Strategies for curriculum design and effective utilization of its systems for blended learning at Saudi Electronic University

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A R T I C L E   I N F O

A B S T R A C T

The COVID-19 pandemic has brought tremendous changes in the way mankind goes along with its day-to-day responsibilities. The world is undergoing a transformation like not been seen for decades before. Academic and educational institutions are also striving to adapt to changing circumstances. IT systems have proved to be a vital tool at hands of academic institutions to continue imparting quality education while ensuring compliance with health and safety guidelines during these times. Blended learning is a new and evolving academic model which emphasizes combining traditional face-to-face learning with the use of IT systems to provide ease of learning while maintaining student-teacher physical interaction intact. The times of the COVID-19 pandemic have compelled Blended Learning institutions to transform their academic strategies as well as increase their reliance on IT systems. Saudi Electronic University (SEU) is one of the largest Blended Learning academic institutions in the Middle East and North African (MENA) region. In this paper, we have presented an overview of processes, IT systems, and Infrastructure upgrades carried out at SEU to face the challenge of the COVID-19 pandemic and maintain the quality of its Blended Learning academic environment.

1. Introduction

Coronavirus disease 2019 (COVID-19) is a contagious disease whose root cause is severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The disease was first reported in Wuhan, China, in December 2019. As of July 27, 2021, the outbreak of the coronavirus disease (COVID-19) had been confirmed in over 210 countries and territories. The virus had infected around 195 million people worldwide, and the number of deaths had reached almost 4.2 million. Several testing methods have been developed to diagnose the disease. Preventive measures include physical or social distancing, quarantining, ventilation of indoor spaces, covering coughs and sneezes, hand washing, and keeping unwashed hands away from the face. As a result of a concerted global effort, several vaccines have been developed to combat the pandemic which is being administered vigorously all over the world. As of July 27th, 2021, a total of more than four billion doses of vaccines were administered worldwide. On the same date, more than 21% of the population inside the kingdom of Saudi Arabia was fully vaccinated.

Owing to the massive scale of destruction caused by the spread of COVID-19, the way of doing business had undergone immense transformation all over the world. Academic institutions have been no exception. The academic activities in most institutions of elementary and higher learning were reduced to online learning with students required to take the lessons from home using IT systems. Curriculums needed to be updated and awareness of new systems was urgently required to continue the process of imparting education. The process proved to be challenging and a daunting task for the level of enormity in transforming education and the scarcity of time to complete the task were both proving to be formidable challenges. There is an urgent need to redesign the curriculum in relation to the COVID pandemic and arising environment as the new variants keep emerging causing disruption in the academic process.

Blended Learning was poised to be positioned in a uniquely advantageous situation since it relies on both traditional face-to-face as well as modern

online IT-based teaching techniques. Yet, the effects of COVID-19 worldwide were upon this model of education as well and it required urgent and efficient adoption to meet the challenges. Saudi Electronic University is one of the largest institutions imparting Blended Learning education in the Middle East and North Africa (MENA) Region. Established in 2011 and spanning more than ten branches across the Kingdom of Saudi Arabia, the university enrolls more than twenty-seven thousand students in both undergraduate as well as graduate programs in five of its colleges. From the start of the COVID-19 pandemic, the university adopted serious measures to transform its academic systems keeping in mind the needs of changing times while ensuring the strict quality standards for academic excellence. In this paper, we highlight and summarize major steps undertaken in three areas namely (1) Safety and Health (2) Academic Curriculum Transformation, and (3) Evolution and Adoption of IT Systems.

The remainder of the paper is organized as follows: Section II provides a brief literature review about current state of art research in Blended Learning, COVID-19, and its impact on academic institutions. Section III introduces steps undertaken during this pandemic including physical measures, evolution and updated curriculum of various programs, and enhanced use of IT systems to align the academic process with changing environment. Section IV describes a brief summary of opportunities and challenges arising from these steps in the academic process in a Blended Learning environment. Finally, a conclusion and future work is presented.

