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Student Perspectives on Face-to-Face vs Online Learning During COVID-19 Times in Biomedical Engineering: Reflections from Singapore

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ABSTRACT

This paper aims to understand undergraduate and graduate students' perceptions and reception towards the use of online learning for a biomedical engineering technical elective module. Students were asked to provide their opinions comparing their experience with online remote learning to face-to-face learning. Results were split, with students raising points on flexibility, student engagement, asynchronous learning, impact on mental health, quality of education, learning infrastructure, assessment methods, and the intrinsic value of universities. While feedback showed generally positive experiences with online learning, many of the students showed a preference for a shift back to face-to-face learning. Regardless, the feedback suggested a need for improvements in the implementation of both online learning and face-to-face learning, which may also be combined to further improve learning experiences and students' mental wellbeing.

Keywords: Online learning, asynchronous learning, synchronous learning, COVID-19, tertiary education

INTRODUCTION

Almost two years have passed since the first case of COVID-19 was confirmed in Singapore (Ministry of Health, 2020). The outbreak has affected the whole population and brought changes to the way we learn, work, and live in general. Since February 2020, in response to an increasing number of cases, universities in Singapore have moved swiftly to provide education and learning through online platforms. By April 2020, following safety restrictions, online learning became the default for most modules. The shift to online and remote learning was aimed to curb local COVID-19 transmissions, and also allow staff and students to continue participating in teaching, learning, and assessment (TLA) activities even if they are overseas, under quarantine, or serving self-isolation orders.

While online-based educational tools such as lecture recordings, online assessments, learning management systems, and blended learning activities have long been used to assist teaching, the main teaching mode in most universities has remained face-to-face up until the start of the outbreak. The COVID-19 pandemic pushed for a sudden shift to fully online learning. Recent literature discussing student responses to this rapid shift found mixed reviews, with students identifying both advantages and disadvantages of online learning as compared to face-to-face learning. Similar points were found in studies held in India (Agarwal & Kaushik, 2020), Pakistan (Mukhtar et al., 2020), Poland (Bączek et al., 2021), and Indonesia (Giatman et al., 2020), suggesting similar experiences across the globe. Though it was understandable that online learning was the only way to go at the peak of the outbreak, the situation has much improved. In Singapore, the outbreak has remained mostly controllable, and the continued use of online learning was met with some criticism from students.

Thus far, only limited studies have been performed on the online learning experiences of tertiary students in Singapore. This Article aims to analyse feedback from students to understand their perceptions and reception towards the use of online learning in university-level education as compared to face-to-face learning, during the COVID-19 outbreak. Arguments regarding learning flexibility, quality of education, learning infrastructure, student engagement, learning satisfaction, preparedness for work, and the intrinsic value of universities will be discussed further to compare the two learning modes. The last part of this Article will also dwell on students' suggestions and expectations for the use of online learning in the post-COVID era.

LITERATURE REVIEW

Online or remote learning is defined as synchronous or asynchronous learning environments that utilise different devices with internet access and are accessible from anywhere (Singh & Thurman, 2019). The literature on online learning is mainly focused on accessibility, flexibility, learning pedagogy, and lifelong learning. It is widely acknowledged as a method that allows teaching-learning processes to be more student-centred, innovative, and flexible (Reese, 2015; Dhawan, 2020).

The shift from face-to-face to online learning, especially one that was abruptly propelled by the pandemic, is termed emergency remote teaching (EMT). Hodges et al., (2020) defined EMT as a temporary shift of instructional delivery to an alternate delivery mode due to crisis circumstances. In this case, the primary objective is not to create a completely robust online education system, but rather to ensure continuity in the delivery of instructional support, while maintaining that classes will return to face-to-face format when the situation improves.

Especially during a pandemic, when cross-border travels are limited and social distancing is key to curbing disease transmissions, accessibility and flexibility are huge advantages that online learning has over face-to-face learning. These two characteristics allow students and lecturers to continue participating in TLA activities from anywhere at any time, allowing more freedom in scheduling and minimising disruptions (Dhawan, 2020).

