ADAPTIVE AND FLEXIBLE ONLINE LEARNING DURING COVID-19 LOCKDOWN

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ABSTRACT

The COVID-19 pandemic has adversely disrupted higher education. During March-May 2020, universities had to move from physical campuses to online globally to curtail the spread of the virus among students and staff which has restricted and prevented hands-on learning on campus. At Canterbury Christ Church University (CCCU), we have identified several challenges of online teaching and learning from observations and conversations with students: for challenges, students struggled as they had no face-to-face interaction with teaching and technical staff, no access to hardware equipment nor the campus library. Additionally, they had increased mental stress, digital poverty, reduced social contact with university life and experienced self-isolation. Opportunities on the other hand were identified as flexibility to study in a comfortable environment, better pace and time, cost-saving, access to more online resources as a substitute, new simulation tools for equipment. To incorporate the opportunities of online learning, we have implemented a multi-faceted approach to mitigate the impact of challenges of COVID-19 on the learning, teaching and assessment such as adaptable online live teaching (lecture and practical) session for synchronous learning and recordings of the live sessions, provision of pre-recorded sessions for asynchronous learning and online assessment formation, Virtual practical sessions to make them acquainted with software tools, Virtual CDIO (Conceive-Design-Implement-Operate) project sessions so that students could utilize the benefits of the CDIO framework and enhance their critical thinking to find an innovative solution while emphasizing team efforts and hands-on skill, a virtual engineering cafe for supporting students psychologically during the pandemic. Therefore, students could avail the benefit of flexible online learning, reduce isolation and increase accessibility to the learning, the teaching materials and the resources as per their pace, place and mode. In this paper, we have emphasized the above teaching strategies to develop adaptive and flexible online learning method.

KEYWORDS

Flexible online learning, online CDIO, professional skills, digital poverty, Higher Education, Standards: 6

INTRODUCTION

During the first wave of COVID-19, the education sector encountered many difficulties (UNESCO, 2020) because the majority of universities have had to close their physical campuses worldwide. Following the UK government lockdown guidelines, all higher education institutions in the UK were closed from approximately March to August. The move to off-campus learning restricted and prevented conventional face-to-face learning on campus; therefore, students are unable to engage in practical session such as hands-on training.

Around the world, academics responded rapidly, shifting programmes to online learning and increasing the development of online pedagogy learning (Huang et al, 2020). Online learning/e-learning is not a new approach and started in 1989. Nevertheless, the online educational programme is getting popular among people with part-time jobs and caring responsibility because it appears to be the only option for them to change their career/progression. Despite its prominence in web-platform, online learning has a major drawback such as a sense of connection as students feel detached from others and cannot share their experience.

In the UK, for engineering students, hands-on skills are identified as one of the important learning outcomes in most of the modules and it must be developed within the higher education curricula by the UK engineering council and accreditation bodies, (Engineering Council, 2014): universities must fulfil these required activities. To continue to support student learning and to fulfil the requirements of PSRB (Professional, Statutory and Regulatory Bodies), most universities, including Canterbury Christ Church University (CCCU), have switched to online teaching and learning platform during COVID-19 (Dhawan, 2020), and rapidly developed on-line practical learning (Bangert et al, 2020). There are several challenges and opportunities for online teaching and learning method (Adedoyin and Soykan, 2020). A review on online learning reflects the socio-emotional aspects of students (Delahunty et al, 2014). It shows that social interaction improves the knowledge-sharing capacity of students and encouraged them to build their own identity. Because of 'virtualness', students will lack social interaction and a sense of community. After conducting a qualitative study on university students, Gabriel et al, 2020 raised some positive sides of online learning. Although students expressed their feelings about missing social contacts with friends and lecturers, they observed some elements of e-learning is effective for the future because of time, flexibility and engagement. A multi-institutional research study (Carter et al, 2014) shows four important components of e-learning: human connection, IT support, design, and institutional infrastructure. There are few challenges of e-learning for both students and tutors such as insufficient technical support and training, inadequate instructional design support, lack of institutional support in educational sectors. To overcome these issues, adequate technical infrastructure should be built by keeping student learning experience at the centre and technological need in e-learning should be separated from administrative functions. After reviewing the challenges and opportunities of online learning, we have accumulated a few of those issues (shown below).

