REVIEW ARTICLE

A Wake-up Call: Covid-19 and Its Impact on Reforming Biosciences Education Towards Resiliency and Sustainability

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ABSTRACT

COVID-19's global pandemic has had a significant impact on bioscience education, which has switched to online learning. Every entity within the higher education ecosystem, whether technical, pedagogical, or social, has faced a number of challenges as a result of this. Regardless, biosciences education stakeholders have been fast to implement innovative strategies to maintain high standards and quality of biosciences online teaching and learning. This paper focuses on the biosciences education transition toward developing resiliency, as well as the technology resources and approaches that have been deployed in the current context to change biosciences education to be robust in the face of the COVID-19 upheaval. Finally, significant insights into 'resilience sustainability' approaches that may be employed in relation to the digitisation of biosciences education in a concerted effort to promote resiliency, adaptability and sustainability in biosciences education are presented.
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INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic has impacted many sectors worldwide including the educational systems. The forced adaptation has compelled higher education to reconsider and change its business model by altering application procedures, improving crisis management approaches, and, ultimately, rethinking teaching and learning pedagogies (1) by rapidly digitalising education and training procedures (2). As a result, there has been a significant increase in online learning, in which teaching is delivered remotely and via digital platforms (3). This has posed great challenges and drawbacks to all stakeholders within the higher education ecosystem including biosciences education (4). Numerous articles have reviewed the obstacles encountered during the pandemic ranging from technology access and affordability, engagement, well-being and mental health, technology, health and moral support, assessment's consistency and objectivity, communication between peers and teachers, standardising online teaching, self-regulation, adequate learning environment amongst others (5-8). Resilience was emphasised as one of the mitigating factors to challenges faced in online teaching and learning during the pandemic. Resilience is the ability to continue to work or function as well as it did before experiencing a change especially when environmental influences are unpredictable, abrupt, and sudden (9). Hence, resilience in higher education is the ability to adapt, cope, respond, sustain and prosper in the face of change. The importance of resiliency and, as a result, sustainability, particularly in biosciences education, has yet to be fully explored and addressed; hence, this paper synthesises and discusses key findings that highlight resiliency in higher education during the digitisation of biosciences education in the pre- and post-pandemic world. In addition, successful biosciences educational innovation and transformation must also be built on the foundations of long-term viability, breadth, and scale (10) that embeds and develop a participatory culture, connectivity, collaboration, and promote evidence-based decision making and transparent form of online learning. As digitisation and technology progressed at a rapid rate, resilience would no longer

be sufficient to overhaul and future-proof biosciences education. As a result, this paper strongly advocates for the adoption of 'resilience sustainability' in biosciences education and insights on how to do so. It is about students, educators, and higher education institutions being repurposed by reorienting and refocusing on sustainability. Destabilising unsustainable aspects and transitioning into a new stable "sustainable" system is required for repurposing biosciences education. This can be accomplished through restoring functioning, controlling and moulding unanticipated changes, making constant adjustments, and reflecting and improving on sustainability hurdles (11, 12). As a result, new methods to reimagining biosciences education as an inclusive, resilient, and sustainable ecosystem will emerge. Thanks to the advantages it will provide, it will revolutionise how teaching and learning in biosciences programmes are led, ensuring their future progress adaptability and sustainability.

ADAPTATION AND SHIFT TOWARDS RESILIENCE BIOSCIENCES EDUCATION

As the world battles for survival during this pandemic, the education system struggled to adapt to the new normal. With the closing of university campuses and shifts of face-to-face teaching and assessment to virtual platform have caused major changes not only to students as per say, but also to the academicians and higher education institutions (13). Universities worldwide started to adapt to a new learning culture while maintaining alignment with syllabus set in the curriculum with the focus on academic continuity during the pandemic. These adaptations and the building of resiliency during the aftermath of the pandemic was also seen in biosciences education that will be addressed in subsequent sections below.

