Issues and challenges of technology-enhanced learning during the Covid-19 era: a case study

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ABSTRACT: The conventional teaching and learning (T&L) approach involving face-to-face (F2F) classes and activities had to be adapted to the new norm of on-line teaching and learning, when the world faced the Covid-19 pandemic in March 2020. At the University of Technology Malaysia (Universiti Technologi Malaysia) (UTM), Johor Bahru, Malaysia, on-line T&L began soon after the onset of the pandemic and has continued to the present day. In this article, the authors focus on the challenges experienced by UTM electrical engineering students and instructors, including network connectivity, the learning experience and teaching transferable skills in engineering. The motivation to conduct this research was due to the drastic changes from F2F to on-line T&L. It was found that the mean Internet connectivity rate was more than acceptable for smooth on-line T&L throughout the country. However, the large standard deviation values show that there were differences in the students' Internet experience and accessibility. The results also showed that students had difficulty mastering the engineering skills when they were learned through an on-line teaching method.

INTRODUCTION

The world is still facing one of the worst health, economic and political crises it has seen in decades. The World Health Organisation (WHO) declared a public health emergency of international concern when a novel coronavirus disease known as Covid-19 was detected in December 2019 and subsequently announced a Covid-19 pandemic in March 2020 [1]. As the virus started to spread throughout the globe since it was first detected, Malaysia has not been spared from the rapid infection. Since the transmission is primarily caused by close human contact, to curb the infection, the Malaysian government declared a movement control order (MCO) on 16 March 2020. The MCO limits many activities, such as economic and social activities, including face-to-face (F2F) teaching and learning (T&L) in higher learning institutions [2].

For the University of Technology Malaysia (Universiti Teknologi Malaysia) (UTM), Johor Bahru, Malaysia, a new education form was introduced, whereby since 1 April 2020, T&L has been conducted 100% on-line. During the first few weeks of the 1st MCO, students were sent back home, leaving their hostels, which are located inside the UTM campus, and they continued their studies remotely from various locations outside the campus. Since the 1st MCO was implemented in March 2020, the T&L for the semester 2 session 2019/2020 was divided into two parts. The first part was F2F T&L in the classroom before the MCO, and the second part saw the migration to 100% on-line classes when the MCO enforcing on-line T&L was implemented. Hence, initially, many new T&L approaches were adopted that both students and lecturers had never experienced before, such as using on-line meeting platforms for on-line classes, virtual laboratories, on-line tests and using alternative communication tools, such as messaging services (WhatsApp, Telegram) to convey information to students remotely and quickly. This is a common scenario that occurred not only in Malaysia but also in other countries [3-5].

In this article, the authors present some of the issues and challenges of technology-enhanced learning that were faced by students. The motivation to conduct this research was due to the drastic change from F2F to 100 % on-line T&L. As this happened rather unexpectedly, students and instructors were in a state of uncertainty at first which negatively affected their mental and emotional functioning. In this article are discussed the access constraints, students' reflections on on-line or e-learning, and methods for teaching transferable skills in engineering. This study gauges the effectiveness of students' on-line learning experience by determining different qualities of connectivity for them, as well as it investigates how engineering or technical skills can be effectively transferred to students without F2F sessions.

Technical skills are hard skills that refer to capabilities that can be learned and measured. They are perceived to be connected to cognitive intelligence and relate to the ability to perform a particular type of activity or task [6]. The findings of this research can be helpful in better understanding the needs of UTM students both in terms of physical infrastructure, as well as in designing a method for effective T&L that is context-specific to the UTM, but that could also be applied to other institutions in similar situations.

LITERATURE REVIEW

On-line T&L is not a new concept, and it has been in place since the start of the Internet era, although at the beginning it was known as open access and distance learning. It has been suggested that on-line technologies via the Internet can help address issues of accessibility to educational opportunities. However, the lack of educational and technology infrastructures, lack of trained teachers, negative attitude towards distance learning, and lack of access to adequate learning resources and basic education limit the implementation of on-line T&L to realise its full potential [7]. Developing countries in particular still face some of these issues, and the Covid-19 pandemic while changing the educational landscape worldwide, has abruptly compounded the situation in those countries.

The transition from F2F to completely on-line T&L has taken a toll on both students and lecturers. Such a sudden transition can affect the quality of T&L, as well as the emotional state of its participants. Casacchia et al conducted research to determine the effects of distance education on the emotional conditions of lecturers [4]. The surveyed lecturers reported experiencing difficulties in regard to technical aspects and also emotional strain. Another work focused on the effects of distance learning on problem-based learning (PBL) tutorials during the Covid-19 pandemic [5]. The study aimed to compare the performance of students using distance learning PBL tutorials and conventional F2F approaches. The study found that students in the distance learning group had significantly lower scores in five areas of proficiency: participation, communication, preparation, critical thinking and group skills.