Above that, this "anytime-anywhere" feature also allows a greater diversity of students taking an online course, and may create a learning environment that is rich in communication, collaboration, and community (Reese, 2015). That said, studies have found that students may feel a lack of community (Singh & Thurman, 2019) and be socially disconnected and isolated in an online learning environment (Phirangee & Malec, 2017).

There are still doubts about the quality of online learning, especially whether it is rigorous enough for implementation in higher education (Reese, 2015) and the extent of skill transfer, both technical and non-technical (Bączek et al., 2021). Previous literature reported that students may feel a lack of opportunities to develop soft skills, as it is often overlooked in online learning curriculums (Tseng et al., 2019). On technical skills, numerous studies with undergraduate and graduate students reported negative feedback on the lack of hands-on experience when online learning is the default (Mukhtar et al., 2020; Bączek et al., 2021). However, it is also important to note that the effectiveness of learning does vary greatly in each individual learner, owing to the increased flexibility and learning independence. Especially in online learning environments, a student's academic self-efficacy is a determining factor of their academic achievement (Cho & Shen, 2013).

In the implementation of online learning during the COVID-19 outbreak, student feedback has been generally positive. When used in teaching medical students in India, the feedback indicated that online learning is relevant to their learning needs and clinical practice. Students also suggested that online classes should be made a part of the medical postgraduate curriculum and that online learning has a good impact on students' morale by creating a diversion from the ongoing pandemic situation (Agarwal & Kaushik, 2020). However, this does not come without issues. Students experienced connectivity and technical issues during their online classes (Agarwal & Kaushik, 2020). Similarly, students in Indonesia also highlighted unstable Internet connectivity as the main barrier to online learning, with 82% of the research participants identifying such concerns (Giatman et al., 2020).

However, the issues faced by students in countries where the majority of the population has stable Internet access and the necessary infrastructure to join online classes tend to differ. Muilenberg and Berge (2005) highlighted that in developed countries, cost and access to the internet are considered less important barriers to online learning. Experiences also differ depending on the university's readiness to shift to online learning. Singapore, having had experience with the SARS outbreak in 2003, was much more prepared to respond to the situation, both from the public health and academic standpoint (Lin et al., 2020). Universities in Singapore already have the necessary infrastructure, such as online conferencing platforms, recording systems in lecture halls, university-wide Internet connection, and a learning management system to directly shift to online learning. Above that, lecturers were also told to always be prepared to shift to online learning in case an outbreak or natural disaster were to occur. Students themselves were also used to accessing class material through personal laptops or tablets. A survey found that most students did not encounter major problems, and were mostly concerned about the complexity of online assessment proctoring and changes in the grading scheme (Åhag et al., 2020). This is in contrast to concerns about online learning readiness, specifically, the lack of infrastructure and experience with online learning, which were raised in studies held in other countries (Åhag et al., 2020; Dhawan, 2020).

Instead, concerns about how online learning during this pandemic may impact learning motivation (Åhag et al., 2020), learning satisfaction (Muzammil et al., 2020), mental health, the theory-skill gap, and readiness for work (Dhawan, 2020) seem to be highlighted to a greater extent.

Moving forward, as borders reopen and vaccines become more available, the obvious expectation is that schools and universities shift back to mainly face-to-face learning. However, online learning has its set of advantages, and various literature suggest that online learning has opened up new possibilities for borderless collaboration, communication, and learning that may improve tertiary education (Sim et al., 2021). Studies also found that outcomes from online learning can be comparable to face-to-face learning (Pei & Wu, 2019).

For that reason, rather than reverting to the status quo, it may be worthwhile to consider a new normal that would improve on previous practices.