2. Literature review

In 2008, Bharat and Sharma published a teacher's resource book where they employed the term "Blended Learning" (Sharma and Barrett, 2008). The term has been used widely since then to represent an academic model which comprises both traditional face-to-face as well as novel online learning models (Hockly, 2018). The design of any blended learning system depends on several significant factors but mainly on academic content and implementation duration (Rossett et al., 2003) as shown in Fig. 1. Blended learning is usually classified along with three models namely (1) Skill Driven (2) Attitude Driven and (3) Competency driven (Valiathan, 2002). These models distinguish from each other based on the peculiar nature of academic stakeholders such as students and faculty. In one of the landmark studies carried out in 2013, it was found that blended learning offers more favorable academic performance as compared to both pure traditional or complete online academic models (Tayebinik and Puteh, 2012).

The COVID-19 pandemic has brought dramatic changes in our lives and transformed the way we do our daily activities. It had disrupted the financial, economic, professional, and personal spheres of people's lives and the impact has varied from person to person depending on the criticality of the disease in the neighborhood (Jin et al., 2020). Research already shows that containment and control measures to overcome the pandemic are involving a very high economic cost (Deb et al., 2021). Researchers foresee no short-term solution in sight to the damage caused by COVID-19 to the economic as well as health sectors (McKibbin and Fernando, 2020). It is expected that the academic sector will also bear the effects of COVID-19 in the short to medium term.

While the effects of COVID-19 are visible in every sphere of our daily lives, our focus here is academic institutions, the effect of COVID-19 on academic institutions, and the study of methods adopted by academic institutions to overcome these adverse effects. It is a well-known fact as described earlier that this pandemic has greatly affected academic institutions (Daniel, 2020). The extent of this effect can be judged by the fact that according to UNESCO, as of 1st April 2020, academic institutions in 186 countries worldwide were already closed and approximately 89.4% of learners were forced to adapt to new models of learning (Marinoni et al., 2020).

To cope with this situation, the academic community has been adopting several mechanisms to facilitate the process of teaching and imparting education. The adoption of online academic systems saw a rapid increase in most parts of the world (Bao, 2020) Several governments and higher education institutions took meaningful and concrete steps to bridge the digital divide between rural and urban centers to improve the academic process (Crawford et al., 2020). Several educational and awareness programs were launched by higher academic institutions worldwide to increase awareness about pandemic control and safety for the benefit of students and their families. Physical facilities for monitoring detection and control were also established by higher institutions in the face of challenges posed by the pandemic (Illanes et al., 2020).

Higher education not only faced and coped with challenges related to the physical effects of COVID-19, but these institutions also had to evolve the curriculums and teaching strategies to overcome the challenges (Li et al., 2021). Many reputed academic institutions all over the world have presented their methods of evolving curriculum design in the face of challenges posed by COVID-19 (Van Nuland et al., 2020; Hughes, 2020). At the same time, more focus has gone into developing such teaching strategies that encourage students to be more hands-on learning (George, 2020). Interactive learning systems have sought an increase in interest because of their effective utilization in these times of crisis (Kaup et al., 2020).

Blended Learning has been a front runner in the adoption of technology since its inception. That, fortunately, helped Blended Learning institutions adapt more robustly to challenges posed by the approaching pandemic (Siripongdee et al., 2020).