Embracing technology and fortifying engagement and authentic assessment in online biosciences education

Over the course of the pandemic, students have adapted to the setting and concept of online learning and are familiar with the use of teleconference software, online tools and online chat tools and other applications (14). However, online learning strategies are not appealing and fail to grasp student's attention and interest as the learning environment and approaches used by academics are not so 'online friendly'. Therefore, learning materials and contents requires further improvement by integrating interactive and engaging formats (15). Recent research conducted in Aston University reported that, despite many limitations faced during lockdown, adaptation in teaching and learning within biosciences courses had shifted to online learning via Zoom, Google Meet, Microsoft Teams, and other online platforms. Assessments, revisions, and students' centred learning were also prepared via online. Survey data showed that students enjoyed online interactive lectures despite uncomfortable being seen on camera (13). This may be due to poor lighting, background noise, and struggle to find a spot for privacy setting and wanting to control good appearance on camera (16). Meanwhile, although assessments were done open book, students still preferred a 24-hour assessment window to further address issues such as internet access and religious observances such as Ramadhan (13). This similar technical issues were also highlighted to tackle the online learning process as well as to keep up with the high momentum in learning among students. Thus, a technology mediated learning with a stable internet access and integration between face-to-face learning is able to increase the student engagement in class, help in developing critical thinking and improving learning outcomes (17). To guarantee well-ordered teaching and learning processes in this new normal, continuous efforts and best practices are crucial to be implemented in order to ensure the transformation of online learning in higher education is successful and yet flexible. Addressing the aforementioned challenges, collecting feedback from academics and students online learning experiences, seeking ways of solving the unexpected problems are essential for quality knowledge delivery in an online setting. Many articles and organisations including the United Nations Educational, Scientific and Cultural Organization (UNESCO), United Nations (UN), Organisation for Economic Co-operation and Development (OECD) have provided valuable information on strategies, best practices, perspectives, viewpoints and suggestions on transitioning and providing the best online learning experiences and quality (4, 18-21). As such, higher education is moving forward in tandem with digital and technology advances. The safest and best approach for biosciences education is blended or hybrid learning which is able to keep pace with the digital trend to build a resilience and sustainable future in biosciences education (1).

The need of blended/hybrid learning in biosciences education

Blended learning has been known to expand academic performance and can be applied in broader university courses (17). Similar positive feedback has also been received from students who applied blended learning in the pharmacotherapy course (22). Thus, this method is used with some modification to fit with online delivery as well as hybrid model approaches that combine the online and face-to-face course delivery. However, this model needs the students to attend both modalities (23). Another model that also combines face-to-face and online learning is known as Hyflex model. This model can be offered in person, synchronously online and asynchronously online which allow the students to decide (24). However, the disadvantages with this model are it may create more discrepancy in student learning experiences and disrupt the experience of feeling part of a cohort. This usually occurs when a student chose to learn remotely while the rest of the class chose to learn on campus (13).

Despite all the challenges faced, online learning for higher education has been more accessible since it gives more educational opportunities with unlimited time and geographic constraints (25). It also enables the uploading of pre-recorded lectures to give students the flexibility to digest the materials at their own pace. There were also platforms where lecturers can provide the 'chunked-lectures' such as journals, relevant video and examining clinical cases for further reading. Several online teaching tools such as Kahoot, Vevox, screencasting software, blackboard and illustrative teaching were broadly used to keep up with the blended learning and to ensure a high level of learning excitement (13). However, with the implementation of hybrid learning and teaching, it will create a more dynamic and stimulating environment since it involves physical and virtual learning. For the biosciences program, the Hyflex model may not be an ideal model since it involved more online simulation software with basic laboratory techniques (13).

Making laboratory practices online friendly

One the major drawbacks during lockdown restrictions since biosciences program involved hands-on laboratory skills. Psychomotor, critical reflection, critical thinking, communication and collaboration skills are all ineffectual and difficult to be implemented through online learning especially hands-on practical/laboratory sessions (26, 27). Thus, hybrid and/or blended models are suggested to provide balance between online learning during lectures and face-to-face during laboratory practical. Recent survey also reported that 40% of first year undergraduate biosciences students preferred the hybrid learning style which gives them more flexibility especially for practical sessions (13). It allows them to meet their friends while maintaining the social distance and may help reduce their loneliness which has greater risk in developing mental illness including depression and anxiety (28). It has been reported, lockdown increased the experience of blue mood, despair, anxiety, and depression among 20% of students (13). Thus, with the hybrid model, it is suggested to benefit the isolated students to have access to campus facilities, having friends to talk to, sharing ideas while attending the face-to-face elements of the course which they may not get if strict Hyflex model is being applied. Health sciences students have shown a mixed response towards virtual labs as more preference are geared towards traditional experiments as compared to virtual labs as it increases students motivation and perceived performance (29). Therefore, an ideal approach is to blend both online and hands-on laboratory experiments (30).