APPLICATION DESIGN

This case study was developed based on the data collected from the Biomedical Signal Processing (BSP) course at the School of Electrical Engineering, UTM, for semester 1 in 2018/2019, 2019/2020 and 2020/2021 sessions. Twenty-one students in session 2018/2019 and 18 students in session 2019/2020 attended the course via F2F mode, while 19 students via on-line mode during the session in 2020/2021. All students were in their final year, and the latter was their second semester of study under the MCO that had imposed on-line T&L. During semester 1 of the 2020/2021 session, the University allowed final-year students to return to the campus, if needed, to complete their final-year project. Thus, a fraction of the students (8 out of 19 students, 43%) decided to return to the campus and stay in the UTM hostels. One student had previously stayed in a nearby rented room before moving back to the UTM hostels. The remaining 11 students (57%) were in their hometown, staying with their family, where one of them previously stayed in a nearby rented room to UTM before deciding to go back home. Two students had to access on-line classes in public places as they faced constraints in their homes.

For session 2020/2021, T&L for the BSP class was conducted on-line via an on-line meeting platform using Cisco Webex for synchronous classes and the UTM e-learning platform for asynchronous classes. A total of 71% of the T&L was done synchronously, while the remaining was done asynchronously. Attendance was taken using an on-line Google Form, and students were required to key in their Internet connectivity details (download and upload speed, ping time and jitter time) each time they joined the on-line class. Outside the on-line class, two-way communication was established through a WhatsApp group. Meanwhile, quizzes were conducted on-line via the Socrative platform.

At the end of the course, an end-of-course survey was conducted via the UTM e-learning platform to gauge the students' perception and reflection on the T&L for the course. At the School of Electrical Engineering, the questions for the end-of-course survey are standardised for all courses and it is one of the feedback items used to gauge students' learning outcome attainment. One of the questions in the survey was designed as an open feedback form, where students could submit a text-based reflection on their experiences during the T&L process. This survey was then analysed and findings obtained. Other questions in the survey, such as student perception of their course learning outcomes attainment and private study hours outside contact hours, are not included in this study.
A summary of the application design is shown in Table 1.

Table 1: Application design summary.

No.	Item	Data type	
1	Course	Biomedical Signal Processing - BSP (SKEL 4533)	
2	Session	2020/2021 Semester 1	2018/2019 and 2019/2020 Semester 1
3	Students	Final year	Final year
		2nd semester studying under the MCO:	F2F
		• 8/19 students (43%) mostly stayed in the UTM hostels; • 11/19 students (57%) mostly stayed with family at their respective hometowns.	All students stayed in the UTM hostels.
4	On-line session	• 71% of T&L was completed via synchronous mode using Cisco Webex; • Remaining T&L was done asynchronously using the UTM e-learning platform;	UTM e-learning platform was used to share course materials and conduct the survey only (no asynchronous T&L).

		• Quizzes were conducted on-line using the Socrative platform; • Survey was conducted on-line using the UTM e-learning platform, where students submitted a text-based reflection on their experiences during on-line T&L.	
5	Attendance	On-line Google Form including Internet connectivity details (download and upload speeds, ping and jitter times).	Taken during the F2F session.
6	Communication channel	Mainly through the WhatsApp platform.	During the F2F session.

FINDINGS AND DISCUSSION

Access Constraints

Table 2 shows the Internet connectivity for all the students based on their area of residence during semester 1, session 2020/2021. The Internet connection quality was based on the Speed Test Web site provided by Telekom Malaysia Berhad. Students were required to perform the on-line speed test each time before the class session. The data were then submitted using a Google Form. Then, the connectivity was measured from the collected data in terms of statistical mean and standard deviation for all the connectivity quality parameters of ping, jitter, and download and upload speed.

Table 2: Students' Internet connectivity.

