Digitizing Learning During the Outbreak of COVID-19 Pandemic: Lessons Learned from the Most Infected Countries

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Abstract In late December 2019, a novel coronavirus (COVID-19) was determined in Wuhan, China. Within a short period, more than 100 countries were infected with this epidemic. To mitigate the development of this virus, many countries have announced the closure of their educational institutions. The closure decision has left many institutions unable to select the appropriate technology for delivering the learning materials to their students. To assist those institutions attempting to digitize their learning during this pandemic, the main aim of this research is to review the leading technologies used for delivering the learning materials by considering the experiences of the most infected countries at the time of conducting this study. Through a mind map, we have concluded that the most leading technologies used for online learning are video conferencing, Massive Open Online Courses (MOOCs), educational national portals, recorded video lectures, cloud computing platforms, Microsoft Teams, and educational TV. We have also discussed the main challenges that might encounter the delivery of online learning. It is believed that the conclusions drawn from this study would assist those institutions trying to digitize their learning materials during the outbreak of COVID-19.

Keywords Novel coronavirus · COVID-19 · Educational technologies · Online learning

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1 Introduction

In late December 2019, a novel coronavirus (COVID-19) was discovered in Wuhan, China [1]. In less than two months, this epidemic has spread from China to more than 100 countries worldwide [2]. As of today (28-03-2020), the number of confirmed cases has increased to 622,316, and more than 28,800 death cases were reported across the infected countries [3]. This urgent threat has forced universities and schools across numerous countries to close their doors and digitize their learning activities.

Due to this pandemic, the educational systems across many countries have gradually dismantled. The spread of COVID-19 has affected students’ ability to attend classes and acquire their learning activities. This has changed the way on how millions of students would be educated globally. These changes would lead to a paradigm shift in the educational systems, whether for the better or the worse situations in the long run [4]. In light of the rapid spread of COVID-19 across Asia, Europe, the USA, and the middle east, many universities and schools have decided to deliver the learning materials to students through online technologies in an attempt to mitigate the development of the epidemic. These urgent decisions have forced students to take a home-schooling environment, particularly in the most infected countries at the time of conducting this study, like China, Italy, the USA, Spain, Germany, Iran, and South Korea.

The call for online teaching during the wake of this epidemic has hurriedly encouraged educational institutions to turn their physical classes into virtual ones [5]. While this might be the best immediate reaction from the pedagogic and epidemiologic perspectives, it has affected the instructors in reformatting and retrofitting the learning materials in a way to be acceptable by the students [5]. A large number of research studies were conducted in the past concerning the issues related to the delivery of online teaching [6, 7]. However, none of these studies have discussed the issues related to the use of information technologies in promoting educational activities during the outbreaks of such an epidemic. As a means of supporting those universities trying to digitize their learning materials during the outbreak of COVID-19, this research aims to provide a holistic view of the leading technologies used to deliver the learning materials from the lenses of the most infected countries. Due to the lack of scientific articles concerning the use of educational technologies during the spread of this epidemic and specifically at the time of conducting this study, it is imperative to report that the sources through which this study relied on, were derived from newsletters, magazines, and other relevant websites.
2 Delivery of Learning in China

In response to the deadly coronavirus pandemic, many higher education institutions have made dramatic paradigm shifts to adapting pedagogy to online tuition [8]. To conserve equality in education and enable students to sustain their studies during the novel coronavirus outbreak, Chinese universities have launched digital instructional platforms to deliver a variety of courses utilizing ultra-modern digital tools [9]. Although it is a contingent delivery method, this inclusive model of distance teaching and learning targets all students, including international students and worldwide learners [8]. Since the crisis has provided the impetus for transforming campus-based degrees into fully-fledged online degrees, it has become imperative for online education to go viral [10].