Challenges	**Opportunities**
• Poor engagement in study • Hard to stay motivated during this crisis • Too many online resources available and difficult to find the appropriate one • Unable to access the library physically • No face-to-face interaction with teaching and technical staff • Some classes require software/ hardware that is only available at the University • Mental stress • No communication with peers/sense of isolation • Difficult to organise a study group project / communicate and work as a group collaboratively • Digital poverty • Poor internet bandwidth • Losing social contact with university life	• Flexibility to study in a comfortable environment • Flexibility to work at a flexible pace and time • Opportunity to participate in classes from anywhere • No need to travel • Cost-saving • Have access to more online resources as a substitute; tutoring sessions moved online, and new simulation tool for equipment • Increased opportunities for extended virtual peer interaction beyond class time • Opportunity for 1 to 1 online session with the tutor • Continue to provide education for students self-isolating or shielding

At CCCU, one of the taught modules (delivered though online) was a programming module entitled 'Fundamentals of Computer Programming' for foundation year mechanical engineering students. In this module, we undertook several teaching strategies and considered it as a case study to improve the learning experience of students. As a part of the module learning outcomes, students should critically analyse how system interfaces to microprocessor/microcontroller and software programming, communicate and control peripheral components of an embedded system. Along with module-specific learning outcome, the course was supposed to incorporate professional skills (hands-on skill, teamwork, critical thinking, project writing skill), providing mental support while adhering to COVID-19 regulations. To achieve these objectives, the following learning and teaching methods were adopted to support the students during the lockdown such as flexible online teaching, virtual practical session, virtual CDIO project sessions and engineering cafe (Figure 1) The whole process was backed by the instructional infrastructure and IT support. The process of achieving technical/professional attributes is mapped with acquired activity (Figure 1). For example, flexible online teaching helped students to nurture their critical thinking through new type of knowledge, session on project writing skill while virtual CDIO project session enhanced their critical thinking, team effort, hand-on skill and project writing skill.

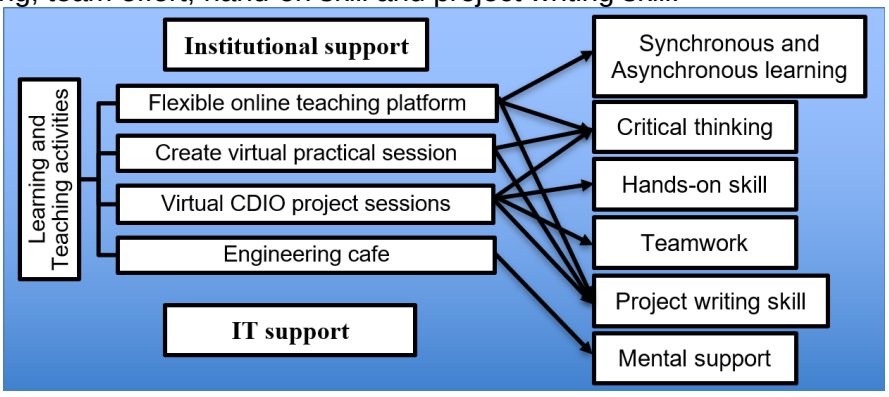

Figure 1. Teaching approaches to mitigate the limitations of online teaching and learning

FLEXIBLE ONLINE TEACHING PLATFORM

In CCCU, we have been provided with online learning and teaching software, Blackboard Collaborate Ultra that provides us with a user-friendly, flexible and interactive platform for both students and tutors, where we can easily record those sessions that could be followed and recapped by students later if necessary. Blackboard Collaborate Ultra is an effective, accessible, online teaching and learning tool that established a flexible learning environment (Zayapragassarazan, 2020) for tutees. It provides a platform where students can access the learning material in advance, can attend live academic session (lecture, practical, seminar, workshops and tutorial) as a form of synchronous learning (Finkelstein, 2006), can retrieve and download recorded sessions (asynchronous learning, Chen, Shang and Harris, 2006) and can attend online assessments. Submission of students' assessments and marking was easily done using this software. All lecture, practical and CDIO project sessions were delivered online using this software. Students could meet their peers virtually, pair up to create a group, interact with them and tutors from a socio-emotional perspective. Lectures on cutting edge technology, CDIO project helped students to develop innovative ideas around coding-based architecture while online training on project writing improved their report writing skill. Online teaching also facilitated socio-economic benefits to students and opened the door for other possibilities.

- Students could assess the learning material according to their convenience.