Access from	Internet connectivity			
	Ping (ms)[#]	Jitter (ms) [#]	Download (Mbps)[^]	Upload (Mbps)[^]
UTM hostel	23.83 ± 35.16	13.90 ± 36.20	30.24 ± 19.97	30.26 ± 23.10
UTM campus (ex. hostel)	11.00 ± 00.00	40.00 ± 00.00	93.40 ± 00.00	94.55 ± 00.00
Rented room near UTM campus	18.65 ± 14.64	7.00 ± 1.41	11.20 ± 5.80	3.90 ± 2.26
Public area	78.33 ± 97.50	8.33 ± 2.10	24.50 ± 0.50	9.17 ± 6.60
Home	54.90 ± 94.07	23.52 ± 48.28	20.62 ± 29.37	15.33 ± 18.69

*Note: mean ± std. dev. [#]lower is better, [^]higher is better

Referring to Table 2, the Internet connection quality varied based on location. For a good quality of service, the ping (latency) should not go over 85 ms [8], while the jitter should remain below 30 ms [9]. Based on these requirements for video streaming and VoIP, it was found that the home location had a higher ping (highest was public area) and jitter compared to other locations. The download and upload speed also depended on the type of broadband used. An acceptable download speed for on-line T&L is an average of 4.3 Mbps - 5.5 Mbps (peak) download bandwidth [10].

From the data collected, the download bandwidth was more than acceptable. Overall, based on Table 2, it is evident that there were access constraints for some students, especially those staying at home, compared to their peers who chose to stay on the UTM campus. To cater to students with a poor Internet connection, each on-line class was recorded and uploaded to the UTM e-learning platform. This allowed students to access the T&L material anytime and anywhere to facilitate their learning process.

Students' Reflection on On-line Learning Experience

At the end of the course, students were asked to give feedback on their on-line learning experience. Figure 1 shows a snippet of the UTM e-learning platform used to conduct the end-of-course survey, while Figure 2 shows the Web page when the link was clicked on. From there, there were options for an overview, questions editing, templates, analysis and to show responses. The questions asked were similar for all sessions except that the students of session 2020/2021 had an additional question on their on-line learning experience.

To view students' feedback, the lecturer needed to click on the analysis tab (Figure 3). There is also a download tab available to download students' feedback in spreadsheet. For session 2020/2021, 12 students provided their response, and while some students liked everything and adapted to the new way of learning, there were students who experienced difficulties, as their comments demonstrate:

- Kind of challenging to me to [do] the on-line learning.
- Limitation occurs because [we] use data from hotspot.
- Not too convenient due to Internet access during the classes but the initiative from the lecturers to record video during the classes [helps] me a lot.
- Challenging because on-line learning increases student laziness.

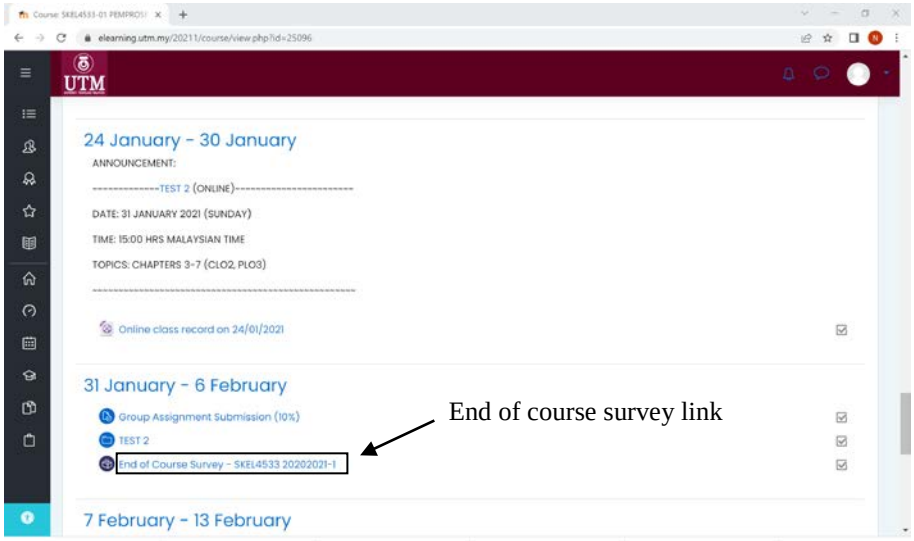

Figure 1: UTM e-learning platform.

