students prepare in advance, leading to a highly engaging class.

VII. Reflection

The results contribute to the field of engineering education through a theoretical framework that guided the data collection and analysis, which in turn confirmed the suitability of the proposed framework. The study reflects the most important factor influencing students' readiness for any sudden disruption is effective communication between tutor and student at every stage is very important to help students understand the need and benefits of the change. It is interesting to note that the result of this study allowed us to discover new dimensions in the online teaching of engineering modules. During the pandemic period of Covid 19, as mentioned before, online education was implemented using different technological tools and methods available. As a result, at the university level, many modules are developed using digital learning techniques, including e-learning platforms, video conferencing, video recording using annotation, voiceover slide presentations, computer-based simulations, online examinations, etc. With growing awareness and competence of digital learning skills by faculty members, integrating these

methods to support students learning will be an ongoing trend for the future of engineering education.

On the other side, the survey and module results confirm that this synchronous online learning approach is very effective in achieving the mentioned learning outcomes as students collaborated for learning very well by using the zoom platform, breakout room, and also live chat using Teams. During the presentation at mid-term and the end of the term, students communicated their design ideas very well to all via an online oral presentation.

VIII. Conclusion

In this study, we sought to explore students' (learners') experience of going through online live lectures and studio sessions during Education disruption developed due to the sudden change in government policies for Covid 19 situation. The effectiveness of this approach was measured through a survey conducted with students at the end of the trimester, and it has been evaluated based on the survey results presented in the results and discussion. From that, we can conclude that students found themselves comfortable using technology and engaged well with technologies to gain subject knowledge during online learning. The approach adopted by universities and educators was adopted easily by students and helped achieve the learning outcomes. Even though students are happy to continue with a similar approach in future learning, we may find some differences between students' preferences for the use of different online learning tools as well as we as an educator need to keep in mind that students' perception of online learning may change over some time according to the situation.

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