Some research has been carried out which has shown that the use of technology and IT systems has yielded better and more impressive results during the COVID pandemic when compared with the application of the same systems by formerly traditional face-to-face or purely online systems (Rachmadtullah et al., 2020; Ożadowicz, 2020). Siripongdee et al. (2020) presented an IoT-based blended learning model that could make learning ubiquitous and more efficient for students. In another work authored by Alrazeeni (2021), the psychological effects of the COVID-19 pandemic on students and the utilization of technology to alleviate those effects have been studied with concrete case studies. Amongst several works published in this domain, Alsaqri et al. (2021) have written significant research highlighting the social stigma associated with COVID-19 and its ensuing effects.
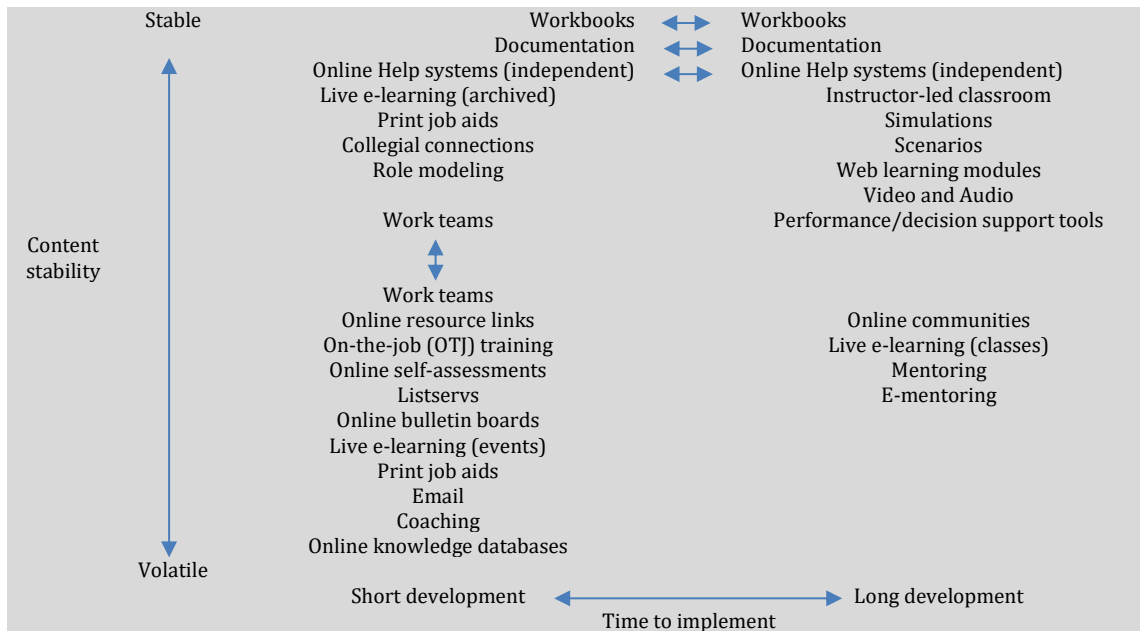

Fig. 1: Major contributing factors in blended learning (Rossett et al., 2003)

The focus of our work in this paper is to summarize various strategies adopted by a premier blended learning institution in the Middle East to cope with and manage the challenges of COVID-19. The context of this study is to demonstrate the focus of these steps in ensuring the safety and health of all stakeholders involved and at the same time continue and excel with the academic process. In the coming sections, we will list various initiatives taken by Saudi Electronic University from the perspective of safety, academic curriculum, and utilization of IT systems.

3. Evolving environment of blended learning during COVID-19

In this section, we briefly introduce steps taken by Saudi Electronic University to ensure a smooth and meaningful academic process during COVID-19. The purpose of this study is to highlight the evolving nature of academic infrastructure and processes during the days of the pandemic. The section is broadly categorized into three subsections, which deal with updates in Curriculum, IT Systems, and Physical Infrastructure.

3.1. Curriculum design

From the early days of the pandemic, it was envisioned that a need to overhaul the curriculum for various degree programs offered at Saudi Electronic University is needed to face the emerging challenges. By 2020, a programmed initiative in this regard is underway. As a study, we present salient features of curriculum overhaul in the College of Computing and Informatics (CCIT) at SEU. Following are some of the highlights of this curriculum design initiative:

- New programs design: In the current cycle of Curriculum design, new programs at both undergraduate and graduate levels have been formalized and established. As a result of this drive, a new bachelor's program in Computer Science has been started. The program of Masters in Data Sciences has been established as well.
- Credit distribution: The credit hours for all undergraduate and graduate programs have been redesigned to bring them in synch with international standards. The example credit hours distribution for undergraduate programs offered at CCIT is presented in Table 1. The redesigned curriculum emphasized offering enhanced professional learning. The upgraded curriculum also introduced new specializations in line with emerging trends in technology such as Cloud Computing, Cyber Security and IoT, etc.
- Program and course learning outcomes: During the curriculum review process, the Program Learning Outcomes (PLOs) and Course Learning Outcomes (CLOs) were reviewed and upgraded for all programs at CCIT. The most relevant taxonomy and

terminology were chosen to reflect the program objectives and make it easier for the students to relate to the program in an environment of enhanced self-learning as posed by pandemic constraints. A structured methodology as shown in Fig. 2 was adopted to streamline the process of PLOs and CLOs development. The mapping of these learning outcomes was carried out and reviewed later on by national curriculum accreditation authorities.