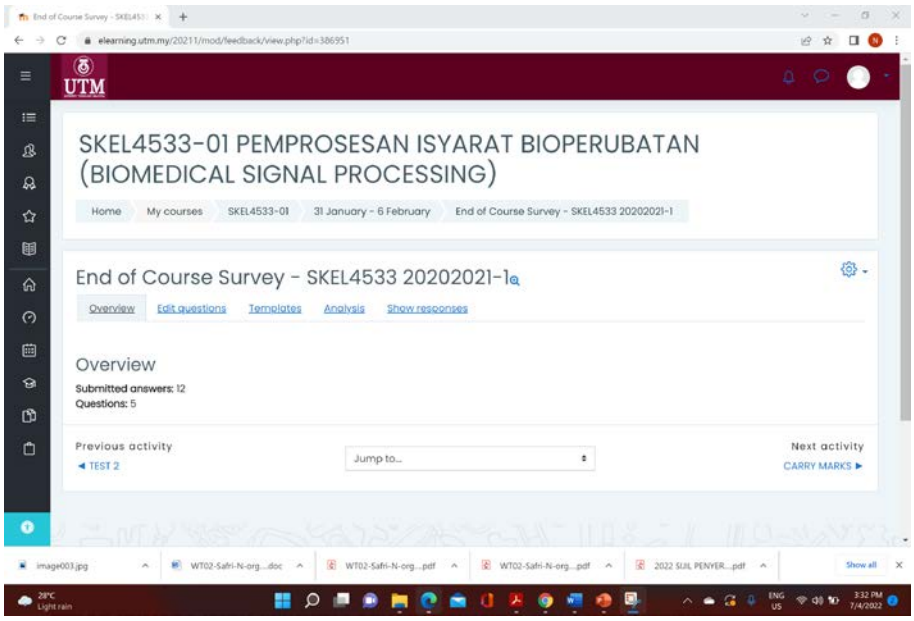

Figure 2: End-of-course survey interface in the UTM e-learning platform.

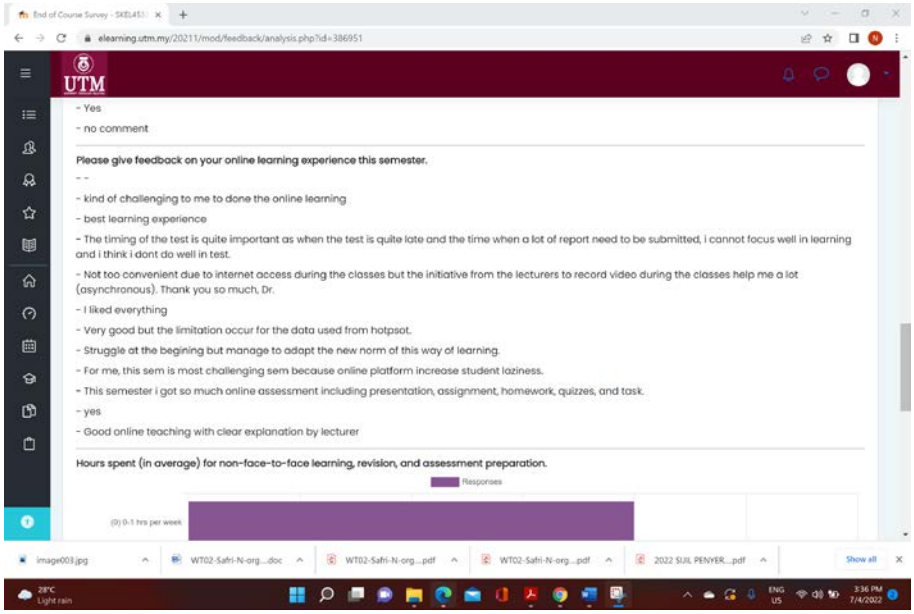

Figure 3: Session 2020/2021 students' feedback on their on-line learning experience as recorded in the UTM e-learning platform.

Even though some students enjoyed their on-line learning experience, some still could not cope with and adapt to this on-line technology-based T&L, even though, in fact, this was their second semester using an on-line T&L method. Based on one of the comments from the feedback, on-line T&L was challenging because it made the student lazier. Hence, the self-attitude of the student jeopardizes the effectiveness of on-line T&L. To counter this and to ease access constraints, it is suggested that lecturers develop asynchronous activities that help to increase the student's engagement with T&L. The UTM e-learning platform provides some kinds of activities that promote students' T&L, such as glossaries and lessons.

Teaching Transferable Skills in Engineering

Research has shown that people learn best by doing things and reflecting on what they have done, not by watching and listening to someone else telling them what they are supposed to know. Hence, in the BSP course, skills relating to the ability to perform critical analysis, such as in the problem of minimising error in signal analysis, are acquired using the MATLAB/Scilab/GNU Octave software tool, as biomedical signals are small signals with artefacts. Previously, to complete a certain assignment using these software tools, students had to programme and learned to analyse biomedical signals during F2F sessions.