In addition, online learning has gradually reduced the opportunity of engagement between students and students have less opportunities to create a community through a virtual learning environment. Hence, online learning fails to create a real-world situation for users to communicate spontaneously and critically as they need to build their experiences by frequent reflection of their communication. Students can reflect, communicate and interact through frequent scheduled meetings with course mates and academics using real-time collaborative online bulletin boards, forums or chats (4, 31, 32). Moreover, extended reality (XR) has the potential to fulfil this requirement as it can be performed through physical and virtual environments that mimics the actual condition of the physical laboratory (4). More authentic experiences can also be implemented such as team-based projects (33) where students are introduced to use creative online learning tools that are supportive with collaborative and communication formats. This enhances student-centred experiential learning primarily empowers students to apply the knowledge practically. It includes various design models that include quality real world context such as problem- or case- or inquiry based-learning amongst others (32, 34). Nonetheless, the implementation of meaningful discourse can be one of the appropriate methods of effective online learning. This activity requires the ability of the students to present well planned ideas on a particular topic while showing effort in critical response. Students will undoubtedly tend to evaluate their own performance and learn from their experiences (26, 27). Thus, virtual engagement is desirable and can be easily implemented for students to create a sense of community through online platforms.

Academics' roles in building resilience online biosciences education

Prior planning is now a necessity for academics to create new interactive and engaging teaching lessons and materials especially for practical classes. Well planned and executed teaching lessons with interactive and engaging elements are important to increase students' focus and attention especially for contents that are highly contextualised and factual. The teaching content can be shortened to several parts to catch the attention. Academics can emphasise on the use of voice and respective words to point out the important points within the lesion (35). The extracted information should be easily understood and students are able to keep abreast with the learning outcomes. Meanwhile, implementation of interactive sessions during lectures in the form of online quizzes, games or small-group discussions are also indispensable to increase understanding. In addition, small team-based projects would encourage and foster collaborative effort among students. Small divisions of groups are convenient for academics to manage and engage as well as to monitor the level of student's understanding by analysing their performance. In addition, another important aspect worth considering is self-learning. Self-learning is necessary to provide space for students to digest course materials before and/or after classes. Reading materials must be distributed before and after lessons to encourage students to preview teaching contents which will increase engagement as students will request for clarification on the subject matter and experience deep learning during synchronous online class (4). Cheema suggests a set of instructional

practices that might aid in the improvement of this new approach of learning and teaching in the classroom (4). This would provide flexibility in teaching and improve the attainment of learning outcomes in a virtual teaching and learning setting (36, 37). In addressing practical classes' drawbacks, virtual and visual reality approaches are available to teach several practical subjects remotely and collaboration with local and international academic programmes is a plus (38). Interactive cases, simulation-based practical and to some extent the use of social media such as TikTok, Twitter and Telegram were also suggested (39).