METHODOLOGY

The study involves undergraduate and graduate engineering students taking a technical elective module, BN5208 "Biomedical Quality and Regulatory Systems", that dwells on the essentials of medical device quality systems and device regulation, as well as the role of engineering professionalism, ethics, and social responsibility in AY2020/21, at the height of COVID-19. There were 61 students enrolled in BN5208, of which 42 responded to the feedback exercise providing varying amount of qualitative data. Students were asked to compare their experiences between online learning and face-to-face classes. No personal information was collected. Students were asked to describe the pros and cons of both teaching methods and their expectations, as well as recommendations for implementing online learning in the post-COVID era, with regard to BN5208 and other modules they took previously. Qualitative feedback from students were tabulated under various sections/categories as described in this study later. Students were also asked if online remote learning may be the way to enhance the effectiveness of the teaching-learning process, or whether a judicious combination of both teaching strategies may be better.

Context: Technical elective on medical device regulation

For Semester 1, AY2020/21, BN5208 was conducted fully online. Zoom was used as the main online teaching platform, and the module's lecture and tutorial sessions, which were previously separated, were combined into one three-hour live session weekly. These live sessions were recorded, but students were only given access to the recordings a week before the final quiz. With regard to assessments, the final quiz was open-book and proctored through Zoom. Post-lecture discussions, which involved case studies and the final project presentation, were also held online through Zoom.

RESULTS

Advantages of online learning

Students' reflections highlighted improvements in flexibility, student engagement, and mental health, as well as a high preference for the availability of asynchronous learning in the form of recorded lectures. Excerpts of students' feedback can be found in Table 1.

Table 1
Students' comments on the advantages of online learning

Themes	Sub-themes	Excerpts
		Advantages
Flexibility	Location	"They are much more convenient as compared to physical classes as they can be taken from the convenience of their own homes, or even in public areas with internet access."
		"Online learning has also encouraged the use of online meetings for group projects. I can honestly say it's way more convenient than having to agree on a meetup location and travelling to that location for the meeting."
	Time	"Student could allocate the time required for travel to more productive purposes."
		"It is more convenient to get ready for class and it has definitely improved attendance."
	Safety	"Online teaching is suitable for theoretical modules and allows for modules to be held safely during the pandemic."
Student engagement	New methods of communication	"There is a broader range of participation opportunities which are good for students who are introverted. In the online lectures, we can ask questions both verbally and by chat tools, privately and publicly."
	Student-led discussions	"It is easy to create break-out rooms to encourage discussions between students and allows kinesthetic learners to better understand the topic, rather than merely listening throughout the lesson."
	Increased interactions	"During Zoom presentations, people are more willing to pose questions to the presenters."
Personalization of learning experiences	Asynchronous learning	"I can appreciate being able to study the lesson materials at my own pace. This reduces some stress."
	Ease of reviewing content	"Recorded lectures provide students the opportunity to review the content being taught, especially for modules with final exams."
	More adaptable	"There is a lot of noise during the day due to constructions and other family members working from home. Recorded lectures allowed me to review the webcasts later at night when these environmental factors were all not present and I could properly focus on learning."
Mental health	Comfort	"The independent quiet learning from their homes was a more conducive environment to learn."
	Less pressure	"At home, I feel that I learn better as there is no pressure from the surrounding environment."

Disadvantages of online learning

In contrast, some students also felt that the quality of education, student engagement, and the overall value of university education had decreased with the shift to online learning. They also experienced issues with inadequate infrastructure and how assessments were held. In addition, while some highlighted how online

learning improved their mental health, others disagreed and instead felt that online learning caused isolation and emotional distress. Excerpts of students' reflections on the disadvantages of online learning as compared to face-to-face learning can be found in Table 2.