- Introduction of pre-programs: During the design of the new curriculum, it was realized that under the circumstances imposed by the pandemic, it will be paramount to make sure the shortcomings and limitations in the body of knowledge of students are overcome before they enter the actual program. Keeping this in mind, the preparatory year was designed as part of the curriculum for both undergraduate and graduate programs. Students are asked to undertake courses identified by faculty in order for them to overcome the deficiencies before starting their respective academic programs.
- Course content design: Starting from Fall 2020 and still ongoing, the college embarked on a program of indigenous course content overhaul. Several committees comprising faculty members from the college are involved in a yearlong exercise of course content development. The new contents reflect the upgraded academic plans, POs and CLOs. The activity is a complete year project and is expected to conclude before the start of Fall 2021. During the design of new content, it has been ensured that content complexity, distribution and assessment methods are cognizant of the prevalent pandemic-related situation.
- Reorientation of academic counseling: The process of academic counseling was completely overhauled during the year 2020 keeping in mind the special constraints posed by COVID-19 and possible consequent counseling and support that may be needed by students. The faculty underwent several orientation sessions to equip them in guiding students through their academic process. A special emphasis of these academic counseling sessions was to help students perform their academic assignments while coping with stress caused by circumstances resulting from COVID-19.

Table 1: Curriculum breakdown after a redesign

	ACM/IEEE CS 120 Credits	BSC IT Program 130 Credits	BSC CS Program 130 Credits
IT/CS Curriculum	45 (37%)	75 (57.69%)	76 (58%)
Math	12 (10%)	15 (11.53%)	15 (11.53%)
Science	6 (5%)	6 (4.65%)	6 (4.65%)
Others	57 (48%)	34 (26.15%)	33 (25.8%)

The activity of curriculum design and upgrade is being carried out along the same lines in other colleges of SEU and is expected to help in maintaining quality standards of education.
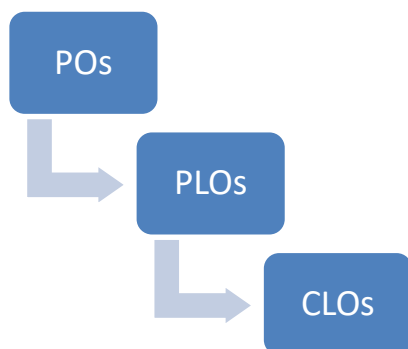
Fig. 2: Transformational model between POs, PLOs, and CLOs

3.2. IT systems application

IT Systems have always been a backbone of the academic process at SEU. Current circumstances resulting from COVID-19 necessitated increasing the application of these IT systems on much deeper and broader levels. Consequently, several developments have taken place in the application and usage of IT systems for the academic process. A brief list of recent developments in this regard are as follows;

- University portal redesign: The university portal (www.seu.edu.sa) was redesigned to improve its utility and functionality. A more user-intuitive design helps the students in locating required information in an efficient manner. Multi-Lingual support has been helping faculty and students. A clean layout helped increase performance time and reduce unnecessary clutter. Emerging technologies have been integrated now such as Artificially Intelligent bot assistant to help the students' queries round the clock.
- University web portals have been identified as a major source of information dissemination in all various parts of the world. Fig. 3 shows the level of satisfaction shown by respondents in the information provided by web pages of the universities in various categories of the countries (Neupane et al., 2020). The aim of redesigned SEU web portal is to increase the provision of reliable accurate information to its users.
- 360 degrees of IT systems: Since the advent of COVID-19, a concerted effort has been made by SEU to bring all academic and administrative processes of the university online. This initiative is to ensure that various academic stakeholders can carry out their roles and responsibilities with minimum physical contact. From the advent of the academic cycle to the registration of courses, submission of fees, complaint resolution, announcements, grades, etc. are all automated. This has helped reduce physical contact during

these days and helped keep the number of COVID-related exposures to the minimum.

- Blackboard learning management system (LMS): From its inception, SEU adopted Blackboard as its LMS partner (https://lms.seu.edu.sa/). Online learning hours have always been conducted through blackboard. From the start of the COVID-19 pandemic, all learning was carried out through Blackboard. Blackboard is being effectively used not only to deliver lectures but to disseminate academic resources and conduct assessments during the semester (barring examinations).
- Online Examination System: One further foray into the adoption of IT systems during the COVID-19 pandemic was the adoption and introduction of Swift Assess as its Online Examination System (https://exam.seu.edu.sa). Concerted and planned adoption of the examination system within weeks of the pandemic showed the level of commitment from SEU to provide seamless and efficient education to students during these disruptive circumstances. Since early 2020, the complete examination process for both midterms and final examinations is being handled by Swift Access. This has been a significant factor in helping combat COVID-19 at SEU throughout this time.
- Technical Support: Just-in-Time (JIT) Resolution of technical problems for students and faculty related to the academic process was initiated. Consequently, the whole process of technical support and complaint resolution has been automated. Round-the-clock remote assistance by IT teams for troubleshooting and maintenance of IT systems maintained by SEU is provided now. The benchmark Quality of Service parameters for technical support are enforced and regularly audited.
- SEU Digital Knowledge: The university has committed itself to provide state of the art, current, and relevant knowledge resources to the students with the help of IT systems. The focus got renewed