Because COVID-19 is highly contagious, the real-time interaction between instructors and students has been jeopardized [11]. That being the case, the government-mandated closure of campuses has oriented tertiary education in China towards the endorsement of Massive Open Online Courses (MOOCs), aided by live-streaming apps and synchronized video-conferencing systems to fulfill practical teaching needs, such as Zoom, Skype, Alibaba’s DingTalk, and Google Hangouts [8, 12]. A national portal called “National Cloud-Platform for Educational Resources and Public Service” was also used to provide millions of students with continued educational services [13]. Within a matter of weeks, the COVID-19 has become a catalyst for the trajectory of higher education to be digitally expediting learning innovation. In mainland China, 120 million students have accessed and shared learning materials via live broadcasts, virtual reality tuition, and learning cloud platforms. Such a trend has been consolidated by the government initiative of launching national internet cloud educational services [4, 12]. Additionally, more than 20 online curriculum platforms, 24,000 courses for higher education institutions, and library digital resources have been offered for free within a short period of time since the initial cases have been diagnosed [11]. In Chinese territories like Hong Kong, the vast majority of students have commenced using interactive apps while learning at home [4]. The flourishing of 5G technology in China has brought along the momentum for the prevalence of new modalities of digital education. Nonetheless, it has made the pedagogical efficacy of digital modalities of education vulnerable to pitfalls in terms of the infrastructure of the online education system and the impact of several aspects of the digital divide on students’ and instructors’ engagement with distance education [14]. In essence, the COVID-19 public health crisis has risen red flags of other hidden emergencies; viz-to-viz, “digital divide”, or “digital exclusion”. That is to say, in more impoverished or more rural areas with underdeveloped digital technology infrastructures, the construction of the medium for online learning to take place would be an enormously overwhelming task. Simultaneously, the access to digital information sources does not necessarily warrant that learning does occur, which makes the credibility of online-pedagogy questionable.
The decisive measures were undertaken by Chinese authorities to revoke the hazards of face-to-face instruction by setting into motion state-of-the-art digital learning programs that persist in being haphazard and short-term for two reasons. First, rather than being holistic and persistent in the long run, the transfer from offline to online education remains contingent on the fade or otherwise the outbreak of the epidemic. Second, for digital education to succeed substantially, an extraordinarily high level of systematic collaboration and cooperation among higher education institutions is considerably in demand to develop a new cloud-based online learning and broadcasting platform as well as to upgrade a suite of education infrastructure [4, 9]. This state of affairs vindicates the argument that on more profound levels of analysis, there comes to the surface an acute deficiency in the sustainable endeavors to bridge the digital divide on the levels of technology infrastructures, legislations, logistic readiness, inclusiveness, digital equity, bandwidth connectivity, and digital literacy among various hierarchical levels of stakeholders in the educational enterprise. These pillars are essentially vital in accelerating and facilitating the transition from offline to online education in virtual contexts for students, parents, instructors, administrators, and digital curriculum developers, while taking caution to mitigate the skeptical remarks on the quality of electronic tuition, especially in the era following the fourth industrial revolution, in which the world has become wireless.

The unprecedented distance learning model that has been emerging and evolving under the exceptional epidemic circumstances resembles, to a noticeable extent, the MOOCs paradigm. Thus, shortcomings that are inherent in MOOCs such as the low rates of completion, as opposed to small private online courses, and the difficulty to maintain attentiveness and engagement into the online format of education are amongst the salient challenges that hinder fully reaping the pedagogical gains of online instruction. Furthermore, securing clear and concise communication channels to manage learners’ anxiety, the adaptation of assessment tools to ensure robust learning, and nurturing individualized cognitive and metacognitive development of learners constitute major milestones to cultivate the growth of remote online learning [15].

3 Delivery of Learning in Italy

Italy has the second top COVID-19 confirmed cases after China, with an increasing number of patients suffering from coronavirus [16]. The growing number of COVID-19 infections leads to paralyzing different aspects of Italian lives [17]. Many schools, universities, and companies rely on e-learning and smart working as alternatives to conventional education across different levels. Smart working cannot solve the production processes problems and workflows in factories [17]. The digital transformation can solve some of the COVID-19 issues, but it is not a magic solution to the COVID-19 problem.
On March 4th, 2020, Italy’s education minister, Lucia Azzolina, announced the closure of all academic establishments, including schools and universities, starting from March 5th, 2020 to March 15th, 2020. The closure later is extended to April 3rd, 2020 [17–19]. To handle the closure situation, Italy has used two national portals. The first one is called “La scuola continua”, which was dedicated to school students. The other portal called “Nuovo Coronavirus”, which was devoted to show how to deal with COVID-19 in emergency cases [13].