Institutions' roles in building resilience online biosciences education

University management must be the team leader and provide clear execution plans on the immediate changes in the educational plans according to the external factors that may affect delivering of teaching and learning (40). Announcement of new and updated information can be done through university portal for student's information (40). Frequent monitoring of teaching and learning conditions is necessary. Feedbacks and complaints by students and academics need to be seriously well-thought-out and addressed. One major obstacle is poor internet connectivity and affordability especially for students living in remote areas (41). As such, universities should provide suitable solutions for these students so that they can learn in parallel with other fellow students. Schools in Alabama, USA are turning buses into mobile hotspots to provide internet connection and bridge the digital divide. This approach will benefit students from low-income families and remote areas (33, 42), which are often lacking of appropriate online learning gadgets. Online learning facilities can be provided to students (15) who are facing financial difficulties in attending online classes. These challenges can be addressed by universities collaborating with telecommunication companies or industries to offer students with cheaper internet data packages (37). Emergency plan is needed to face the disruption and accessibility when online learning platforms are overwhelmed (35). Emergency plan includes pre-recorded session of lecture or asynchronous learning through materials in relevant websites. Furthermore, tuition fee is also an aspect of concern in higher education. Universities are requested to revise their expenditure and tuition fee since the teaching and learning occurs digitally. Since majority of students are staying home and not utilising campus facilities, the collection of tuition fees, including college management fees, materials fee for experiments needs to be re-looked at and revised (43-48). Moreover, most students' families are facing financial problems as their parents' jobs are affected by the economic crisis due to this pandemic. Universities should provide financial assistance and support to these by reducing tuition fees, temporary payment deferment packages (49). In fact, those expenses are fully covered in the educational fee for subscription of online learning applications especially for those universities developing their own online learning platforms. However, the financial support is not enough for improvement of quality as some online learning options are expensive compared to conventional learning (47). Therefore, financial sustainability is of utmost importance especially in higher education institutions from low- and middle-income countries. In the digital teaching and learning environment, phishing assaults continue to play a dominating role. Online security needs to be upgraded and strengthened in keeping universities information secure (50). Recruitment of technician and professions in infrastructure technology rather than general technician is required and frequent and constant online monitoring is needed. Hence, university management plays a crucial role in preparing students for online learning while protecting their privacy.

Holistic approaches in building resilient online biosciences education systems

There is a need to make a significant investment in biosciences education and shifting it into the digital era by creating robust and resilient online biosciences education platforms. To achieve it, holistic approaches that include all dimensions and perspectives within the ecosystem are necessary to be wholly addressed. Ferri et al., 2020 suggested several actionable strategies to address the aforementioned challenges. It includes i) developing reliable network infrastructure; ii) providing more affordable devices; iii) accessible and diverse modalities (telecourses, TV, radio, online courses) should be used; iv) providing systematic training initiatives for both academics and learners; v) a well-defined and consistent strategy should be devised; vi) creating strategies for communication and digital education assessment; vii) using blended approach whenever possible; viii) improving virtual and augmented reality technologies; ix) reinforcing the use of intelligent technologies for remote teaching and x) developing more inclusive tools, platforms and devices (51).

A conceptual model of students' Academic Resilience Model (ARM) was also developed (52). It describes the origins of stress and/or adversity, as well as the protective mechanisms and/or factors that have an impact on students throughout the curriculum. From this model, individual, academic, and external systems are the primary causes of stress and/or adversity, as well as protective mechanisms and/or factors. Low initial desire for the programme, personal health concerns, faculty didactic-pedagogical deficit, challenges in interactions with peers, and conflicting professional responsibilities were all examples of sources of stress/adversity. The key protective mechanisms/factors discovered, on the other side, were flexibility, self-control, and personal organisation, strong connections with faculty, peer integration, and family support (Figure 1). One of the most important focuses is the technical issues related to internet connectivity among students especially those