attention during COVID-19. The online knowledge resources provided by the university save the students and faculty the hassle to search and acquire resources physically. The knowledge resources (https://seu.app.deepknowledge.io/index) list some of the most extensive academic databases and repositories in the world to help students and faculty search for required information.

The section shows the active and purpose-oriented evolution and adoption of IT systems at SEU to cope with the challenges arising out of COVID-19. In the last subsection, we will discuss some regulatory and administrative measures adopted by SEU to combat the effects of COVID-19.

3.3. Results and analysis

From the beginning, Saudi Electronic University took lead in taking measures to control the spread of the pandemic among its members including the administration, faculty, and students. In this regard, several measures were taken on the administrative level keeping in mind international best practices regarding combatting and prevention of COVID-19. A small list of steps carried out in this regard:

- Standard Operating Procedures were designed and implemented in the first few weeks of the pandemic. These procedures were widely circulated amongst all stakeholders to ensure awareness.
- Mandatory distancing and mask policies have been enforced at all the branches of SEU from the beginning of the pandemic. International high standards of social distancing, hygiene, and masking have been properly followed during all this time.
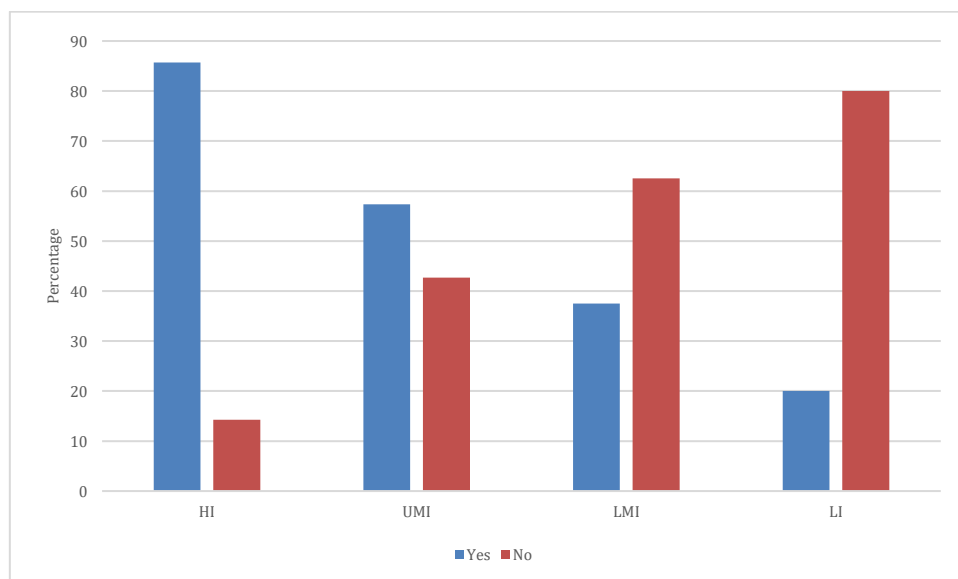
Fig. 3: User satisfaction with up-to-date information at universities webpages in high, upper medium, lower medium, and lower income countries (Neupane et al., 2020)

- As a socially conscious and responsible member of society, University launched and contributed to several awareness campaigns aimed at bringing understanding about the prevalence and effects of COVID-19. Various IT platforms at disposal of SEU including its portal as well as social media platforms were effectively used for this purpose.
- University equipped its medical centers at various branches for testing and subsequently vaccination support for its employees, students, and the general public. The medical facilities efficiently help the patients as well as disseminate relevant information.
- The university actively encouraged and pursued research on various aspects of COVID-19 and its impacts on society. A significant body of faculty and students in disciplines of IT, medicine, and other areas is busy conducting research and collecting data that helps provide insight into the disease and its impacts.