Table 2
Students' comments on the disadvantages of online learning

Themes	Sub-themes	Excerpts
		Disadvantage
Quality of education	Lack of hands-on training	"We were not able to carry out the real experiment and were instead given data and lab videos. I couldn't fully get the sense of experiments as compared to a normal lab session."
	Lack of opportunities to improve soft-skills	"Soft skills such as picking up on someone's feelings during conversations and public speaking will be missed out on digital lessons."
	Dependency on each individual student	"The quality of the lecture is solely dependent on how the student manages it. Some just logged into zoom pretending he/she is listening."
Student engagement	Limited discussion	"Communications and discussions tend to be one-sided which may not be ideal for classes that rely more heavily on analysis and questioning."
	Lack of physical cues	"In-class demonstrations that would be most effective when students were able to observe them in person. E-learning takes away the interactivity in learning, it makes the content duller and more difficult to understand."
	Limited attention span	"With a lack of dynamic cues, students may find it harder to stay interested in the lesson."
		"As students study with their own laptop, they may easily be distracted or even be tempted to perform multitasking."
	Increased cognitive load	"It feels draining and it is hard to concentrate as lectures and tutorials are now combined into one 3-hour slot."
Infrastructure	Home environment	"With the whole family working/studying from home, I do not have an adequate space to study."
	Technical issues	"Unpredictable situations such as service outages may occur. Such situations cause stress for students, especially during online assessments and meetings."
Assessments	Exam set-up	"It is hard to set up two cameras and even so there is still a possibility of cheating as it is hard for invigilators to check each individual student."
	Concurrent deadlines	"Some modules choose to replace exams with projects but fail to account that the ending datelines are way too packed. There is usually a break between the exam weeks and the final instructional week but now all deadlines are set before the break."
Mental health	Isolation	"Remote learning may make students feel isolated and alone in their learning. Being unable to physically meet classmates deprives students of a source of emotional support and a sense of togetherness."
	Emotional distress	"Online exams cause me severe emotional distress as half the time besides worrying about the content, I would need to worry about whether the zoom call is dropped due to poor internet connection."
	Burnout	"With group meetings being mostly online, I felt that people expect others to be available even outside the normal school hours, blurring the line between my study and personal time."
Value of university	Lack of networking	"The social aspect of university and opportunities to network between peers and with lectures becomes inexistent."
	Decreased satisfaction	"Online learning devalues my experience and university education for me now is just really similar to other online learning platforms like Khan Academy and Coursera."

Recommendations

As can be seen in Table 3, student feedback highlighted the need for improvements in both face-to-face and online learning in terms of teaching methods, assessment methods, and learning infrastructure. Students mentioned that a hybrid approach—one that includes both face-to-face and online learning—might be beneficial in allowing students to learn at their own pace. With regard to the class itself, students showed preference towards shorter lecture sessions with multiple breaks in between, as well as the use of technology-enhanced learning (TEL) methods such as gamification and scenario-based learning (SBL) to reduce cognitive load and increase engagement. Moving forward, students also hoped for a clearer progress outline and a better explanation of the learning objectives so that they are able to stay on top of their learning progress. Above feedback for modules, students also highlighted the importance of having a clear assistance framework with regard to technical, academic, and mental wellbeing issues. Finally, while feedback towards online learning has been fairly positive and its use has been understandable in times of a pandemic, students still showed preference towards a shift back to face-to-face learning, especially for hands-on classes and implementation of assessments.