- This approach was useful for the students who were unable to travel to campus because of financial hardship, part-time job, or having to provide care for individuals affected by the COVID-19 pandemic, by providing flexible access to the teaching materials and recorded class sessions online.
- Another student demographic which was benefitted are mature students or students with sibling caring responsibilities who found balancing family/caring responsibilities and studies easier with flexible online teaching (lecture and practical) and recorded sessions. Due to the closure of schools, it was difficult for them to provide caring responsibilities at home when busy with the home-schooling of children rather than their study. The online teaching and learning platform and recorded academic sessions provided flexibility which made their lives easier whilst supporting family life.
- These recorded sessions were also considered beneficial to 'weaker' students and even enabled a few students to re-engage with the learning materials since students may need to recap certain material several times depending upon their comprehensive power. It also reduced the engagement time from tutors as students can revise from recorded material.
- Students who started new jobs in healthcare, retail, and social work, were unable to attend the scheduled taught session but were able to access it after their working hours.

CREATE VIRTUAL PRACTICAL SESSION

Since the university's research facility including labs had to be closed due to UK COVID-19 guidelines, there was no option available for students to continue the group-work based practical sessions on electronic circuits and hardware-based embedded system at the campus. In this programming module, the learning aspect of the practical session emphasized the fundamental concept and design of the Arduino board, the working principle of various sensors and its interfacing with Arduino. Students were also supposed to learn the relevant C/C++ programming for controlling it. Because of having online sessions, the students could not meet their peers to discuss group projects and missed personal guidance from module tutors, therefore it was not only difficult for them to fabricate and troubleshoot the Arduino circuit board but also to debug errors in the code. Although we could not facilitate physical lab sessions, we developed a similar kind of learning platform virtually (Babich and Mavrommatis, 2004) with Tinkercad software where the physical hardware-based electronic circuit had been replaced with a virtual board (Figure 2). Utilizing this tool, students could easily build Arduino circuits virtually with all its associated sensors, embed the programming code in the controller board to test and evaluate its function, and assess the compatibility of the programming in the virtual circuit board without making it. Separate sessions were delivered to students on how to write a project report describing the aims, methodology, design, development and testing results. Using the simulation-based software, students were not only able to attend the virtual practical session but also acquired the prerequisite knowledge for job-related skill.

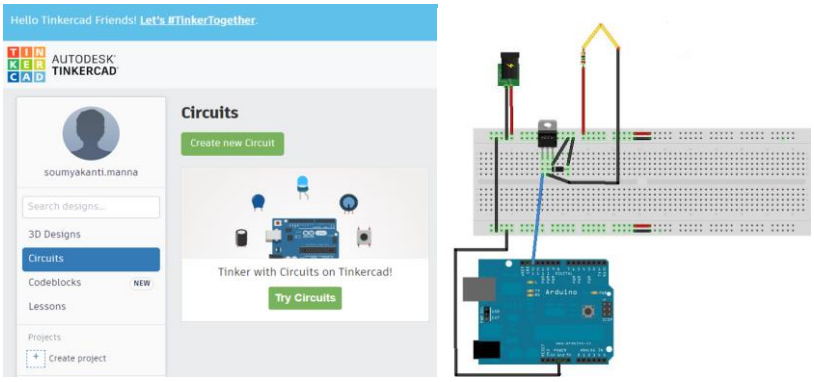

Figure 2. Building of Arduino circuit using Tinkercad software

FOUR STAGES OF DELIVERING CDIO PROJECTS

To deliver the programming oriented CDIO project online among students, we formed an indigenous way (Manna, Sheikholeslami and Nortcliffe, 2020) of pursuing it so that students could use the advantages of the CDIO framework in which they would get a chance to conceive an idea, design and develop a feasible and useful solution to implement that idea, operate the system/solution to evaluate its working function for additional adjustment and improvement of it. Four stages were involved in the process (Figure 3). Most importantly, students, first of all, perceived the current advancements in the field of science, designing, innovation and technology so that they could become familiar with the current technical issues with its prospective solutions. In the following stage, students were shown a few hobby projects with a basic engineering design and became acquainted with its engineering aspect so that they could analyse and interpret the reasonable conceptual link between a hobby project and industry-oriented design. They could also realise how an industry-standard item was formed, form a basic hobby design with specialised technical skill and engage in active learning support. In the last stage, students effectively took part in planning and delivering a CDIO project in a group with their fellow peers, which enhanced their teamwork capability making their decisions perfect based on a couple of suggestions. Finally, a feedback survey from the students was accumulated for critical reflection.