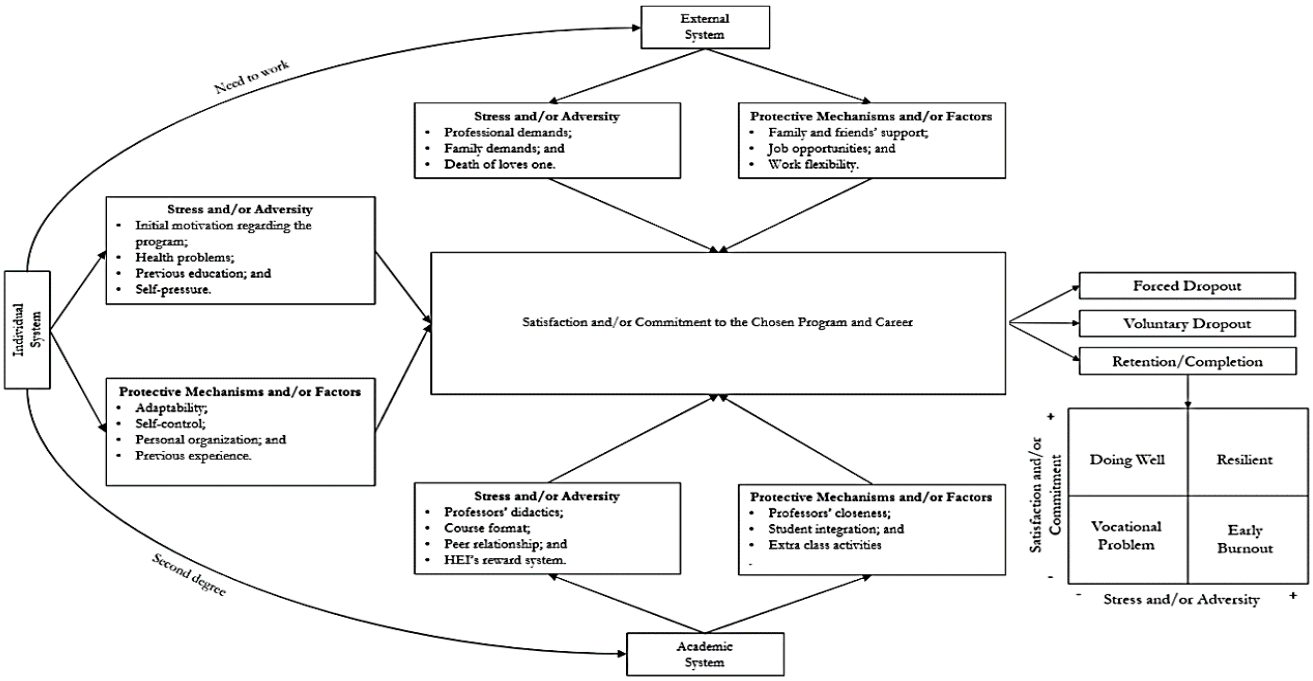

Figure 1: A conceptual model of student Academic Resilience Model (ARM) taken from (52).

from middle- and lower-class families. Other focuses also include the well-being of the students, barriers to effective studying, quality of life and socioeconomic background. Thus, universities worldwide had adapted several new practices to ensure the flexibility in education delivery during the lockdown (13).

Nandy et al., 2021 recommended that institutions should use the composite resilience model with three dips, as illustrated in Figure 2, to reconstruct the system along with the application of the person–environment fit (PE fit) model that has long been the referred functional model (53). Therefore, resilience is made up of the ability to navigate and address these 3 dips (crisis, exhaustion and competition) by auditing and strengthening areas of weakness as recommended by Nandy et al., 2021. For institutions in various levels of crisis, they advocated to examine rebuilding options that may be used in the aftermath of a crisis both for short-term (rebuild mode; Figure 2) as well as the long term (thrive mode; Figure 2). This investigation must begin with a candid appraisal of the existing situation (survival mode; Figure 2) and an

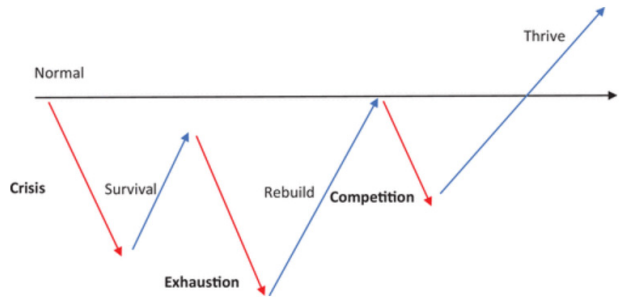

Figure 2: The three dips resilience model for institutions. Taken from (53).

understanding of what is doable in terms of the ultimate aim.

Given the rapid shift away from face-to-face learning, there are speculation if the acceptance of online learning would survive and thrive post-pandemic, and how such a move would influence the global education ecosystem indicating that the changes COVID-19 have caused might be here to stay. Hence, the entire higher education ecosystem needs to be well-prepared, resourceful, engaged and adaptable in ensuring the sustainability of online learning in the future. Enhancing 21st century skills (critical thinking, communication, creativity, collaboration, adaptability, etc.) should be the main focus rather than traditional academic skills and rote learning. Could the shift to online learning be the trigger for a new, more successful approach to student education? While some are concerned that the rapid pace of the online move has hampered this objective, others want to make e-learning part of their "new normal" following first-hand experience with its benefits. Hence, developing sustainable resilience in the current biosciences education landscape is a necessity. This primarily concerns the suitability of traditional campus-based learning and teaching operations, as well as the reskilling and upskilling of learners and instructors in preparation for a drastically transformed and non-traditional learning and teaching environment.