All students were required to bring their laptops during the session, and the lecturer acted as a facilitator to assist students in their learning. However, since the learning of analysing biomedical signals using software tools took place on-line, a different approach was needed, as engaging students in on-line classes, while each student developed and ran their code during on-line class hours, posed quite a challenge. Therefore, a step-by-step tutorial video on how to develop simple coding to analyse biomedical signals was provided to students via the UTM e-learning platform.

Apart from that, students also watched and listened to the demonstrations given by one of the lecturers during the on-line class. Each student was given different biomedical signals with different parameters to analyse as their individual assignment, similar to previous cohorts.

The current results of students who completed this assignment were compared to previous cohorts who learned and developed analysis codes during F2F sessions (Figure 4). The maximum mark for the assignment was 5%. The cohort from 2020/2021 (on-line T&L) obtained 2.9, and 4 and 2 for the mean, maximum and minimum marks, respectively. Meanwhile, the cohort from 2019/2020 (F2F T&L) obtained 4.1, and 5 and 4 for the mean, maximum and minimum marks, respectively. Comparing these numbers, it is obvious that the F2F approach led to a better performance than the on-line lessons.

In another past cohort, from 2018/2019, students also achieved a higher assignment mark than the current cohort. The mean, maximum and minimum marks were 4.1, 5 and 2.5, respectively. One reason for higher marks obtained during the F2F facilitation sessions is that students obtained immediate feedback when they encountered errors or when they needed assistance, and since all students were present, they were able to learn from their peers as well.

Unless students can share their laptop screen synchronously, it is rather difficult to achieve the same level of F2F T&L for the same assignment on-line. To improve the situation, the lecturer needs to be more creative in designing the T&L that involves using software tools. One way is to break the process of analysing biomedical signals into smaller tasks and to use scaffolding.

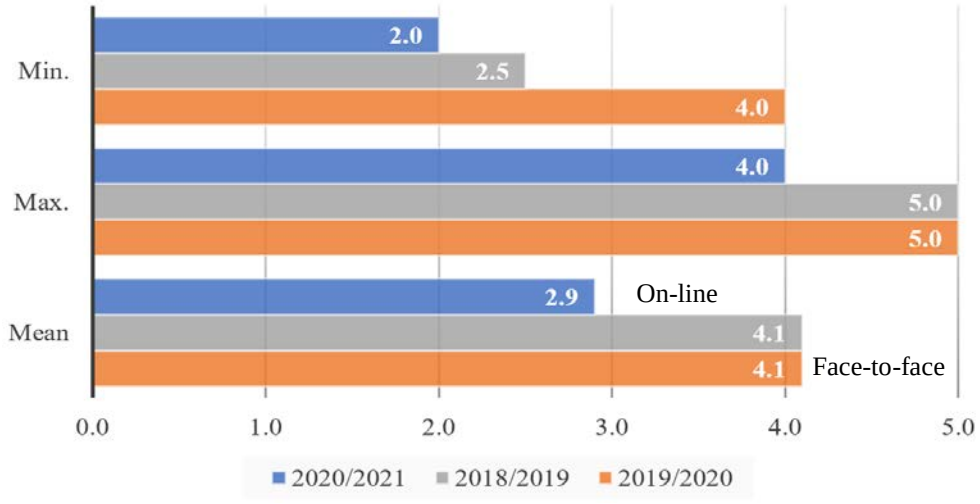

Figure 1: Assignment marks in percentages.

CONCLUSIONS

On-line T&L, as the new norm, can be made more effective if some of the key challenges can be addressed. The case study presented in this article identified the main challenges of both the instructors and students. To have a smooth T&L

experience, both instructors and students should have access to good network connectivity that includes low ping and jitter time and acceptable download and upload speeds, that is, to have favourable two-way communication. Poor connectivity will degrade the learning experience and the ability to perform webcam-based discussion, screen sharing or active on-line learning. Network connectivity largely depends on the user's location, whereby it is limited to fibre/cellular coverage areas or even data plans subscribed to by the user.

On-line T&L is affected not only by technical facilities, e.g. networks, but also by the quality of learning, which depends on personal and social aspects, such as students' mental state and motivation or their home environment. Perhaps, the adaptation to on-line T&L for all courses in a given semester and the implementation of movement control order by the Malaysian government, posed difficulties for final-year students in certain aspects of their study and life. The case study presented in this article also found that knowledge transfer and engineering skills acquisition, such as programming and analysis, are better through F2F compared to on-line learning. This was supported through the observation of the students' performance over three semesters. Hence, as a way of going forward, educators in engineering are encouraged to explore new methods in on-line teaching to enhance the delivery of transferable skills to students.

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