Matthew Loveless is an associate professor at The University of Bologna in Italy who decided to use Microsoft Teams as a platform to deliver lectures to his students [20]. Microsoft Teams is a platform for unified communication and collaboration. It is a hub for teamwork in Microsoft Office 365 Suite. Therefore, it can be used for group chat, video meetings, file storage, and hosting online meetings. Microsoft Teams is compatible with almost all the available operating systems and can be used on desktop and mobile devices. To solve the problem of academic establishments closure, the use of online learning is a good option since it lets the students to pursue their studies from homes regardless of how far these homes are from their schools or universities. The University of Bologna decides to convert all its traditional convertible courses to online courses, whereas some cannot be converted like lab courses [21]. While the library at the University of Bologna is also closed, Antonino Rotolo, the vice-rector for research at the University of Bologna, said that this crisis would help academic establishments to accelerate the process of adopting digital technologies for teaching [21].

Furthermore, online learning is a solution to the problem of timetables for students who have mutually contradictory time courses, as well as avoiding the chances of infections. Online learning is an economical option since we get rid of the transportation and residential costs. The present circumstances enforce the necessity to consider online learning and home-schooling as a viable option for education at different levels for the present and the future. The Italian universities have adopted digital technologies to minimize the harmful effects of placing the whole country under quarantine. Therefore, all courses, exams, and research were digitized to enable these universities to deliver online courses and hold thesis defenses through videoconferences. The lab-based courses could be postponed until the closure and quarantine are lifted, and life returns to normal [21].

4 Delivery of Learning in the USA

The transformation from face-to-face education to online and distance learning is going on all around the world, due to the increasing infections of COVID-19. In the USA, Harvard University stated that it would move for online and distance learning for graduate and undergraduate classes starting from March 23, 2020 [22]. The transformation to online and distance learning is not only restricted to Harvard University, but other universities also adopted it in the USA, such as “American University”, “Amherst College”, “Barnard College”, “Columbia University”, “University of California”, “California Institute of Technology”, “Stanford University”, “University of Michigan”, “University of Chicago”, “University of Pennsylvania”, “Georgia Institute of Technology” and “Yale University”.

4.1 Online and Distance Learning

Since the outbreak of COVID-19, online and distance learning has become a priority for universities and schools worldwide, particularly in the USA. Many universities in the USA, such as Stanford University, University of California, and Georgia Institute of Technology, adopted online learning as a means to continue education during the pandemic.

4.1.1 Stanford University

Stanford University decided to move all of its classes to online platforms starting from March 9th, 2020 [23]. The university chose to use Canvas, a learning management system, to deliver lectures and assignments. This decision was made to ensure the continuity of education and prevent the spread of the virus among students.

4.1.2 University of California

The University of California also adopted online learning as a means to continue education during the pandemic. The university used Canvas to deliver lectures and assignments. The university also provided additional support to students in terms of academic counseling and mental health services.

4.1.3 Georgia Institute of Technology

Georgia Institute of Technology also adopted online learning as a means to continue education during the pandemic. The university used Blackboard to deliver lectures and assignments. The university also provided additional support to students in terms of academic counseling and mental health services.

4.1.4 Summary

Online and distance learning has become a priority for universities and schools worldwide, particularly in the USA. Many universities in the USA, such as Stanford University, University of California, and Georgia Institute of Technology, adopted online learning as a means to continue education during the pandemic. This decision was made to ensure the continuity of education and prevent the spread of the virus among students.
“University of California San Diego and Berkeley”, “Hofstra University in New York”, “Ohio State University”, “Princeton University”, “Seattle University”, “University of Southern California”, “Stanford University”, and “University of Washington”, according to multiple news outlets.

Prior to the COVID-19 crisis, Johns Hopkins University (JHU) has handled the problem of shortages of dead human bodies that were used to teach autopsies through the use of multimedia platforms as a solution [23]. During the spread of the COVID-19 epidemic, the JHU published a practical guide for faculty members through its website to explain the process of moving their online courses as an alternative to traditional face-to-face courses [24]. The JHU launched a website called “Keep Teaching @ JHU”, which is a hub of hyperlinks and frequently asked questions to provide the faculty members with all necessary guidance to prepare their online materials.

It is urgent under the current circumstances to move into virtual classes. This transition requires creative learning activities and to think deeply about how to conduct assessments. In this sense, the faculty members can use Zoom and Panopto, which are web-based video conferencing tools, to communicate with their students and deliver their lectures. Transitioning to online learning is not easy due to the differences between face-to-face classes and virtual ones [24]. Many colleges and universities in the USA have closed their face-to-face classes, and the transition to online learning is coming ahead [25, 26]. The transition to online learning is not an easy option since there is a large portion of faculty members who are not familiar with educational technologies. Furthermore, there is a large portion of students who do not have access to reliable and fast Internet services [26].