'RESILIENCE SUSTAINABILITY' IN BIOSCIENCES EDUCATION POST- AND BEYOND COVID-19

The COVID-19 have directed universities to discontinue face-to-face training for most of its students, forcing them to transition very immediately to online teaching

and virtual education (54). Throughout this experience, sustainability and resilience are two concepts that coexisted in the educational system. Resilience is the capacity to recover from an unexpected event using sustainable practices. Hence, sustainable practices promoting resilience is the ultimate objective for creating a robust biosciences education system (55). As a result, it is critical not only to address resilience and sustainability practises as separate components in ensuring the future progress and adaptability of biosciences education in a post-pandemic world, but also to develop resiliency in sustainability practises in what is referred to as 'resilience sustainability'. The authors of this article argue that, in future, bioscience education should incorporate and adopt the notion of 'resilience sustainability'. That would usher in a new era in biosciences education that is future- and crisis-proof. This necessitates repurposing students, academics, and universities by reorienting and refocusing on sustainability. This can be achieved by repurposing biosciences education by strengthening unsustainable aspects and moving to a new stable, sustainable structure. Integrating resilience into this system (i.e. biosciences education) will help to guarantee that it adjusts and copes with the destabilising stresses in times of uncertainty and unforeseen challenges (i.e. thrive mode in Figure 2). This article will now suggest some thriving approaches as shown in Figure 2 in developing 'resilience sustainability' in biosciences education.

Thriving blended/hybrid learning models

Given the special requirements of biosciences students for hands-on laboratory experience and the students' favourable attitudes toward online assessment, a hybrid method might be desirable for biosciences courses to embrace in the future. It is critical for higher education institutions to closely examine their student demographics; while a hybrid approach may appear attractive at first glance, as it would allow students to study entirely online if they so desired. Data clearly demonstrates that biosciences students benefit from the university on-campus environment, which increases their motivation to study and helps them overcome the challenges associated with distance learning (13). Additionally, in uncertain economic times, many higher education institutions would struggle to fund a hybrid approach. It is suggested that developing material for online instruction takes more time than face-to-face instruction (56). Additionally, consideration must be given to the technical load associated with maintaining devices and equipment, as well as the availability of suitable online tools and platforms to encourage student connection and participation (19). While universities may see video cameras as a means of reproducing classroom interactions online, instructors should be cognizant of students' camera use choices. Education providers must embrace online teaching and offer opportunities for a hybrid approach to teaching, learning, and assessment. While institutions that teach face-to-face in classrooms or on campuses will likely return to that method of education with some relief, the exceptional arrangements made during the COVID-19 crisis will leave a permanent imprint necessary for sustainable resilience.

Blended or hybrid learning models are indispensable for future learning in higher education. Blended learning is the most ideal approach post COVID-19 as it allows education to be conducted both physically and virtually in fulfilling communal and embodied experiences. Lessons that require hands-on activities (i.e. laboratory practical) can be conducted physically whilst theoretical parts can be conducted virtually. For example, undergraduate forensic studies acquire physical experience in crime scene investigation by contact with materials such as skeletal bones etc. while lecture mode for contamination avoidance, scene control, and evidence recovery methods can be studied via online learning application (57, 58). In Yemen, the government establishes a hybrid education system as a fully online system is difficult for medical and engineering programmes (59, 60). Thus, some compulsory courses in their studies require practical sessions that can be done physically (36). The combination of online and physical mode of learning are able to provide the best learning experience. Universities in the United Kingdom adopted the online and campus (OaC) model as a sustainable blended teaching and learning (36). Similarly, HyFlex model as an instruction blended approach on hybrid and flexible concepts in online and campus models. The HyFlex model mainly focuses on the efficiency and effectiveness of learning while being resilient in facing any circumstances that may affect delivery of education in the future. This model greatly emphasises the safety of students while attending campus in order to reduce the risk of infection by COVID-19 (33). At the university, students are eager to experience university life where they have more opportunity to socialise and build independent personalities especially through learning (57). The pandemic has restricted these activities as learning occurs at home or in isolation. Therefore, universities can plan for hybrid learning to address these challenges while strictly following standard operating procedures to ensure the safety of students. Subsequently, employment of more manpower and ensuring adequate infrastructural facilities are necessary for hybrid learning. Activation of electronic portals to monitor student's activity or collect feedback from academics ensures the efficiency of hybrid learning (36). The concept of 'Cyber University' is to provide formal learning opportunities over electronic media. Cyber Universities employ online learning to give access to everyone, regardless of geographic location, flexibility, or other factors. It comprises a set of human (students, academics) and non-human (technological devices, internet and online learning tools) components as a medium of communication (43). For instance, among 346 medical staff members of Zagazig University in