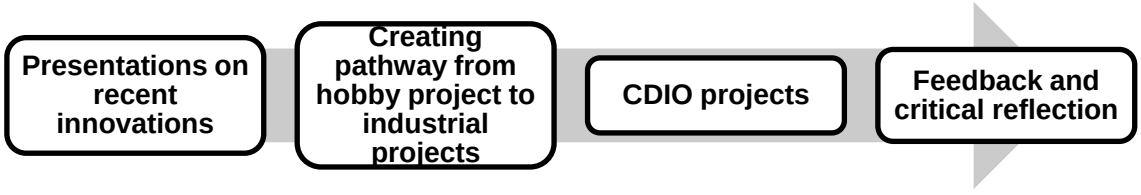

Figure 3. Stages of delivering CDIO projects

In this module, the CDIO project aimed to design and develop a line tracking robot with obstacle detection. Because of the limitation of conventional group work on campus, students were permitted to create a flexible online group in the blackboard collaborate platform following the think-pair-share method (Kaddoura, 2013) to investigate their thoughts (Figure 4). In blackboard breakout group sessions, students continued their discussion freely with team members, shared ideas and finally produced a collaborative outcome. Constructive criticism of ideas is always helpful for a group project. Through this technique, they enhanced their critical thinking on the project, improved their hands-on skill and teamwork. Students also used social media networks such as discord, WhatsApp and Facebook to continue their group work outside the scheduled sessions. Following the discussion, only one student in the group can build the hardware model although every member of the group contributed towards developing the final

prototype from other areas such as mechanical design, electronics circuit and programming. Academic support was provided to individuals (on a one-to-one basis) and groups (using group practical session) through the Blackboard Collaborate tool. The Microsoft Team platform was used on specific occasions. There were several difficulties involved in making the prototype apart from face-to-face interaction such as purchasing components, financial support as well as motivation during the pandemic. Out of eight student groups, two student groups were successful in completing the project despite all the hurdles (Figure 4).

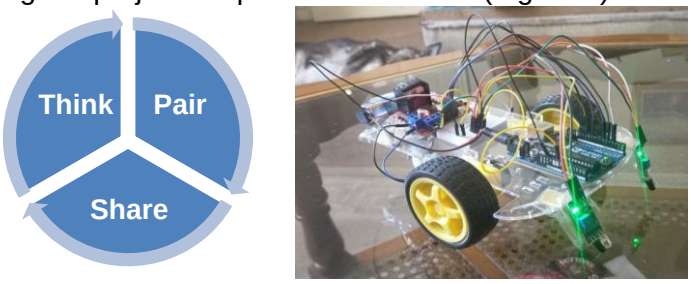

Figure 4. Virtual groupwork and developed CDIO project

ENGINEERING CAFE

In the cohort, a large number of students came from diverse backgrounds with varying cultural, ethnic and regional differences from across the world. Almost 30% of the cohort belonged to BAME (Black, Asian and minority ethnic) community. To support them psychologically beyond the academic environment, we arranged a weekly online cafe which was purely an informal chit-chat session for tutors and students. Due to the closing of the campus, students were socially confined and could not meet their peers physically. International students who had been staying far away from their family and could not travel back to their country due to lockdown were feeling alone and detached from their families and friends, which often created anxiety and mental illness among them. This type of initiative supported a comfortable environment among the students and a holistic learning framework where all students were invited and known to each other by name. It helped us to become familiar with the students as more than an academic bot, sometimes provide pastoral care, notice their interests and behaviours and create a sense of belonging.

DIGITAL POVERTY

Alongside the lack of face-to-face interaction and unavailability of practical sessions, one of the major problems in online learning is digital poverty. Many of our CCCU students could not afford the required IT equipment (Hi-spec laptops, headphone), hi-speed internet (for attending live lecture and practical sessions) to support online learning. This issue affected the students globally especially in underdeveloped and developing countries. In CCCU, the issue was partially resolved using several supporting arrangements such as:

- Hardship fund for students to support their online learning.
- Long-term laptop loan scheme where students can borrow a laptop for a long time.
- Recorded sessions for students to watch the lectures and practical later.

FEEDBACK AND CRITICAL REFLECTIONS

The learning material of the programming module was successfully delivered and covered all aspects of the learning outcomes as per the validation document. There were 32 students enrolled in the module. The average student attendance in the module was 80% before lockdown. Even during the lockdown, students were engaged in the module throughout the

online learning sessions (Figure 5) and there was an opportunity for student participation in all four sessions. Follow up emails from students revealed that a few students were unable to join the sessions because either they struggled with digital poverty, had left for their home country, were medically unfit, or had started working as keyworkers.