4. Challenges and opportunities

As the number of vaccinations grows, the world aims to return to pre-COVID times. The SEU aims to return to its standard Blended Learning education practices in days to come with compliance with vaccination protocols. At the same time, we have to be mindful of the emerging threats that potential variants of the virus may pose to this objective. Following are some of the challenges and opportunities identified during this study that could be crucial in the coming days:

- First and foremost, an important challenge in these times is to keep the focus and attention on emerging threats and to evolve quickly in face of any new adverse conditions. We have to understand both as a society and as an institution that we are in the phase of nascent recovery and there is no scope for leniency at this stage.
- Collection of data and foresight to avert any unpleasant situation is also a critical challenge. It is highly encouraged to involve academia in the development of IT systems capable of analyzing COVID-19-related data and providing advanced knowledge using state-of-the-art concepts of Artificial Intelligence and Data Mining.
- An important challenge is to educate society in general and members of the institution in particular about the importance of continued adherence to best practices that evolved during the time of this crisis. Focused and purpose-oriented information dissemination should be a responsibility and a challenge for all academic institutions in the days to come.
- The times of this pandemic have necessitated the adoption of IT systems. Yet, these times have also shown that the systems are not without their flaws. It should be an important challenge for academia to work and improve the systems at their disposal. The development of new more accurate models and technologies to cope with such situations is an important challenge.
- The research and adoption of new concepts and technologies is an exciting opportunity that should be availed in the future. The emphasis on the development of user-friendly systems that help us as members of an academic institution in carrying out our responsibilities should be encouraged.

As part of a larger study, we are currently involved in the collection of data from the students, faculty, and administrative members of SEU. That data should help us identify the actual impact of these transformations carried out at SEU in response to COVID-19. The analysis and findings from the data may also help in understanding the magnitude of these challenges and opportunities as described above.

5. Conclusion

The emergence of COVID-19 has been a transformational event in the history of mankind. The world has been evolving and adapting to the new realities of COVID-19 from the beginning of 2020. Now, with a significant amount of data available to us, we can study and analyze the impacts of this pandemic and the transformations it has brought. The role of IT systems in providing a conducive academic environment during COVID-19 in particular and in blended learning environments, in general, is very obvious. In this paper an overview of major steps taken at a Blended Learning institution to ensure a smooth academic process has been presented. The major focus of this study is the increased adoption of IT systems and curriculum design to face the challenges. The study highlights the potential benefits these steps may provide in ensuring the standard quality of the academic process and increased use of technology.

In the future, we aim to compile and analyze data regarding the impact of these changes in the academic process and the introduction of new IT systems. The analysis should help understand the extent to which technology can help adapt and evolve in times of challenges of such magnitude. The study should also help in identifying limitations and shortcomings of current practices as well as suggest improvements in this regard.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

Alrazeeni D (2021). Public anxiety during Coronavirus-19 disease (COVID-19) in Saudi Arabia: Indication for a psychological assistance intervention. International Journal of Advanced and

Applied Sciences, 8(4): 12-16. https://doi.org/10.21833/ijaas.2021.04.002

Alsaqri S, Pangket P, Alkuwaisi M, Llego J, and Alshammari MS (2021). COVID-19 associated social stigma as experienced by frontline nurses of Hail: A qualitative study. International Journal of Advanced and Applied Sciences, 8(8): 52-57. https://doi.org/10.21833/ijaas.2021.08.007

Bao W (2020). COVID-19 and online teaching in higher education: A case study of Peking University. Human Behavior and Emerging Technologies, 2(2): 113-115. https://doi.org/10.1002/hbe2.191 **PMid:32510042 PMCid:PMC7262082**

Crawford J, Butler-Henderson K, Rudolph J, Malkawi B, Glowatz M, Burton R, and Lam S (2020). COVID-19: 20 countries' higher education intra-period digital pedagogy responses. Journal of Applied Learning and Teaching, 3(1): 1-20. https://doi.org/10.37074/jalt.2020.3.1.7

Daniel SJ (2020). Education and the COVID-19 pandemic. Prospects, 49(1): 91-96. https://doi.org/10.1007/s11125-020-09464-3 **PMid:32313309 PMCid:PMC7167396**