Table 3

Students' recommendations for the post-COVID era

Themes	Sub-themes	Excerpts
		Recommendations
Teaching	Hybrid learning	"Allowing both face-to-face and online asynchronous learning will be beneficial as it allows students to learn at their own pace."
	Recorded lectures	"Students may miss certain parts of the lecture due to unforeseen circumstances such as health and technical issues so it is best to have recorded lectures at least for revision before the exams."
	Reduce cognitive load	"Split lectures into 'bite-size chunks' and include breaks between sections to allow us to rest and absorb the information."
	Improve engagement	"Pilot new modes of learning through the use of gamification techniques or introducing game design elements such as leader boards and mini-competitions for the class."
	Guided interactions	"Facilitate group discussions where groups will have different people more often, include points to discuss, and choose someone to share their discussion afterwards."
	Hands-on classes	"Small groups of lab sessions and tutorial sessions go on if possible. Otherwise, at least record and explain clearly the steps of data collection so students understand better."
	Progress outline	"Implementing a concrete progress report would decrease confusion and allow students to better track their learning."
	Clarify learning objectives	"Explain the aim of each lecture, project, and/or task so that students understand why certain things are done the way it is."
	Immediate feedback	"Encourage students to ask more questions during lectures so it can be discussed together."
Assessment	Ensure attentiveness	"Include short questions for the students to answer at the end of the lectures, to test their attentiveness during classes and to see how well they understood the topic taught."
	Shift back to F2F	"As much as possible, it will be ideal if exams are conducted in person."
	Improve exam integrity	"If online exams were to continue, use two cameras to record the session, jumble up questions and answer options, give a short time limit per question to reduce chances of collaboration and ensure that the test is conducted fairly."
Infrastructure	Sound quality	"Mic quality is especially important to ensure that students can understand what the lecturer is saying."
	Assistance framework	"Clearly outline support channels for all possible issues such as technical, academic, and mental wellbeing."

DISCUSSION

This study reflected on students' experiences with online learning and face-to-face learning, comparing the advantages and disadvantages of the two learning modes, as well as recommendations moving forward.

The current study found that students perceive online learning to improve learning flexibility and allow better personalisation of learning experiences. Feedback on its implementation during this pandemic was mostly positive, with students acknowledging online learning as the best option given the current situation.

However, they highlighted that the shift to online learning led to a lack of practical and soft skills training. The online setting also means fewer networking opportunities and limited student life events, components that students perceived as intrinsic values to tertiary education. There also lies issues with a lack of adequate home environments and unpredictable connectivity, both of which caused much stress during assessments.

As such, while the majority of student feedback respondents responded positively to online learning, they are hoping for a gradual shift back to face-to-face learning as the condition improves. Other points on student engagement and mental health were also raised, but the results were varied, seeming dependent on each student's personality and learning style.

From the feedback, it can be observed that, in comparing the two teaching modes, students place great importance on having control over their learning experiences, as well as having adequate technical, academic, and mental wellbeing support.

Personalisation of learning experiences

Online learning allows for greater autonomy and personalisation of learning experiences in which recorded lectures provide students with the opportunity to review or catch up with the content should they miss any parts, be it due to technical issues or otherwise. Recorded lectures allow students to at least be at ease, knowing they can review the content later. In addition, some reported not having the adequate infrastructure to focus during live online lectures as they share the home living space with their families. The availability of asynchronous learning in the form of lecture recordings makes online learning a more adaptable choice compared to face-to-face learning.

However, not all students place personalisation of learning experiences as an advantage. With recorded lectures and increased learning flexibility, there is a greater degree of self-regulation involved. The quality and effectiveness of lectures now solely depend on how the student manages them (Cho & Shen, 2013; Cheng & Xie, 2021). Some students in our study find this newly gained flexibility to be unnecessary and encourages procrastination, a point also raised in previous studies (Quinn & Aarão, 2020). That said, most students from this study and previously published reports still support its implementation (Moore et al., 2017).

Technical issues

Technical issues have been noted time and again as potentially being a source of stress to students' online learning experience. While Internet access is not an issue for most, if not all, Singapore university students, unstable and unpredictable connectivity remains a concern and can be a huge stressor to students, especially during assessments. At times, there were also unpredictable technical issues with the conferencing application and students felt that there is a lack of technical support provided by the university.

With everyone being in different locations, both students and lecturers were unsure who to contact for help should they experience any disruptions. The responsibility of ensuring a smooth proceeding falls back on the individual, something that would not be the case in face-to-face classes where the university's IT team will be able to provide support.