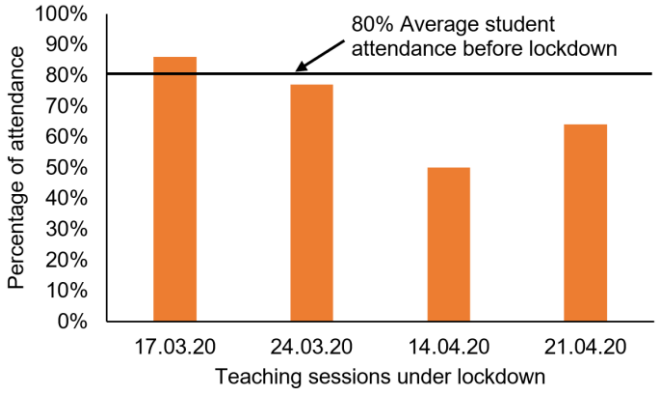

Figure 5. Engagement of students in online sessions

The module was supposed to be assessed by two assessments; coursework (40%) and CDIO project report (60%). Due to the university instructions, the submission of the CDIO project report was cancelled, however, the majority of the students completed the coursework. We also created a self-assessment online quiz to keep them engaged in the module. Overall, the performance of the students was satisfactory (Figure 6) considering the pandemic and circumstances; 63.63% of the students passed on their first attempt. . It was surprising to find that several disengaged students, who were detached from their course, engaged with the online sessions due to the flexible nature.

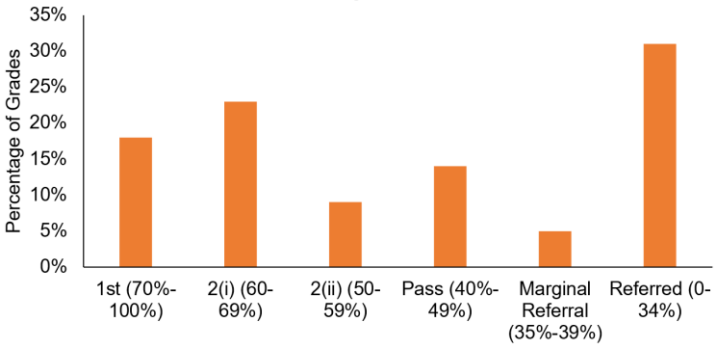

Figure 6. Performance of students in coursework

A few positive feedbacks from students are shown below about their learning experience.

From student 1

'I've enjoyed as much as I can your online lectures and feel it's going as well as it can do considering the circumstances.....'

From student 2

'The lecture this morning was very useful and found that on the whole the format works as well as possible in the situation given…...'

A few negative feedbacks from students are shown.

From student 1

‘The online lectures were less engaging than the face-to-face lectures and I found them harder to understand.’

From student 2

‘Online lectures as they were harder to learn from. Unfortunately, i did not enjoy online learning as I work and learn better when teaching is face to face.’

CONCLUSION

Flexible online learning platform encouraged students to be adaptive during the pandemic through online live classes, virtual labs, recorded video and advance learning materials. Students obtained the advantages of synchronous learning (live session) and asynchronous (recorded video and material) learning. Informal sessions apart from academic classes helped the students to keep motivated in their personal life and engaged in the course. Moving forward in a post-vaccine or post-COVID-19 scenario, it will be an important question in the academic world whether to retain online learning or revert to face-to-face learning on campus. The student feedback revealed that they enjoyed all the classroom sessions, chats with tutors and peers as it kept them social and lively. Students learned new software tool which made their portfolio stronger for future project and career goal. They also had been trained on how to peruse CDIO project online and to achieve professional attributes. The engagement report was satisfactory in the online lecture and piratical sessions, however, they always prefer face-to-face session instead of online (retrieved from their feedback). During the online learning, students missed face-to-face interaction from tutors and social networking among peers. Additionally, it was challenging to manage the practical sessions and supervising students in the group work - particularly for the hardware projects. Although flexible online learning has proven to be beneficial during COVID-19, it should not be the ultimate solution in the future. The appropriate approach could be blended learning that is a combination of online and face-to-face learning to avail the benefits of both learning platforms. Many universities including CCCU undertook the blended learning policy from September 2020 onwards, we have endeavoured to keep on-site face-to-face contact hours with students to a minimum while maintaining all health and safety measures. It also provides students with flexibility in engagement with their learning as well as a safe environment. We have been delivering lecture sessions online and practical session on campus in a group of 15 cohorts to ensure the contact time is as little as possible. We enacted a one-way system of movement throughout the campus, provided hand sanitiser in each room and corridor, and had the staff move between rooms for the class session rather than the students in order to avoid the mixing of cohorts. This was based on the government guidelines for a COVID-19-safe campus. Based on this experience, it would be our recommendation to deliver theory-oriented modules online, where there is no need for on-campus lab equipment whereas the practical-oriented module should be facilitated through a combination of online learning (specifically lecture and tutorials and seminar) and face-to-face sessions where hardware equipment is required in order to provide hands-on training. In several experiments where large equipment was involved, practical experiments were conducted by tutor and students watched it online, recorded the experimental data and analyse it remotely. Although it did not allow students to do the experiments physically, students became familiar with the system and its working principle. We also recommend providing a space for informal social contact such as our engineering cafe to keep the students motivated and engaged in the process, either online or face-to-face, based on the situation. We are committed to finding innovative solutions to overcome current limitations to improve the student learning experience going forward.