Deb P, Furceri D, Ostry JD, and Tawk N (2021). The economic effects of COVID-19 containment measures. Open Economies Review, 33: 1-32. https://doi.org/10.1007/s11079-021-09638-2 **PMCid:PMC8669043**

George ML (2020). Effective teaching and examination strategies for undergraduate learning during COVID-19 school restrictions. Journal of Educational Technology Systems, 49(1): 23-48. https://doi.org/10.1177/0047239520934017 **PMCid:PMC7301292**

Hockly N (2018). Blended learning. English Language Teaching Journal (Elt Journal), 72(1): 97-101. https://doi.org/10.1093/elt/ccx058

Hughes C (2020). COVID-19 and the opportunity to design a more mindful approach to learning. Prospects, 49(1): 69-72. https://doi.org/10.1007/s11125-020-09492-z **PMid:32836430 PMCid:PMC7387802**

Illanes P, Law J, Mendy A, Sanghvi S and Sarakatsannis J (2020). Coronavirus and the campus: How can US higher education organize to respond? Mckinsey and Company, London, UK.

Jin YH, Cai L, Cheng ZS, Cheng H, Deng T, Fan YP, and Wang XH (2020). A rapid advice guideline for the diagnosis and treatment of 2019 novel coronavirus (2019-nCoV) infected pneumonia (standard version). Military Medical Research, 7(1): 1-23. https://doi.org/10.1186/s40779-020-0233-6 **PMid:32029004 PMCid:PMC7003341**

Kaup S, Jain R, Shivalli S, Pandey S, and Kaup S (2020). Sustaining academics during COVID-19 pandemic: The role of online teaching-learning. Indian Journal of Ophthalmology, 68(6): 1220-1221. https://doi.org/10.4103/ijo.IJO_1241_20 **PMid:32461490 PMCid:PMC7508127**

Li Y, Zhang X, Dai DY, and Hu W (2021). Curriculum innovation in times of the COVID-19 pandemic: The thinking-based instruction theory and its application. Frontiers in Psychology, 12: 1140. https://doi.org/10.3389/fpsyg.2021.601607 **PMid:33912100 PMCid:PMC8071859**

Marinoni G, Van't Land H, and Jensen T (2020). The impact of COVID-19 on higher education around the world. IAU Global Survey Report, International Association of Universities, Paris, France.

McKibbin W and Fernando R (2020). The economic impact of COVID-19. In: Baldwin R and di Mauro BW (Eds.), Economics in the time of COVID-19: 45-51. CEPR Press, Washington, USA.

Neupane D, Rai J, Chaulagain S, Jha N, Sah A, and Bhuju DR (2020). Role of academic institutions during the COVID-19 pandemic. International Journal of Infection Control, 16(4). https://doi.org/10.3396/ijic.v16i4.024.20

Ożadowicz A (2020). Modified blended learning in engineering higher education during the COVID-19 lockdown—Building automation courses case study. Education Sciences, 10(10): 292. https://doi.org/10.3390/educsci10100292

Rachmadtullah R, Marianus Subandowo R, Humaira MA, Aliyyah RR, Samsudin A, and Nurtanto M (2020). Use of blended learning with moodle: Study effectiveness in elementary school teacher education students during the COVID-19 pandemic. International Journal of Advanced Science and Technology, 29(7): 3272-3277.

Rossett A, Douglis F, and Frazee RV (2003). Strategies for building blended learning. Learning Circuits, 4(7): 1-8.

Sharma P and Barrett B (2008). Blended learning: Using technology in and beyond the language classroom. Macmillan, New York, USA.

Siripongdee K, Pimdee P and Tuntiwongwanich S (2020). A blended learning model with IoT-based technology: Effectively used when the COVID-19 pandemic? Journal for the Education of Gifted Young Scientists, 8(2): 905-917. https://doi.org/10.17478/jegys.698869

Tayebinik M and Puteh M (2012). Blended learning or e-learning? International Magazine on Advances in Computer Science and Telecommunications, 3(1): 103-110.

Valiathan P (2002). Blended learning models. Learning Circuits, 3(8): 50-59.

Van Nuland SE, Hall E, and Langley NR (2020). STEM crisis teaching: Curriculum design with e-learning tools. FASEB BioAdvances, 2(11): 631-637. https://doi.org/10.1096/fba.2020-00049 **PMid:33205004 PMCid:PMC7655092**