5 Delivery of Learning in Spain

Concerning the delivery of learning in schools during the spread of COVID-19, the Ministry of Education in Spain offers three national learning platforms. First, INTEF as a pedagogical resource to support distance learning. Second, Procomún collection with around 100,000 educational resources and learning objects. Third, an online channel called Educlan [13].

In terms of higher education, the University of Deusto in Spain offers several teaching support resources such as Moodle, a free and open-source learning management system, and Google Meet to make video conferencing between the students and their instructors [27]. The University of Deusto advised the faculty members and students to use emails, Google Calendar, Google Hangouts, and Google Drive to communicate virtually. In Spain, there are few distinguished online universities like the Open University of Catalonia (UOC) and the National Distance Education University (UNED) [23]. These two Spanish universities offer online learning, while others offer traditional (face-to-face) learning. The traditional learning provided by the vast majority of Spanish universities can change face-to-face learning into distance and online learning. Still, the question is, would
this transition be good enough for the students? Many think that distance/online learning means the use of different technological tools only, such as recorded lectures, educational platforms, PowerPoint slides, PDFs, simulations, virtual reality (VR), etc. This concept of distance/online learning that depends on technical tools ignores the quality through which the interaction between the mentor and his/her students is affected [23]. This means that the most essential factor is the adopted pedagogical model.

The Spanish Ministry of Universities and the Conference of Rectors have launched an educational platform to enable the instructors and their students to attend classes virtually. This educational platform was mainly designed by both UNED and UOC. This platform mainly aims to provide guidance and training resources for instructors to enable them to convert their face-to-face classes into virtual ones [28].

6 Delivery of Learning in Germany

Germany, as other European countries, forced restrictions on schools and universities to slow down the spread of COVID-19. The Technical University of Munich (TUM), as one of the German Universities which forced these restrictions, had tried to use online learning to overcome this crisis [29]. The TUM has informed the instructors to teach online instead of teaching on its campus [30]. A booklet entitled “Flexible Solutions for Digital Teaching” was published on the web by the TUM in order to enable the instructors to convert their traditional classes into virtual ones easily [31]. The booklet shows the instructors the appropriate tools used for conducting an online lecture, seminar, or meeting. Furthermore, this booklet shows how to record different online activities and create educational videos [31].

7 Delivery of Learning in Iran

The Iranian students have already experienced the distance learning approach for the first time during the eighties in the first gulf war using their state TV to broadcast different lectures to their students. This means that the distance learning method has already been experienced around 35 years ago in Iran. It is, therefore, that Iran has adopted the same approach in the COVID-19 era. Currently, the Iranian used different techniques in their second distance learning experience, which enables various parties to interact with each other [32]. From their first experience with distance learning through TV, the Iranians realized the difficulties of including all school classes and courses and conducting different exams, and that was due to the one-way communication method [32]. To overcome these limitations and to deal with the current urgent situation, the University of Tehran has published on one of its webpages about the availability of many online classes...
Concerning the delivery of learning at Iranian schools, it has been argued that the Iranian school students may have to continue their studies next summer, and this means there will be no summer holiday for school students [34]. Furthermore, the idea of adopting distance education, offering videoconferencing classes, and State educational TV is highly encouraged [34]. It is hoped that adopting these technologies may help to improve the quality of the educational system in Iran. In line with the increasing number of national portals to help students in pursuing their education across several countries, Iran has also launched a national portal called “Dedicated TV programming” that was created by the Ministry of Education to deliver the learning for different grades during this crisis [13].

8 Delivery of Learning in South Korea

Unlike the other highly infected countries, South Korea has resorted to its functional and consistent standard operation procedure to hold sway over risk factors in public health crises. With the eruption of the fatal disease, the closure of higher educational institutions and retrieving their students from study abroad programs, have been compulsory approaches to restrain public gatherings, and hence, to contain the prevalence of the novel coronavirus [22, 35, 36]. Since South Korea is one of the most technologically equipped countries in the world, mobile mass indiscriminate awareness-raising and smartphone apps providing GPS maps have been set into action to observe the infection spread carefully [36].

South Korea has demonstrated a role model for the world in the employment of smartphone apps to constrict the contagion, and consequently to reduce mortality. On the other hand, the South Korean vigorous information technology infrastructure has not been manifested comparably and robustly in the conversion to online education. In a nation where education is highly competitive on global levels, South Korean universities have not managed to confer their students, including nationals and international students, convenient and pathological distance online learning experiences in compensation for face-to-face instruction. As such, the crisis has left higher educational institutions in South Korea to be incapable of alleviating the negative feedback of frustrated students [37].