REFERENCES

Adedoyin, O. B., & Soykan, E. (2020). Covid-19 pandemic and online learning: the challenges and opportunities. *Interactive Learning Environments*, 1-13.

Babich, A., & Mavrommatis, K. (2004). Virtual laboratory concept for engineering education. In *Proc. International Conference on Engineering and Research "Progress through Partnership* (pp. 1043-1050).

Bangert, K., Bates, J., Beck, S. B. M., Bishop, Z. K., Di Benedetti, M., Fullwood, J., ... & Woolley, R. (2020). Remote practicals in the time of coronavirus, a multidisciplinary approach. *International Journal of Mechanical Engineering Education*, 0306419020958100.

Carter, L. M., Salyers, V., Myers, S., Hipfner, C., Hoffart, C., MacLean, C., ... & Barrett, P. (2014). Qualitative insights from a Canadian multi-institutional research study: In search of meaningful e-learning. *Canadian Journal for the Scholarship of Teaching and Learning*, *5*(1), 10.

Chen, C. C., Shang, R. A., & Harris, A. (2006). The efficacy of case method teaching in an online asynchronous learning environment. *International Journal of Distance Education Technologies (IJDET)*, *4*(2), 72-86.

Delahunty, J., Verenikina, I., & Jones, P. (2014). Socio-emotional connections: Identity, belonging and learning in online interactions. A literature review. *Technology, Pedagogy and Education*, *23*(2), 243-265.

Dhawan, S. (2020). Online learning: A panacea in the time of COVID-19 crisis. *Journal of Educational Technology Systems*, *49*(1), 5-22.

Engineering Council. (2014). The accreditation of higher education programmes [online at] https://www.engc.org.uk/engcdocuments/internet/Website/Accreditation%20of%20Higher%20Education%20Programmes%20third%20edition%20(1).pdf (Accessed 13 January 2021).

Finkelstein, J. E. (2006). *Learning in real time: Synchronous teaching and learning online* (Vol. 5). John Wiley & Sons. ISBN: 978-0-787-97921-8.

Gabriel, S. (2020, October). Suddenly eLearning: A Qualitative Study of University Students During COVID-19. In *European Conference on e-Learning* (pp. 198-XV). Academic Conferences International Limited.

Huang, R., Tlili, A., Chang, T. W., Zhang, X., Nascimbeni, F., & Burgos, D. (2020). Disrupted classes, undisrupted learning during COVID-19 outbreak in China: application of open educational practices and resources. *Smart Learning Environments*, *7*(1), 1-15.

Kaddoura, M. (2013). Think pair share: A teaching learning strategy to enhance students' critical thinking. *Educational Research Quarterly*, *36*(4), 3-24.

Manna, S., Nortcliffe, A., & Sheikholeslami, G. (2020). Developing engineering growth mindset through CDIO outreach activites, 2, 356-367.

Ragusa, A. T., & Crampton, A. (2018). Sense of connection, identity and academic success in distance education: Sociologically exploring online learning environments. *Rural Society*, *27*(2), 125-142.

UNESCO. (2020). Education: From disruption to recovery [online at] https://en.unesco.org/covid19/educationresponse (Accessed 13 January 2021).

Zayabalaradjane, Z. (2020). COVID-19: Strategies for Online Engagement of Remote Learners. *Online Submission*, *9*(246), 1-11.

BIOGRAPHICAL INFORMATION

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