Egypt, 88% prefer to have technology-based learning (46) while in the USA, survey conducted among 838 university, showed that more than half the number of universities opted to conduct face-to-face learning while only 7% of them will conduct virtual learning in Summer 2021 (59). Students felt that the efficiency in online learning is higher (25-60%) compared to physical learning (8-10%) but would prefer to have face-to-face learning moving forward (61). Hence, blended learning is the ideal compromise between online and campus approaches and the application of semi-Cyber University is in line with blended learning (43). Technology, pedagogy and organisational aspects in higher education will definitely undergo evolution post COVID-19. Online learning's spread in higher education including biosciences education will increase, and institutions will arrange themselves more systematically to pursue the components of technology-based learning that they have found most beneficial. Each institution will benefit from the systems they have established to ensure the continuation of their educational and training missions during times of crisis (54).

Thriving digital educational technologies

Nowadays, education is closely associated with the use of technology equipped with online learning platforms, websites and connecting interaction between people. Educational plans must be flexible in providing freedom to students in choosing their preferred learning method or style. Open education programmes consisting of massive online open courses (MOOC) or learning management system (LMS) are becoming a norm in higher education (62) as both approaches are fully operating in an online manner. MOOC mainly focuses on the credibility of flexibility for students in planning their learning outcomes, additional skills and development of their profession. Since the pandemic, countries such as Malaysia are adopting the MOOC practice (63, 64). LMS is able to manage and evaluate student's progress while providing feedback to academics to revise and improve their teaching methods (65, 66). Implementation of MOOC style modules or TED-style talks can be implemented and feedback is collected from the users in evaluating their effectiveness (67). Well organised and implemented technology-enhanced teaching pedagogies would improve learning quality and experiences (64). Courses integrating inter-cultural and experiential learning that enhance 21st century learning, literacy and life skills will create changes in the learning environment and encourage a positive mind set (68, 69). Positive feedback and reinforcement by academics would improve student's performance and create a positive learning environment (50, 70). Digital education technology for instance augmented reality (AR), virtual reality (VR), mixed reality (MR), artificial intelligence (AI), wireless technology or smart data are able to make higher education more accessible as it allows learners to move from the classroom into a virtual environment of online learning. It also provides the flexibility of personalised or individualised education. Individualising education translates to a human-to-AI interface that watches and learns about the learner until it understands what they know and what they still need to learn. The AI teaching bot will assess what the learner needs to learn based on this information. It gives students knowledge in bite-size chunks based on what it knows about the best times and methods for learning various types of material for each individual (4, 61). The AI is able to achieve the ability to assist in student's learning by providing services out of the classroom (61, 66). This advancement provides value with time flexibility and fulfils a student's preference in pursuing part-time learning and distance teaching and learning (46).

Thriving flexibility in the running of biosciences education programmes

Flexibility in credit transfer programmes is also essential in higher education post COVID-19. Providing credit transfer options would be a way to address inclusivity, diversity and equity aspects in higher education and facilitating mobility between institutions, regions and countries. Students will be able to learn from other institutions and have different experiences in their studies. Collaborative efforts between institutions are necessary to provide opportunities for students in exploring new skills that are not listed in their course outline (36, 37). Microcampus network would provide an avenue for pairing of institutions. Students in one university can earn dual degrees from the university and its partner universities worldwide. Besides institutions collaboration, government-government collaborations are possible to provide advancement in future teaching and learning (40). Quality education is the fourth goal among the 17 sustainable development goals established by the UN (71, 72). To achieve this goal, collaboration between governments is crucial as it enables the exchange of ideas and best practices (73). In Chile, collaboration between government and other institutions created an impactful partnership. They manage to collaborate with technology professionals to help students and academics in the teaching and learning process at higher education institutions (42).