Academic

Perceived change to academic outcomes was varied. Some reported improvements in engagement with online learning as there are multiple ways to participate in the lecture, be it directly speaking up or indirectly through the chat function. The breakout room function in Zoom also encouraged discussion between students. Some reported that they were more engaged during these small-group discussions and were truly understanding the content rather than only passively listening to the lecture.

However, previous studies found that while attendance and punctuality increased with the shift to online learning, students tend to only be passively present during an online lecture in which they are listening but not learning (Ganigara et al., 2021). With the use of laptops being central and inevitable in an online class setting, online distractions were easy to access. Several students also found that online learning limited discussions as conversations tend to be one-sided, where only one person talks while the others mainly listen.

Some students also highlighted that online learning is not suitable for technical modules as there is a lack of hands-on practical training. While there are cases of virtual laboratory sessions successfully replacing hands-on sessions (King et al., 2020), there are still concerns highlighting the theory-skill gap, especially in majors that are technical skills-heavy in nature (Greenway et al., 2019; Mukhtar et al., 2020).

Students also raised concerns about the lack of opportunity to develop soft skills and build meaningful networks, two aspects that are important determinants of a student's employability. With the lack of social interaction, both between peers and with lecturers, students find themselves deprived of opportunities to form new relationships and experiences. This also affects students' satisfaction with their university experience as most expect universities to provide opportunities to not only learn and gain skills, but also to build valuable networks (Muzammil et al., 2020). With online learning as the main teaching method, a few students have likened their university experience to non-degree online courses. While those have their own set of advantages, students who enrolled in a physical university expect more than theoretical education when they agreed to the much higher tuition fee.

The findings in our study suggest that the lack of active attention is linked to the decreased interaction between students and lecturers. With the lack of engagement and interactivity, students mentioned that the content felt duller and harder to understand. Students have a limited attention span and with the content being less engaging and classes being longer, they are more likely to be distracted (Hassan et al., 2021). By extension, interaction and student engagement are also linked with their learning satisfaction. The absence or lack of student engagement devalues a university and may affect not only learning outcomes, but also dropout rates, retention rates, and graduation rates (Muzammil et al., 2020).

Mental wellbeing

The impact of online learning on students' mental wellbeing was also varied. Some students found the increased learning flexibility to be more comfortable, with less stress and social pressure. The availability of the chat function in Zoom, which can be public and private, acts as a new participation method that some students would use to have increased discussions between the lecturer and their peers. This finding is also reported in other literature (Shim & Lee, 2020). Students also noted that the improved flexibility allowed them to have more control over their learning progress, decreasing overall academic stress.

However, others also mentioned that being at home for long periods of time resulted in increased feelings of isolation. Similarly, varied responses were found in Lazarevic and Bentz (2021). Above isolation, students also reported a decrease in study-life balance as the use of online conferencing tools made it more acceptable

to have discussions beyond normal school hours. With everything happening in the same location, the lack of separation between commitments and daily life may also be a cause for stress (Palumbo et al., 2021).

This stress tends to reach its peak during online assessments as students have to worry about technical issues on top of the course material. Previous literature reported changes in the grading scheme, concerns with assessment integrity, and complexities in setting up online proctored exams as a few main causes of stress (Åhag et al., 2020; Moawad, 2020). Above academic stress, the ever-evolving pandemic along with constant policy changes may also lead to an increased sense of uncertainty and stress (Wu et al., 2020).

In addition, with conversations being mostly one-sided, the lack of student engagement, especially in terms of physical and dynamic cues, can be draining, leading to a phenomenon known as 'Zoom fatigue'. The brain needs to exert more energy when people communicate through online platforms as compared to face-to-face interactions (Wiederhold, 2020). All these stressors may build up, causing anxiety and stress.

Recommendations for the post-COVID era

Recommendations focused on improving teaching methods, assessment integrity, and infrastructure.