Apart from online education initiatives, Seoul has devoted the vast technological resources it enjoys at its disposal to primarily save lives by creating and implementing smartphone apps with two main aims; (a) mass testing and tracking of suspected cases, and (b) educating the population of the preventive mechanisms. To that end, the first app is mandatory for people arriving in South Korea from immensely impacted areas. The app forwards users to the teleworking executive to report any suspicious symptoms on a regular basis. The other app is not compulsory, but it alerts public health officials whenever someone leaves the isolation zone. Concurrently, the Centers for Disease Control and Prevention in South Korea
have published a full amount of transparent information punctually every day to educate minutely the public, including experts and citizens to improve their understanding of how the virus evolves and functions in addition to the conveyance of relevant data that relieve the population concerns. Such valuable information has been communicated to residents using a national mobile phone alert system [38].

South Korea has a penetration rate of over 90%, which is anticipated to narrow the digital divide in the country to a considerable extent. Despite that, university students in South Korea might perceive the recorded video lectures and real-time telelectures as a poor substitute for face-to-face instruction. This stems from the design of universities online platforms, which simulate MOOCs and minimizing lively interactive learning experiences [10]. South Korea has used the educational broadcasting system as a national portal to provide learners with advanced educational services based on the use of multimedia [13]. Bridging the digital divide in South Korea has not been adequately associated with sustainable strategic planning for crisis management in education, which seems to be far underdeveloped as compared to risk management in healthcare sectors. Instead, the core of South Korean educative endeavors under the spread of the epidemic lies in the utilization of smart apps and high-speed connectivity as agencies to the quick containment of the epidemic through the constant disclosure of crystal-clear and intensive up-to-date information to the public, swift widespread testing, social distancing, and digital monitoring of those under quarantine [39].

The lessons gleaned from the South Korean case revolve around the aggressive employment of smart technologies in plotting the trajectory of the pandemic by securing information necessary for effecting extreme proactive measures to break the exponential growth cycle of the infection. However, the country has compromised the quality of online alternatives of conventional face-to-face tuition during lockdowns of campuses for the sake of striking down its epidemic curve [40]. In this respect, the coronavirus catastrophe has been tackled by integrating and readjusting multiple forms of artificial intelligence to share, transmit, process, and reciprocate timely high-quality digital data between the public and governmental organizations, which is vital to make detrimental decisions to eradicate the epidemic [41]. The South Korean experience poses the question as to whether governments should place the information technology capital investment into the healthcare industry or education under prevailing disease quandaries. Such a question leads to a more insisting debate as to whether the educational sectors demand well-established benchmarks for an effective standard operation procedure that prognosticates and correspondingly applies a comprehensive scheme of digital solutions to remunerate for emergency shutdowns of educational institutions.
9 Discussion and Conclusion

Due to the outbreaks of COVID-19, many countries have announced the closure of their educational institutions, including schools and universities [42]. The closure of these institutions has led to a paradigm shift in the educational process in a way to transform the face-to-face classrooms into virtual ones. This transformation has left many institutions unable to decide to select the appropriate technology for delivering the learning materials to their students. In order to help those institutions attempting to digitize their learning during this pandemic, the main aim of this research is to review the leading technologies used for delivering the learning materials with a particular focus on the most infected countries. In that, we have reviewed the educational technologies used in China, Italy, the USA, Spain, Germany, Iran, and South Korea.

It has been observed that a large number of technologies were used to deliver online learning as an alternative to traditional learning among the selected countries. To draw a comprehensive picture of those technologies, we have summarized the leading delivery technologies used for online learning through a mind map, as shown in Fig. 1. These educational technologies include video conferencing, MOOCs, educational national portals, recorded video lectures, cloud computing platforms, Microsoft Teams, and educational TV. It is believed that the conclusions drawn from this study would assist those institutions trying to move into online learning by enabling them to select the appropriate technology that suits their infrastructure capabilities.

Fig. 1 Leading delivery technologies for online learning during the outbreaks of COVID-19 epidemic
While several technologies were suggested, some challenges might still exist through the transition to online learning across several universities. First, many faculty members and students are not familiar with such technologies. Second, many faculty members and students do not have access to the internet, especially those living in remote areas. Third, the differences in quality between traditional classrooms and online learning might be a substantial factor that hinders the transition to online classes.

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