Thriving organisational resilience and digital resilience

Organisational resilience and digital resilience are other key factors in sustaining resilience in biosciences education. Organisational resilience can be achieved by focused and targeted attention towards every aspect of higher education. University management is the foundation of higher education. Organisational resilience with good team management will ensure sustainable knowledge-based capability, resources availability, social resources, power-based capability, coping capability, adaptation capability and anticipation capability (70). Within the framework of complex adaptive systems, examples of sustainability governance within universities are based on the four concepts of (1) managing variety and redundancy, (2) managing

connection, (3) managing slow variables and feedback, and (4) fostering learning and experimentation (74). Financial capacity and sustainability are also a crucial step towards resilience. Universities, governments and private sectors support and alliance is needed to create adequate funding to sustain the quality of learning to achieve digital resilience. Information technology (IT) infrastructures on campuses need to be enhanced and upgraded in preparation of future-proof learning. Students reserve the right to receive education with good facilities while fostering their life skills (44). The setting of this system must be self-reliance, mimicking climate change and digital protection (45). In Vietnam, universities are putting efforts in preparing IT infrastructures to ensure that no one will be left behind in blended learning (44). Leadership in higher education institutions' organisational change is also required towards sustainable development. S6 and Serpa (2020) proposes five guidelines in that higher education institutions may modify to meet the objectives of sustainable development; (1) Transformation of structural structures and integration of sustainable development into university organisational systems; (2) Procedures for making decisions, leadership strategies, and strategic planning dynamics are all significant considerations; (3) The importance of internal variables (e.g., institutional culture, strategic agency, relationships, and power on campus); (4) the importance of external variables (e.g., funding/regulatory agencies, networks, and other higher education institutions; and (5) the focus on organisational learning to study the transformation process explicitly (75).

CONCLUSION

The lesson learnt from the COVID-19 pandemic in regards to biosciences education is that academics and students/learners should be oriented on use of different online educational tools with adequate peer support and technical support. Universities and institutions should be able to provide a solid and sustainable framework with suitable online pedagogies and infrastructures. Making hybrid teaching especially in regards to practical session creative, innovative and interactive through user-friendly approaches and tools are some areas for research and development. This would assist and prepare the biosciences education system in being adaptable and resiliently sustainable for such uncertainties in the future. The need for developing tools for authentic assessments and timely feedback are also some area for further improvement. The affordability and accessibility for learners from varied economic backgrounds is identified as a challenge, for which the educational institutions, service providers and online tools developer could focus on customization. The policy level intervention by high-level management and ministries is also vital. Following COVID-19, bioscience education will be a hybrid environment that combines online and physical learning. It is obvious that the benefits of online learning outweigh the disadvantages in terms of flexibility, improved technology use, and limitless learning opportunities. Combining the advantages of distance learning with the social advantages of being on campus, as well as the immersive value of being in class, the social and emotional value of "being present" will keep campuses and classrooms alive, while "being involved," even when physical attendance is not feasible, enables students to take charge of their own education and stay connected. Future learning will need to shift its focus on adaptability, resilience and sustainability, to being resiliently sustainable (i.e. resilience sustainability) with tactics and techniques tailored to the need to participate in and commit to transformative change. Although there is no such thing as a "one-size-fits-all" solution, students and academics will need training, support, internet and digital infrastructures, hardware and software, digital literacy, and online learning approaches. Despite the fact that obstacles will continue to exist and may become an impediment beyond COVID-19, these issues may be handled via collective and collaborative efforts by all parties. Higher education in general and biosciences education specifically should therefore reimagine and undergo a path of continual empowerment, consolidation, and development in order to promote a just, equal, and sustainable learning society for all.

LIMITATION AND RECOMMENDATION

The authors' concept of 'resilience sustainability' in relation to biosciences education is entirely their own, and they recognise the need to further appraisal to properly define this term, which necessitates further discourse and engagement with all biosciences education stakeholders.

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