Should online assessments continue to be inevitable, students mentioned that it would be good if the assessment questions and answers would be "jumbled up", and that a time limit be allocated for each question to prevent discussion during the assessments. Stricter proctoring protocols should also be implemented and made available for review should cheating allegations be raised. A recent study also recommended one-way navigation and implementation of different forms of the exam (Bdair, 2021). Whenever possible, however, most showed a preference for assessments to be done in person.

With online learning, lectures and tutorial sessions were merged into longer sessions. This increased students' cognitive load and combined with a lack of dynamic cues, proved to be a huge stressor for them. With regard to this, students suggested splitting the lectures into "bite-sized chunks", with breaks in between to allow students the opportunity to rest and absorb the information. They also mentioned that the inclusion of a short quiz would improve engagement and active participation. This is supported by Au (2020) who found that including interleaves—that is, alternating lectures with student activities—may improve student engagement.

With online learning, there are limited opportunities for students to build social relationships with their classmates. A student suggested that the lack of engagement stems from awkwardness between students in the class. As such, students suggested that lecturers facilitate guide interactions where students get to discuss a set of discussion points with fellow peers. Studies found that simultaneous reporting and setting clear expectations on the discussion outcome would ensure that everyone is actively participating (Liyanage et al., 2021). That is to say that from the start, lecturers should clearly define the discussion goal and allocate time for each group to share their findings. As discussed previously, mental distress in students seems to stem from academic stress. All these suggestions thus reflect students' hope for improvements in not only their academic experiences, but also their mental wellbeing.

Whenever it becomes possible to resume face-to-face classes, students expect improvements and the integration of components of online learning to improve on previous solely face-to-face practices. Students support the integration of asynchronous learning through recorded lectures on top of synchronous face-to-face lectures. They suggested that technical skills-based modules should be held face-to-face while theoretical concepts may be explained through recorded lectures. They also hope to see online-based technologies such as gamification and game-based learning be integrated into lecture sessions to improve student engagement. Through previous studies (Al-Azawi et al., 2016; Chen et al., 2020), the potential benefits of both are well established and acknowledged. The recommendations received suggested that students, having experienced

both learning modes, expect improvements in their learning experiences—both academic and non-academic—in the post-COVID era.

LIMITATIONS

Data collection was collected in the form of an optional qualitative reflection exercise with students from a single module (BN5208). Previous literature found that results from module feedback exercises tend to be skewed towards the positive, in this case online learning, which was BN5208's main teaching mode. As the feedback collected was completely qualitative and did not follow a standardised format, comparisons between online learning and face-to-face learning were based on each student's personal criteria. The findings from this study also only reflect user experience and perceptions towards the two teaching modes rather than their impact on learning outcomes. Thus, as mentioned earlier, this work emphasises the learning experience of students from multiple perspectives comparing traditional face-to-face teaching and online learning.

Further research with a broader range of participants, improved methodology and analysis, as well as pre- and post-testing is necessary to quantify students' perception and feedback towards the use of online learning to determine its importance for extended implementation in the future.

CONCLUSION

This paper analysed the perceptions of undergraduate and graduate engineering students in the NUS College of Design and Engineering (CDE) regarding the use of online learning as compared to the more traditional face-to-face learning during the COVID-19 outbreak. The student feedback received was mixed, with respondents highlighting advantages to online learning such as flexibility, student engagement, adaptability, and mental health, as well as shedding light on perceived disadvantages such as how online learning had a negative impact on quality of education, student engagement, infrastructure, mental health, and the diminished value of education. While their online learning experiences have mostly been positive, the undergraduate and graduate engineering students involved in our study indicated a strong preference towards a shift back to face-to-face learning. This is because they found hands-on practical skills training to be of utmost importance in engineering education. However, this does not necessarily mean that students considered face-to-face learning to be the better option compared to online learning. The feedback suggested a need for improvements in the implementation of both teaching methods, which may also be combined to further improve learning experiences, decrease academic stress, and improve overall mental wellbeing.

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